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Modeling the Conditional Relationship Between Military Expenditure and Economic Growth: An Integrated Econometric and Machine Learning Analysis

Bachelor thesis

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Introduction

The ongoing conflict between Russia and Ukraine has triggered a significant surge in defense spending across the globe, prompting a re-evaluation of military preparedness and stimulating renewed debate about the complex relationship between defense expenditure and economic growth. While numerous studies have explored this "guns vs. butter" relationship, a conclusive answer remains elusive, largely due to the limitations of traditional econometric models which often struggle to capture the non-linearities and conditional effects inherent in this dynamic.

This thesis addresses this long-standing debate by moving beyond traditional linear models and employing an integrated data science approach. Leveraging a comprehensive, longitudinal dataset spanning seven decades and a diverse sample of 40 NATO and allied nations, this research utilizes advanced machine learning techniques to uncover the complex patterns that govern the defense-growth nexus. By combining the predictive power of ensemble models with the interpretability of classical econometrics, this study seeks to identify not only if defense spending impacts growth, but more importantly, how and under what conditions its influence is felt.

The central research question of this thesis is therefore twofold:

What are the most significant economic, social, and political drivers that determine whether a country will enter a Low, Medium, or High economic growth regime?

Within this framework, what is the specific, conditional role of military spending, and how does its relationship with economic growth change in the presence of other factors?

To answer these questions, the research unfolds across several key stages. First, an extensive theoretical framework (Chapters 1-2) is established, reviewing the Neoclassical, Keynesian, Endogenous Growth, and Political Economy perspectives that have shaped the academic discourse. This framework directly informs the variable selection and hypothesis testing in the subsequent empirical analysis.

Next, the data and methodology (Chapter 3) are detailed. This section outlines the assembly of the unique multi-source dataset and describes the rigorous preprocessing required to ensure its integrity. This includes the use of advanced imputation techniques (Multiple Imputation by Chained Equations) to handle non-random missing data, the engineering of key features, and the creation of the categorical target variable based on established economic growth regime literature.

Grounding the analysis in contemporary events, Chapter 4 provides a detailed current context analysis, examining the post-2022 surge in defense spending in key Western nations and its immediate industrial and fiscal consequences.

The core of the empirical work is presented in the methodological framework and predictive modeling chapters (Chapters 5-6). This section details the comparative analysis of three distinct models—a Multinomial Logistic Regression, a Random Forest, and a Neural Network—which are rigorously evaluated using a stratified cross-validation framework. The analysis then moves from model performance to deep interpretation, using a suite of modern techniques including Permutation Importance, SHAP (SHapley Additive exPlanations) values, and Partial Dependence Plots (PDPs) to deconstruct the "black box" and understand the nuanced, non-linear relationships learned by the superior model.

Finally, the thesis concludes (Chapters 7-8) by synthesizing the empirical findings and discussing their profound implications for both economic theory and contemporary policy. By moving beyond a simplistic causality debate, this research aims to provide a sophisticated, evidence-based understanding of the "guns vs. butter" trade-off, offering valuable insights for policymakers seeking to balance national security imperatives with the goal of sustainable economic prosperity in a geopolitically complex world.

Chapter 1. Literature Review

This chapter provides an extensive review of the literature exploring the complicated relationship between defense spending and economic growth, setting the stage for the empirical analysis that follows. It moves beyond a simplistic "guns vs. butter" dichotomy to explore the complex and often contradictory effects of military expenditure on national economies, particularly within countries possessing robust domestic military industries.

1.1. The Core Debate

This section introduces the core debate surrounding the impact of defense spending on economic growth.

1.1.1. Neoclassical and Keynesian Perspectives

The academic discourse surrounding defene spending's impact on economic growth is largely framed by two competing paradigms: the Keynesian argument on demand-side stimulation and the Neoclassical focus on supply-side constraints. These perspectives diverge fundamentally in their assumptions about resource allocation, market efficiency, and the role of government expenditure, offering contrasting explanations for how military outlays interact with macroeconomic performance.

Firstly, Keynesian Demand-Side Dynamics. Rooted in Keynesian macroeconomics, proponents of military spending’s growth-enhancing effects argue that defense expenditures act as a fiscal multiplier, stimulating aggregate demand during periods of economic slack (Benoit 1973). This framework posits that government outlays on personnel, equipment, and infrastructure inject liquidity into the economy, raising capacity utilization, employment, and private sector profitability (Tsitouras et. al., 2024; Aydin, 2021). This is especially relevant in developing economies or during recessions where underutilized resources exist. Benoit's (1973) seminal analysis of 44 developing nations, where defense investments correlated positively with GDP growth—later termed the "Benoit Hypothesis"—supports this view (Aydin, 2021). Subsequent studies, including Dimitraki and Win (2021) and Mohanty et al. (2020), reinforce this view, showing short-term growth boosts from military spending in economies with idle labor or capital (Tsitouras et. al. 2024)

Keynesian models also highlight the unique demand characteristics of military spending. Unlike some civilian public investments, defense projects often involve high R&D intensity and capital-intensive procurement. This can generate technological spillovers, with innovations in areas like aerospace, computing, and materials science originating in military applications before diffusing to civilian sectors, enhancing long-term productivity (Tsitouras et al., 2024; Aydin, 2021). However, this perspective's applicability is contingent on the economy operating below full employment. In contexts with tight resource constraints, demand-side benefits may diminish due to inflationary pressures or import dependencies (Tsitouras et al., 2024). Though, the long-term socioeconomic impact of defense spending is complex. While it may initially stimulate military-related industries, it can limit broader industrial diversification, especially if spillovers to the civilian sector are limited. Inefficiencies, cost increases, and reduced innovation are also risks when spending lacks market discipline. Military expenditure's effect on human capital is similarly ambiguous. While military training provides skills, it may divert resources from education, R&D, and healthcare, potentially slowing long-term growth—especially in resource-limited developing economies. The balance between short-term benefits and long-term costs remains an open empirical question (Brauer, 2002).

Secondly, Neoclassical Supply-Side Constraints. Neoclassical theorists counter that defense spending imposes significant opportunity costs by "crowding out" productive private and public investments (Benoit, 1973; Dunne, 2013; Pieroni, D’Agostino, & Lorusso, 2008). This is often visualized as a trade-off between "guns and butter." Building on Barro's (1990) endogenous growth framework, which models optimal taxation and expenditure trade-offs, this approach frames military outlays as a diversion of scarce resources from sectors like education, infrastructure, and healthcare, which may have higher social returns (Aizenman & Glick, 2006; Aydin, 2021). Financing defense through taxation or borrowing can raise the cost of capital, discouraging private investment and innovation (Tsitouras et al., 2024).

A critical Neoclassical contribution is the distinction between short- and long-term effects. While Keynesian-stimulated demand may temporarily lift output, prolonged defense expenditure risks structural imbalances. Countries reliant on imported military hardware may experience currency depreciation and trade deficits, eroding long-run growth potential (Tsitouras et al., 2024). Personnel-intensive militaries, common in developing nations, can divert human capital from civilian sectors, potentially stifling entrepreneurship and skill accumulation (Tsitouras et al., 2024). However, military spending could be considered productive if it is complemetary to priviate investment (Barro, 1990). This creates an optimal size of government and military spending to maximise growth (Devarajan et al., 1996). Recent studies continue to investigate this framework given the changing economic landscape. Empirical support for the Neoclassical view is found in cross-country analyses, such as those by Aizenman and Glick (2006), who find that the growth impact of military spending turns negative after controlling for external threats and corruption, as rent-seeking behaviors signify inefficiencies.

The contrast between these theories emerge partly from differing assumptions about economic conditions and spending composition. Keynesian models often implicitly assume insufficient aggregate demand and domestically oriented procurement, whereas Neoclassical critiques presuppose full employment and imported or inefficient military systems. Aizenman and Glick (2006) introduced non-linearities, showing that defense spending's growth impact depends on external threat levels and institutional quality. In high-threat environments, military expenditure can enhance security, encouraging private investment—a synergy less evident in peaceful contexts. On the other hand, corruption intensifies Neoclassical crowding-out effects, as rent-seeking bureaucracies inflate procurement costs.

Empirical studies further highlight sectoral asymmetries. The composition of military budgets matters; personnel costs may yield short-term demand boosts but create long-term pension liabilities (Tsitouras et al., 2024), while R&D-heavy defense systems can generate technological externalities that partially offset crowding-out effects (Aydin, 2021).

Both paradigms face methodological constraints. Keynesian analyses may overlook supply-side bottlenecks, while Neoclassical models struggle to quantify quality benefits like geopolitical stability. Datasets often rely on aggregated military spending, masking compositional differences (Tsitouras et al., 2024). Theoretical limitations also persist. Barro's (1990) optimal taxation framework assumes perfect substitutability between military and civilian expenditures, which is unrealistic in nations facing existential threats (Aizenman & Glick, 2006). The Benoit Hypothesis, while influential, has been criticized for potentially confusing correlation with causation (Aydin, 2021).

The debate between Neoclassical and Keynesian perspectives remains unsettled, underscoring the context-specific nature of defense economics. Modern research is increasingly employing threshold models that recognize the strengths and weaknesses of each theoretical approach, acknowledging that the effects of military spending on growth vary depending on economic conditions, the severity of external threats, and the quality of institutions.

1.1.2. Endogenous Growth and Technological Spillover

Endogenous growth theory revolutionized the defense economics debate by reframing technological progress as a systemic outcome of R&D investment rather than an exogenous factor. This paradigm shift, articulated in Acemoglu et al.'s (2012) work on 'directed technical change', posits that military spending's growth impact depends critically on its ability to stimulate innovation networks that transcend defense applications. Unlike Neoclassical and Keynesian models that treat technology as a "black box," endogenous growth frameworks reveal how military R&D can catalyze economy-wide productivity gains through four interconnected channels: human capital deepening, cross-industry knowledge spillovers, induced private sector innovation, and institutional learning.

The OECD's countries longitudinal analysis of defense R&D (Moretti et. al. 2025) demonstrates that military innovation generates positive externalities when three conditions align: 1) Defense projects utilize dual-use technologies applicable to civilian markets; 2) Civilian firms possess sufficient absorptive capacity (Cohen & Levinthal, 1989) to decode and adapt military innovations; 3) Public policies incentivize knowledge-sharing between defense contractors and private enterprises (Moretti et. al. 2025; Aghion et. al. 2015). For instance, the development of GPS—initially a military navigation tool—unlocked $1.4 trillion in global economic value by enabling civilian applications from logistics optimization to precision agriculture. Such spillovers depend on complementary investments: the ATI (2019) found aerospace R&D's social return rate (70%) nearly quintuples its private return (15%) when recipient industries like automotive and machinery maintain parallel R&D programs.

Cross-country evidence highlights threshold effects in spillover realization. In France, doubling defense R&D to U.S. levels (2.8% of GDP) would boost private R&D by 10.3% (Moretti et.al 2025). Conversely, nations lagging in STEM education or intellectual property rights — common in developing economies — capture minimal spillovers despite military tech imports, as absorptive capacity remains underdeveloped. This aligns with finding that tertiary education yields greater productivity growth returns in advanced economies versus developing countries (Aghion et. al. 2015).

Spillover potential varies dramatically across industries, shaped by technological proximity to defense applications. For example, analysis of 80% of global aerospace activity reveals concentrated spillovers in five sectors: automotive (elasticity 0.32), rail/transport (0.28), rubber/plastics (0.19), machinery (0.17), and scientific R&D services (0.14) (ATI 2019). These industries share three traits: 1) Overlapping supply chains with defense contractors (e.g., titanium alloys for jet engines and sports equipment); 2) Modular product architectures allowing component reuse (e.g., aircraft sensors repurposed for medical imaging); 3) High rates of workforce mobility between military and civilian employers.

Contrastingly, sectors with divergent innovation trajectories — like textiles or food processing — exhibit negligible spillovers despite substantial defense procurement (Brzoska 2006). The exception occurs during technological paradigm shifts: synthetic rubber R&D for World War II tires later revolutionized civilian polymer industries. Such path-dependent effects underscore the importance of "defense-civilian technology convergence" (ATI 2019)

Maximizing spillovers requires institutional frameworks that bridge military and civilian innovation ecosystems. South Korea's Defense Acquisition Program Administration (DAPA) exemplifies this approach, mandating that 30% of defense contracts include technology-sharing agreements with Small and medium-sized enterprises. This policy raised dual-use patent filings by 18% annually from 2015–2025 while cutting weapons system costs by 22% through civilian process innovations (Moretti et. al. 2025).

Tax incentives also play a catalytic role. France's "Crédit Impôt Innovation Défense" (2022–present) grants 40% R&D tax credits for civilian firms collaborating with military labs, sparking cross-industry projects like submarine battery tech adapted for renewable energy storage. Such measures address the "Valley of Death" in tech transfer—OECD data shows every $1 in matching grants generates $3.20 in follow-on civilian R&D versus $1.80 for tax credits alone (Moretti et. al. 2025).

Globalization has a significant role in the contemporary defense R&D ecosystem. While endogenous growth models traditionally focus on national systems, defense R&D increasingly exhibits transnational spillover dynamics. The OECD study found U.S. defense R&D boosts European chemical firms' innovation spending by 0.12% per $1 billion invested a "free rider" effect exceeding intra-EU spillovers (Moretti et. al. 2025). However, this globalization of benefits complicates cost-benefit calculations: Israel captures 90% of its military R&D spillovers domestically through tight industry-academic linkages, whereas Saudi Arabia imports 78% of defense tech with minimal local absorption (Brzoska 2006).

Integrating with earlier paradigms, endogenous growth theory doesn't invalidate Neoclassical or Keynesian models but contextualizes their predictions. Crowding-out effects dominate when defense R&D focuses on non-convergent technologies (e.g., ballistic missiles) in economies with weak innovation systems. Conversely, crowding-in prevails in advanced sectors like aerospace, where Aghion et al. (2015) estimate military-civilian R&D complementarity generates 2.1% annual TFP growth—triple the economy-wide average (Aghion et. al. 2015). This split explains why Benoit's (1973) positive correlations emerged in industrializing nations importing dual-use tech, while Barro's (1990) skepticism reflected Cold War-era R&D silos.

The theory's implication is clear: defense spending's growth impact isn't inherent but constructed through deliberate institutional design. Nations combining military R&D with STEM education investments, dual-use infrastructure, and open innovation policies can transform defense budgets into growth stimulants—a lesson embodied in South Korea's rise from war-torn state to semiconductor powerhouse. Those failing to build absorptive capacity risk squandering military innovation’s potential, leaving Keynesian demand boosts and Neoclassical crowding-out as the dominant economic legacies.

1.2. Political Economy and Institutional Factors

The interplay between political institutions, economic policies, and governance frameworks profoundly shapes the defense-growth relationship. Historically, theories of government expansion, such as Adolph Wagner’s Law of Increasing State Activity, have provided foundational insights into how economic development drives demand for public goods, including security and defense. Wagner’s Law posits that industrialization and urbanization necessitate greater state intervention, leading to an expansion of government expenditure as a share of GDP (Ghazy et.al. 2021). While Wagner focused on broad public spending trends, his framework offers a lens to analyze military expenditure as a component of state activity. In advanced economies, defense spending often correlates with strategic imperatives and technological advancement, but in developing nations, it may reflect institutional weaknesses, such as corruption or rent-seeking, that distort resource allocation (Gupta et. al. 2001). The institutional context—whether democratic or autocratic, transparent or nontransparent—determines whether defense investments catalyze growth or exacerbate fiscal imbalances and inefficiencies.

Wagner’s Law, formulated in the late 19th century, argued that rising per capita income and industrialization inherently expand the scope of government functions, from infrastructure to public security (Ghazy et. al. 2021). This "law" implies that defense spending, as a subset of state activity, should grow alongside economic development. However, empirical evidence reveals significant divergence. For instance, Singapore’s post-1965 economic boom preceded its defense industrialization, suggesting that strategic imperatives, rather than organic economic growth, drove military expansion (Kuah & Loo 2004). In contrast, mid-20th century Western democracies saw defense spending surge during the Cold War and after 9/11, aligning with Wagner’s prediction of state expansion during periods of geopolitical tension (Hartung 2011). The critical distinction lies in institutional priorities: democratic systems often subject defense budgets to public scrutiny, balancing military needs against social welfare, whereas autocratic regimes may prioritize military power to consolidate political control, even at the expense of economic efficiency (Konrad & Souva 2020).

The institutional quality on its own depended by the efficiency of military spending in promoting economic growth. Current European initiatives illustrate this relationship - the IFW-Kiel's 2025 analysis shows that defense spending's economic impact varies dramatically based on institutional capacity to direct resources effectively (Kiel 2025). For instance, when European defense procurement remains domestically sourced, technological spillovers and productivity gains multiply each euro's economic impact (Kiel 2025).

Institutional frameworks particularly matter for research and development (R&D) efficiency. The striking contrast between U.S. and EU military R&D spending - with America investing 16% of defense budgets in R&D versus Europe's 4.5% - reflects institutional differences in innovation systems and procurement processes (Kiel 2025). This gap has significant implications for long-term productivity growth, as evidence suggests that a 1% GDP increase in military spending can raise long-term productivity by 0.25% when properly institutionalized (Kiel 2025).

Recent developments suggest several institutional reforms that could enhance military spending's economic impact. The European Union's current defense integration efforts exemplify how institutional frameworks can be redesigned to maximize economic benefits (Kiel 2025). Key elements include:

1. Centralizing procurement at the EU level to achieve economies of scale
2. Mandating technology-sharing agreements to enhance spillover effects
3. Implementing dual-sourcing strategies to maintain competition
4. Developing "dual-use" defense contractors to accelerate civilian applications

The Kiel Institute's 2025 analysis suggests that such institutional reforms could help Europe capture significantly more economic value from increased defense spending, potentially generating economic activity equal to the initial investment (Kiel 2025).

Next, there is a symbiotic relationship between governments, armed forces, and defense contractors which illustrates how institutional capture can distort economic priorities. Post-9/11, U.S. defense budgets ballooned to $700 billion annually, with contractors like Raytheon and General Dynamics dominating procurement (Hartung 2011). This consolidation, facilitated by Cold War-era mergers, reduced competition and entrenched dependency on military Keynesianism. However, such growth is often illusory: while the U.S. defense sector employs 3 million workers, studies suggest that equivalent investments in renewable energy or infrastructure could generate 50% more jobs (Kosiak 2025). Worse, autarkic policies, such as Senator Wicker's proposal to raise U.S. defense spending to 5% of GDP ($1.7 trillion annually), risk fiscal instability, as unfunded expenditures exacerbate national debt and divert resources from climate resilience or public health (Kosiak 2025). The military-industrial complex thus embodies a paradox: while capable of driving technological breakthroughs (e.g., GPS, the internet), its political leverage often perpetuates.

Summarizing, the defense-growth nexus is neither fundamentally positive nor negative but dependent on institutional integrity. Wagner's Law provides a starting point for understanding state expansion but struggles in explaining why some nations militarize their economies while others prioritize social welfare. Strong institutions—marked by transparency, anti-corruption safeguards, and civilian oversight—can harness defense spending for growth, as seen in Singapore's strategic investments in dual-use technologies (Kuah & Loo 2004, Kiel 2025). Conversely, weak governance amplifies corruption risks, transforming military budgets into vehicles for elite enrichment rather than national security. As global military spending approaches $2.4 trillion annually, the challenge lies in crafting institutional frameworks that balance strategic needs with economic sustainability, ensuring that defense investments serve as catalysts for innovation rather than anchors of fiscal and democratic decay (Transparency International 2024, Kosiak 2025).

1.3. Defense Spending in the Context of the Ukraine-Russia War

Recent analyses of defense expenditure increases since Russia's 2022 invasion reveal divergent economic impacts depending on methodological approaches. Panel data studies of EU economies from 2021 to 2024 identified a 1.7% GDP per capita decline for every 1% rise in military spending as a share of government budgets, based on Pooled OLS models controlling for inflation, trade openness, and energy dependency (Camelia & Gheorghiţa

2023). In contrast, difference-in-difference analyses indicate that NATO donor states experienced short-term output gains, with $1 in military aid correlating with $0.65–$0.87 in GDP growth within two years due to defense-industrial activation and supply chain multipliers (Chebanova et al. 2023). SIPRI's granular assessment of Russia's war costs highlights structural limitations, showing that despite allocating 6.3% of GDP ($145 billion) to defense in 2024, only 30% of equipment losses are replenished by new production, with the remaining 70% reliant on Soviet-era stockpile refurbishment (Bryjka 2024). The RAND Corporation estimates that Russia's direct military costs reached $40 billion by late 2022—84% of its 2021 defense spending—while annual GDP losses from sanctions and resource misallocation range between 6% and 9% (Shatz & Reach 2023). Ukraine faces similar fiscal strain, with 55% of its 2025 budget ($53.3 billion) directed toward defense, resulting in a $38.8 billion deficit offset by foreign aid conditionalities (Matuszak 2024).

Russia's military-civilian economic separation presents sustainability risks, as the defense sector expands while civilian GDP contracts by 10%, compounded by halved energy export revenues and a 75% drop in tax income from foreign firms (Sonnenfield et al. 2023). Ukraine's initial dependence on Chinese drones, which made up 60% of its 2023 fleet, exposed vulnerabilities to supply chain disruptions, leading to a costly pivot toward domestic alternatives (Nones 2024). Fragmented EU defense procurement, which stood 31% below NATO's 2% GDP target before the war, further delayed artillery shell deliveries, with Russia's projected 2025 output of three million shells surpassing the combined production of EU states (Maulny 2023). However, the war has also driven AI-driven defense innovation, improving artillery targeting, drone navigation, logistics, and cybersecurity. Advancements such as AI-assisted battlefield coordination, FPV drones, deepfake detection, and facial recognition have enhanced decision-making, resource allocation, and operational effectiveness while addressing challenges related to corruption, coordination inefficiencies, and talent shortages through strategic partnerships and governance reforms (Goncharuk 2024).

International collaboration has been instrumental in shaping these developments. The EU's €5.6 billion military aid through the European Peace Facility has catalyzed joint production agreements, such as Rheinmetall's pan-European 155mm shell consortium, which aims to reach an annual output of 1.2 million shells by 2026 (Nones 2024). Ukraine's rapid integration of NATO technologies has created a feedback loop where frontline testing of AI tools, such as Rhombus Power's missile detection algorithms, informs U.S. R&D priorities, contrasting with Russia's reliance on Chinese semiconductor imports and Iranian drone blueprints (Santayana 2024). Meanwhile, Germany's defense budget increase to 2.1% of GDP ($73 billion annually) between 2024 and 2027 has supported cross-border ventures, including drone co-production agreements with Ukraine (DPA 2024). Dual-use spillovers have also emerged, as neural networks originally designed for Lancet-3 drone targeting are now being applied to optimize EU pharmaceutical logistics, demonstrating the estimated 0.25x GDP growth multiplier per 1% defense R&D investment in convergent fields (Camelia & Gheorghiţa 2023).

These developments reflect a broader shift in defense economics, where budgets prioritizing interoperable AI and quantum systems yield higher economic returns than traditional platform-centric spending. However, realizing these benefits requires coordinated multilateral governance to mitigate risks of fragmentation and inefficiencies.

Chapter 2. The Macroeconomic and Financial Dimensions of Defense Spending

In this section we shift the focus to the potential risks and probabilities associated with high levels of military expenditure.

2.1. Public Debt Dynamics and Sustainability

The interplay between defense spending and public debt sustainability has emerged as a critical concern for policymakers, particularly as global military expenditures approach post-Cold War highs. This section examines how military outlays influence sovereign debt trajectories, the thresholds at which debt becomes growth-impeding, and the heterogeneous effects observed across economic context issues amplified by Ukraine-Russian war and fiscal pressures in Europe.

Defense spending can affect public debt through three channels: Direct Deficit Financing: When military expenditures exceed government revenues, the resulting budget deficit often necessitates increased borrowing, directly adding to the national debt (Dunne et. al. 2004). Interest Rates: Military spending can potentially influence the government ability to finance the debt. Growth Effects: Defense spending can have both positive and negative impacts on economic growth, which, in turn, affects the debt-to-GDP ratio. The direction and magnitude of this effect are subjects of ongoing debate.

The IMF’s debt sustainability framework (Rozenov 2017) illustrates these dynamics through a modified debt-to-GDP equation:

$$d_t = \frac{(1+r_t)}{(1+g_t)} d_{t-1} + u_{t-1} + +\delta_2 w_{2,t-1} \ , \ y_t = p y_{t-1} + \alpha u_{t-1} + \delta_1 w_{1,t-1}$$

where d_t represents debt-to-potential GDP, r_t the real interest rate, g_t potential growth, u_t the primary deficit, and y_t the output gap influenced by fiscal multiplier α. Military spending enters this equation primarily through its impact on u_t (the primary deficit). If defense spending increases without a corresponding rise in revenues, dt increases, leading to higher debt accumulation. However, military spending can also indirectly affect d_t through r_t and g_t (Rozenov 2017).

A key question in the literature is whether there exists a threshold level of public debt beyond which economic growth is significantly impaired, though a clear consensus remains elusive. Reinhart and Rogoff (2010) initially suggested a 90% debt-to-GDP threshold beyond which growth rates decline substantially, but subsequent analyses identified methodological issues and data errors that weakened this claim (Rooney et al. 2021). Alternative studies propose varying thresholds, with some suggesting lower limits for emerging markets compared to advanced economies (Alptekin & Levine 2012), while others highlight non-linear relationships where debt's negative impact on growth intensifies at higher levels (d'Agostino et al. 2017). Research also links military spending to debt accumulation, as Dunne, Perlo-Freeman, and Soydan (2004) found that increased military expenditures significantly affect external debt, though they did not establish a precise threshold, while d'Agostino et al. (2017) demonstrated a persistent negative effect of military burden on economic growth.

The relationship between defense spending and debt sustainability is not uniform and depends on several factors. Differences in spending composition matter, as personnel costs may have different economic implications than capital-intensive expenditures like equipment procurement or R&D, which can worsen trade balances and increase external financing needs (Lorusso & Pieroni 2017). Fiscal adjustment strategies also influence outcomes, as Alesina and Ardagna (2010) argue that spending cuts, rather than tax increases, are more effective in reducing debt-to-GDP ratios without triggering recessions. Institutional quality further moderates the impact, as stronger governance, fiscal rules, procurement transparency, and lower corruption can mitigate debt risks associated with defense expenditures (Kuah & Loo 2004).

While defense spending can drive debt accumulation, particularly through direct deficit financing, its long-term consequences depend on multiple economic and institutional factors. The precise existence of a universal debt threshold remains debated, but evidence suggests that persistently high debt levels can negatively affect growth. Understanding the nuances of spending composition, fiscal policy responses, and institutional governance is crucial for evaluating the broader economic effects of defense-related debt.

2.2. Economic Volatility and Uncertainty

The relationship between military spending and economic volatility is complex. While defense investments can contribute to stability in specific industries through predictable government contracts, they can also introduce broader macroeconomic risks. These risks arise from potential trade disruptions, the crowding out of private investment, and heightened geopolitical uncertainty, all of which have been amplified by recent global conflicts, including the war in Ukraine and increased defense spending by NATO member states. The financial market implications of defense expenditures have been widely examined, with Cortes et al. (2024) identifying the "war puzzle," wherein U.S. stock market volatility has historically been lower during periods of conflict. This phenomenon is attributed to the stabilizing effect of government defense contracts, which enhance corporate earnings predictability, particularly for firms engaged in military production. However, while defense contractors may experience reduced volatility, other sectors remain vulnerable to heightened uncertainty, especially those reliant on global supply chains or specific raw materials.

Investor confidence and resource allocation are also influenced by defense spending, with concerns regarding its potential to crowd out private investment. Government borrowing to finance military expenditures can increase interest rates, thereby raising capital costs for businesses in non-defense sectors (Dunne & Tian 2013; Dunne et. al. 2004). While some studies highlight this competitive dynamic (Dunne, Smith, and Willenbockel 2005), others emphasize the positive spillover effects from defense-related research and development (Heo

& Ye 2016). The ultimate effect depends on various factors, including the composition of defense expenditures, the overall state of the economy, and complementary government policies. Military conflicts and geopolitical instability further disrupt global trade flows, with Krpec and Hodulak (2019) identifying mechanisms such as direct blockades, supply chain disruptions, and shifting production priorities. Historical examples, such as the trade embargoes during the Napoleonic Wars (O'Rourke 2006), underscore the enduring economic consequences of war-induced trade restrictions. Even in the absence of formal blockades, geopolitical tensions elevate uncertainty, increase insurance costs, and damage critical infrastructure, thereby reshaping long-term trade relationships.

Uncertainty itself is a fundamental economic challenge associated with military conflict and rising defense expenditures. Firms often respond to increased uncertainty by delaying or canceling investment projects, while investors may shift capital towards perceived safe-haven assets, influencing exchange rates and international capital flows. The defense and security industry is particularly subject to volatility due to ethical concerns, as well as the broader regulatory and political landscape (Kromann Reumert 2024). Although difficult to quantify, uncertainty has been identified as a significant determinant of economic performance, particularly in periods of geopolitical tension. Ultimately, defense spending presents policymakers with a volatility trilemma: prioritizing security risks economic growth through trade and fiscal instability, prioritizing economic growth risks security through defense underinvestment, and adopting a neutral stance risks both through geopolitical marginalization.

2.3. The Sectoral and Regional Impacts of Military Expenditure

This section delves into the industry and labor market impacts of defense spending, offering more granular insights.

2.3.1. Industry-Specific Effects

Defence spending has heterogeneous impacts across industrial sectors, shaped by procurement, R&D intensity, and participation in the global value chain. Through these channels the defence industry and an activity it catches on, several economic growth variables can be impacted, such as: Human capital development, technological advancement, education and skill formation, infrastructure quality, labour market dynamics, innovation and R&D.

First, the aerospace industry plays a fundamental role in defence, acting as the primary producer of military aircraft, weapons systems, vehicles, and equipment.

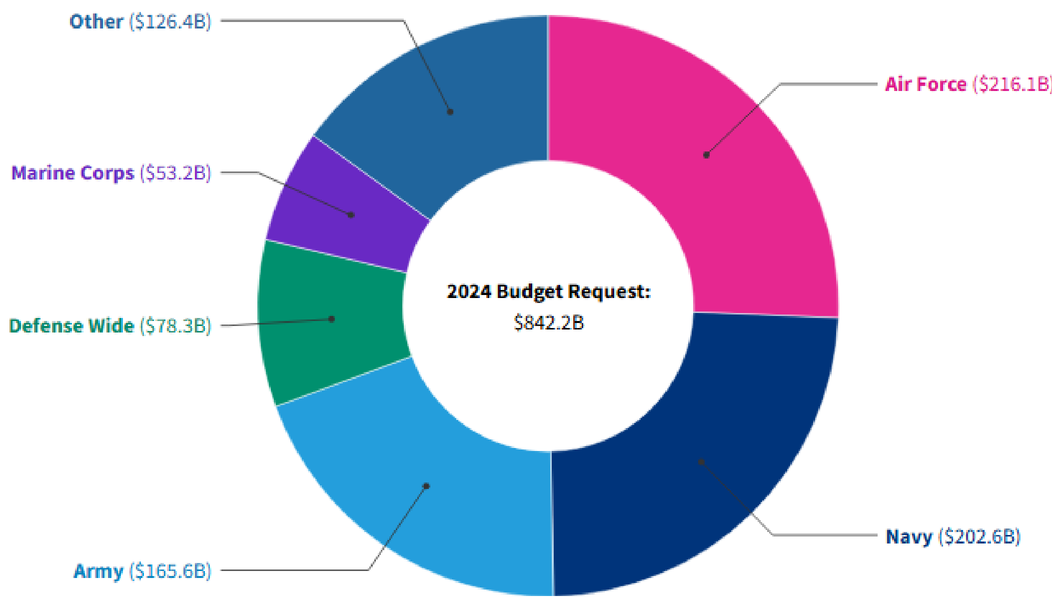

Figure 1: Department of Defence budget request by military department, 2024, Source: Department of Defence

This sector commands a substantial share of defense budgets, with the U.S. Air Force alone receiving $216.1 billion, the largest allocation among military branches (Figure 1). The scale of investment directly shapes the industry's workforce: in 2023, the aerospace and defense sector employed 2.21 million people, with nearly 60% of these jobs-about 1.3 million-embedded in the supply chain operations (AIA 2024). For every million dollars in end-use sales, four jobs are supported across manufacturing and supply operations, reflecting how defense spending fuels workforce development by demanding specialized technical skills and ongoing training.

Defence manufacturing also acts as a powerful engine for technological advancement. The sector's focus on innovation in materials science, propulsion, autonomous vehicles, and communications technology drives the development of dual-use technologies. Anticipated growth in "hard technology," including artificial intelligence, advanced air mobility, and unmanned systems (Berckman et. al. 2024), further amplifies this effect, as breakthroughs in military applications often spill over into civilian markets, raising the overall technological baseline.

Labor dynamics in aerospace and defense are shaped by persistent talent shortages. Companies that successfully attract and retain skilled workers tend to outperform competitors in shareholder returns, yet the industry continues to struggle with matching the growing demand for specialized labor with adequate supply (Weddle at. al 2024).. This talent gap constrains both current production and future innovation, underscoring the importance of workforce investment for sustained economic growth.

The research and development (R&D) sector is another pillar closely tied to defense spending. Governments worldwide channel defense funds into R&D to maintain technological superiority and develop new capabilities, with the European Union's defense R&D expenditure reaching €11 billion in 2023-a 6% increase over the previous year (EDA 2024). These investments flow to research institutions, universities, private labs, and defense contractors, multiplying the impact of public funds. Notably, a 10% increase in government-financed R&D generates a 5–6% additional rise in privately funded R&D, a "crowding-in" effect that substantially increases overall innovation activity (Moretti et. al. 2025).

Defense R&D has long been a source of technological breakthroughs with civilian applications, and these spillovers are not confined by borders; when one country boosts government-funded R&D, private R&D in the same industry tends to rise in other countries as well (Moretti et. al. 2025). This dynamic strengthens global innovation networks and accelerates the diffusion of advanced technologies. Furthermore, empirical evidence shows that increases in private R&D, spurred by defense investment, result in significant productivity improvements (Moretti et. al. 2025). For example, a one-percentage-point rise in the defense R&D-to-value-added ratio is estimated to cause a 5% increase in the yearly growth rate of total factor productivity (TFP) (Moretti et. al. 2025), underscoring the sector's role in driving long-term economic performance.

The connection of the cybersecurity industry to defence has intensified as digital threats become more sophisticated. Military spending in this area reached $36.9 billion in 2023, with projections climbing to $49.4 billion by 2028 (DYNICS 2024). Defense departments increasingly contract cybersecurity firms to protect networks, develop cyber capabilities, and secure critical infrastructure. The acute shortage of cybersecurity talent has prompted the military to explore innovative staffing, such as recruiting tech experts from the private sector as reservist officers (DYNICS 2024). This approach not only enhances defence capabilities but also stimulates broader labor market development by creating demand for high-level technical skills and specialized training.

Naval shipbuilding and the broader maritime industry also benefit directly from defense allocations, with the Navy ranking as the second-largest recipient of defense funding (Figure 1). Naval shipbuilding programs drive significant infrastructure investments, such as the $21 billion, 20-year Shipyard Infrastructure Optimization Program (SIOP), which modernizes public shipyards and aims to reduce costly maintenance delays (J. S. Kim 2023). These infrastructure upgrades improve the efficiency and capacity of the maritime industrial base, supporting both military readiness and broader economic activity.

Labor market in shipbuilding is marked by acute workforce challenges, including a 20–22% attrition rate in critical trades like welding and pipefitting (Luckenbaugh 2025). Despite hiring surges-9,700 workers added in 2023 and 10,000 in 2024, shipyards struggle to retain talent due to non-competitive wages and high local living costs (Grady 2025). Addressing wage stagnation through targeted defence funding could stabilise the workforce and generate positive spillover effects in local economies. For example, every $1 billion in shipbuilding contracts support 6,000 to 7,000 jobs and generates $450 million in labour income (MARAD 2021), illustrating how defence spending can act as both a labour market stabiliser and a growth accelerator in specialised industries.

Across these industries, several cross-cutting factors shape the broader impact of defense spending have become increasingly important, as advances in information and communication technologies allow firms to specialise in specific tasks within the value chain, improving efficiency and fostering international collaboration (OECD 2017). Government policies, particularly in defence procurement, play a decisive role in shaping competition and technological development, with an emphasis on maintaining a robust domestic Defence Industrial Base (DIB) (PwC, 2005).

Technological intensity is another key determinant: high-R&D sectors, especially those heavily reliant on defence funding like aerospace and information and communication technologies (ICT), experience a significantly larger "crowding-in" effect from public defence R&D compared to less R&D-intensive sectors. However, the relationship between R&D intensity and productivity gains can vary, with some evidence suggesting that less R&D-intensive countries may see more pronounced TFP improvements from defence spending (Moretti et al., 2025).

In summary, defence spending exerts a multifaceted influence on economic growth, operating through channels such as workforce development, technological innovation, infrastructure investment, and the stimulation of private sector R&D. The interplay of these mechanisms not only supports immediate military objectives, but also generates broader economic benefits, from productivity gains to the creation of high-skilled jobs and the diffusion of advanced technologies.

2.3.2. Regional Disparities and Development

The relationship between defense spending and economic performance is a complex and widely debated topic in economics. While much research focuses on the aggregate national level, understanding the impact of defense expenditure on regional economic disparities and development within and between nations offers crucial insights. Global military expenditure reached a staggering $2718 billion in 2024, marking a 9.4% real-terms increase from 2023 and the tenth consecutive year of rising spending (SIPRI, 2025). This expenditure is not only growing but also accounts for a significant 2.5% of global GDP (SIPRI, 2025), yet it is rarely distributed uniformly across a nation's territory or across different groups of countries. Indeed, the SIPRI Fact Sheet (2025) highlights that military expenditure increased in all five geographical regions in 2024, reflecting heightened geopolitical tensions, but the scale and drivers of these increases varied substantially. For example, Europe saw a 17% rise in spending, largely driven by the Russia-Ukraine war, while the Middle East experienced a

15% increase linked to the Gaza war and other regional conflicts. In contrast, Africa's overall spending rose by a more modest 3.0%, with significant sub-regional variations such as an 8.8% increase in North Africa versus a 3.2% decrease in Sub-Saharan Africa (SIPRI, 2025). This uneven distribution, coupled with the varying nature of the spending itself, suggests that its effects on economic development are likely to be regionally specific. Consequently, defense expenditure can potentially exacerbate existing economic disparities or, conversely, act as a stimulus in certain regions. The methods chosen to finance these escalating military budgets, such as redirecting funds from social programs or international aid, increasing debt, or raising taxes, also carry significant economic, political, and social consequences that can disproportionately affect vulnerable groups or regions, thereby worsening economic and societal inequality (SIPRI, 2025, Box 2). This chapter aims to explore these dynamics, drawing upon empirical evidence and analyses from recent literature to understand how defense spending influences regional economic trajectories and contributes to disparities in development. Findings from studies analyzing specific developing regions, income-level country groups, the European context, and distribution patterns between US states will be examined. Explicitly addressing the need for regional disaggregation, Saba & Ngepah (2020) investigate the nexus between defense spending, economic growth (proxied by real GDP), and development (proxied by the Human Development Index - HDI) across three distinct developing regions: Sub-Saharan Africa (SSA), the Middle East and North Africa (MENA), and Latin America and the Caribbean (LAC) for the period 1990-2018. Their findings underscore the heterogeneity of defense spending's impact. For instance, regarding the impact on development (HDI), defense spending was found to have a negative effect in SSA and LAC, but a positive effect in MENA. Conversely, when examining the impact on economic growth (RGDP), defense spending showed a positive link in SSA and LAC, but was statistically insignificant in MENA. Furthermore, the study identified bidirectional causality between defense spending, growth, and development in ES, SSA, and MENA, but noted an absence of causality running from HDI to defense spending in the LAC region. This empirical evidence strongly suggests that the economic and developmental consequences of military expenditure are not uniform; they vary significantly depending on the specific regional context, indicating that defense spending interacts differently with the unique characteristics and priorities of these areas (Saba & Ngepah, 2020).

Shifting the focus from geography to income level, Oukhallou (2019) examines the effect of military expenditure on development (GDP per capita) across 77 countries categorized by income groups (Low-Income, Lower-Middle, Upper-Middle, High-Income). The study finds a robust and statistically significant *negative* correlation between the military burden and development specifically in Low-Income Countries (LICs). This is interpreted as the economic consequence of diverting scarce resources away from development needs towards counterproductive expenses, such as weaponry imports, which are common forms of military spending in LICs. In stark contrast, the relationship was generally found to be statistically insignificant in lower-middle, upper-middle, and high-income countries. Oukhallou suggests this neutrality in more developed economies could stem from an offsetting combination of positive spillovers (e.g., from military R&D, technology transfer via offset contracts, infrastructure use, stability) and negative crowding-out effects (reduced civilian investment). Notably, pooled panel analysis indicated that the negative influence observed in LICs gradually decreases as the income level rises, potentially supporting the idea that the *nature* of defense spending and its integration with the broader economy changes with development, thereby influencing its regional economic impact (Oukhallou, 2019).

Examining the European landscape reveals different facets of the defense spending and regional development nexus. Hellberg & Lundmark (2025), analyzing the transformation of European ammunition supply chains following the invasion of Ukraine, focus on EU-level initiatives like ASAP and EDIS. These programs aim to strengthen the overall European Defence Technological and Industrial Base (EDTIB) and enhance collective production capacity. While involving funding distribution to firms across member states, the study highlights that the primary goal is pan-European resilience and capacity, rather than explicitly addressing or analyzing the impact on pre-existing economic disparities *between* member states or regions within them. The focus remains on industrial structure and governance shifts at a European level (Hellberg & Lundmark, 2025).

Similarly, Cepparulo & Pasimeni (2024) document the significant variation in both the level (as % of GDP) and composition of defense spending *between* EU member states. This highlights substantial inter-national disparities within the Union. They discuss EU mechanisms (like PESCO, EDF) aimed at fostering coordination to counter fragmentation. However, their review of the defense-growth nexus literature and their analysis of EU budget roles concentrate on the *national* level impacts and the challenges of multi-level governance. The paper does not delve into the sub-national economic consequences of these spending variations or the effects of EU coordination efforts on regional economic disparities within member states (Cepparulo & Pasimeni, 2024). The European studies, therefore, illustrate the complexity of coordination and the current focus on aggregate capacity, leaving the specific regional disparity impacts largely unaddressed at the EU policy level described. This focus on aggregate capacity is further underscored by the SIPRI (2025) finding that European NATO members alone spent $454 billion in 2024, with all European countries except Malta increasing their military spending, driven by the ongoing war in Ukraine and heightened security concerns.

Data from the United States provides concrete evidence of the highly uneven geographic distribution of defense spending and its potential impact on regional economies. The U.S. Department of Defense's "Defense Spending By State FY 2023" (DoD, 2023) report reveals vast disparities between states in total spending ranging from $71.6B (11.7% of US total spending) in Texas to $0.6B in Vermont/ Wyoming (as a share of state GDP - 1.3% and 1.2% accordingly), spending as a share of state GDP is the biggest in Virginia – 9.7% and smallest in Minesota/Oregon – 0.5%. This concentration is also evident within states, with specific counties hosting major installations or contractors receiving disproportionately large shares of funding (DoD, 2023). This uneven distribution inherently contributes to regional economic disparities, both between and within states.

However, the NADO Research Foundation (2023) report (NADO, 2023) emphasizes the role of military installations as vital economic drivers, particularly for rural and potentially economically lagging regions. By providing stable employment (direct payroll), driving local procurement (contracts), and generating economic multiplier effects, defense installations can act as significant engines for regional development and potentially *mitigate* disparities they might otherwise face. The report highlights that installations can offer economic stability independent of market fluctuations and cites evidence suggesting better social outcomes in communities with a military presence. Furthermore, proactive partnerships between installations and regional entities like Economic Development Districts (EDDs), through mechanisms like IGSAs, can enhance local economic benefits and integration (NADO, 2023). Therefore, while the *distribution* of defense spending is highly uneven, its *presence* can have significant positive developmental impacts at the local and regional level, particularly in areas lacking other major economic drivers.

The literature reviewed demonstrates that defense spending's impact on regional development and disparities is far from uniform. Empirical evidence, whether disaggregated by developing region (Saba & Ngepah, 2020) or by national income level (Oukhallou, 2019), points towards context-dependency. Defense spending appears most detrimental in lower-income settings, likely where it consists primarily of imports or basic personnel costs with limited positive linkages to the broader economy and where opportunity costs related to forgone development spending are highest. In contrast, in middle- and higher-income countries/regions, the effects are more ambiguous, potentially reflecting a mix of negative crowding-out effects and positive spillovers from R&D, advanced manufacturing, infrastructure development, and policy tools like offset agreements.

The European context further complicates the picture, showing significant variation in national commitments and spending composition, coupled with supranational efforts aimed more at collective industrial capacity and coordination rather than explicit regional economic convergence (Hellberg & Lundmark, 2025; Cepparulo & Pasimeni, 2024). The US data confirms the stark reality of uneven geographic distribution, both between states and within them, inherently shaping regional economic landscapes (U.S. Department of Defense, 2023). Yet, the localized presence of this spending, particularly through military installations, can serve as a crucial economic anchor and development catalyst, especially for non-metropolitan or economically stagnant areas (NADO Research Foundation, 2023). Explaining the empirical evidence of defense spending's impact requires acknowledging this multi-faceted reality: the overall level, the specific composition (personnel vs. procurement vs. R&D), the structure of the regional economy and its defense industrial base, the presence of conflict, and the specific policy choices regarding procurement and partnerships all interact to determine whether defense spending hinders development and exacerbates disparities, or potentially offers pathways for regional growth and stability.

Defense spending does not impact all regions equally. The empirical evidence drawn from diverse contexts – developing regions, income groups, Europe, and the United States –

consistently points to a differentiated effect on economic development and regional disparities. For the least developed regions and low-income countries, military expenditure often correlates negatively with development outcomes, potentially acting as a drain on vital resources. In more developed economies, the net impact is often less clear, possibly due to a complex interplay of crowding-out effects and positive economic spillovers facilitated by a more advanced industrial base and specific policy mechanisms. The highly uneven geographic distribution of defense funds, as clearly documented in the US and mirrored in global patterns of expenditure where the top five spenders account for 60% of the world total (SIPRI, 2025), directly contributes to regional economic disparities. However, the concentrated presence of military installations can simultaneously serve as a vital economic lifeline for specific communities, particularly in rural or less diversified areas.

2.3.3. Labor Market Dynamics and Skills Gaps

This chapter delves into the intricate relationship between defense spending and the labor market. It aims to explore how such expenditure influences employment levels and wage structures, identify the types of skills that experience heightened demand, and investigate the emergence of specific skill shortages within the defense sector and the broader economy. Crucially, this analysis will also consider the consequent implications for education and training policies necessary to address these labor market dynamics. The insights presented are drawn from a range of contemporary reports and academic studies, each offering a unique lens to this complex issue.

Defense spending has a notable and often an opposing impact on labor markets, simultaneously driving demand for specialized technical skills while intensifying structural discrepancies between workforce capabilities and evolving military-industrial needs. The sector's unique employment dynamics—characterized by high wages, regional concentration, and competition with the technology sector—highlight critical tensions between short-term job creation and long-term economic resilience.

The challenges in maintaining an adequately skilled defense workforce are further illustrated in the United Kingdom, as detailed in Michael Tysome paper (Tysome 2024). The

UK Armed Forces have consistently failed to meet their targets for trained personnel, with a shortfall of 3,394 individuals (2.5%) reported as of October 2023. Critical "skills pinch points" have been identified in 48 areas, including vital fields such as engineering, communications, cyber, and medical skills. A significant factor contributing to the net outflow of personnel is dissatisfaction with pay. Addressing these challenges necessitates targeted policy interventions. One potential solution is skill-based pay (SBP) systems, as proposed by Michael Tysome, which links wages to verified technical competencies rather than solely to rank or tenure. In regions where SBP has been applied, a key advantage observed is decreased turnover, along with benefits like lower labor expenses.

Expanding this view to a global context, the Boston Consulting Group's report (BCG 2020) highlights that the struggle to maintain readiness due to insufficient troop levels and skills is a worldwide phenomenon among militaries. There is a particular short supply of critical technical skills in digital technology and data analytics, a situation exacerbated by direct competition from the private sector and compounded by demographic shifts. The report provides concrete examples of these challenges, noting recruiting shortfalls in the US Army, the Royal Canadian Air Force, the German military, and the British Army. These widespread issues suggest a pressing need for militaries to adopt more flexible career paths, agile organizational structures, and customized training programs.

Focusing on a regional level, the Defence Industry Skill Gap Study (Senedia 2012) for Rhode Island's defense industry underscores local constraints stemming from the engineering and technician education pipeline. Beyond engineers being highly sought after, the top three critical skill gaps identified are technical writing, experience with shipboard environments and unique defense systems, and the ability to communicate and collaborate effectively with customers. Specific shortages extend to software engineers, individuals proficient in computer-aided design, and those with expertise in emerging fields like modeling, simulation, AI, and IT security

The current surge in demand for defense sector talent is captured by the "Financial Times, Global defence groups hiring at fastest rate in decades amid record orders.pdf" (Financial Times 2024). This report indicates that global defense companies are recruiting at the most rapid pace since the end of the Cold War, driven by record order books. The demand spans a range of roles, including engineers, software developers, cybersecurity analysts, welders, and mechanics. Competition for digital skills from the technology sector remains a significant challenge, and specialized areas like nuclear defense are experiencing particularly acute skill shortages. This heightened demand is compelling companies to ramp up early-career intakes and even establish their own skills academies.

Dr. Julie A. Lockwood's statement (Lockwood 2024) addresses the U.S. Department of Defense's (DOD) position in a competitive labor market. The DOD faces significant excess demand for labor nationally, impacted by job market polarization, an aging workforce, the gig economy, and intense competition for STEM graduates. Current DOD hiring practices are often hampered by long applicant wait times and uncompetitive wages. Lockwood suggests that the DOD should partner more closely with trade schools and community colleges and reform its wage-setting methodologies to be more responsive to local market conditions.

The McKinsey (McKinsey 2023) focuses on Europe's aerospace and defense (A&D) sector, which is confronting a significant talent crisis due to its aging workforce. European employers are reported to be struggling to match their US counterparts in hiring and retaining talent, especially for digital and advanced-analytics profiles. The report emphasizes that younger workers have different expectations, valuing rapid career progression and a strong focus on diversity and inclusion. Consequently, European A&D firms need to radically rethink their recruitment strategies and offer more nonlinear career paths.

Another McKinsey analysis (McKinsey 2024) examines the global A&D talent gap and its economic implications. It reiterates that talent supply is not meeting demand across skilled labor, supply chain, and high-tech roles. This talent gap—encompassing skill, will, and time deficiencies—is estimated to cost a median-sized A&D company between $300 million and $330 million annually in lost productivity. Indeed, more broadly, estimates suggest that closing defense skills gaps could generate over $300 million annually for mid-sized contractors through reduced downtime and rework (Weddle et al. 2024). To mitigate this, the study recommends that A&D companies make HR a strategic partner in workforce planning and actively manage talent and culture.

The updated 2011 study by Robert Pollin and Heidi Garrett-Peltier (Pollin & Garett-Peltier 2011), (using 2009/2010 data from the first study) provides an earlier but consistent analysis of job creation. It found that $1 billion in military spending created approximately

11,200 jobs. In contrast, the same investment would generate around 15,100 jobs in household consumption, 16,800 in clean energy, 17,200 in healthcare, and 26,700 jobs in education. A key finding of this study is that while jobs directly and indirectly supported by military spending offer higher average wages and significantly better benefits (largely due to comprehensive health coverage), alternative investments in clean energy, healthcare, and education still create a greater number of "decent jobs" across all pay categories 32,000 - low, \$64,000 -mid–range and high-paying (over \$64,000)—than military spending. For example, clean energy was estimated to create about 8,300 mid-to-high-paying jobs versus approximately 7,050 for military spending from the same \$1 billion investment. This underscores that policies shifting funds to domestic priorities can enhance overall employment, including the availability of well-compensated positions

Finally, Heidi Peltier's 2023 paper (Peltier 2023) further explores the economic consequences of high military spending in the U.S. It emphasizes that almost half of the U.S. federal discretionary budget is allocated to the Department of Defense, with over half of this DoD spending being channeled to military contractors. This concentration of resources means that the federal government workforce is heavily skewed towards defense-related employment (approximately 72%, including DoD civilians, uniformed military, and Veterans Affairs personnel). While defense spending supports jobs, Peltier reiterates that alternative areas of federal spending create significantly more employment per dollar spent : military spending supports an estimated 6.1 jobs per \$1 million, compared to 11.6 jobs in healthcare and 21 jobs in primary and secondary education. This is greater disparity compared to 10 years earlier study which is attributed to the military sector's higher capital intensity and higher average wages, which means fewer jobs are created for a given expenditure. The paper suggests that a "Just Transition" policy would be necessary to support workers and communities currently dependent on military spending if budgetary priorities were to shift towards these more job-rich sectors.

In summary, the literature consistently indicates that while defense spending sustains a segment of the labor market, often characterized by higher average compensation due to benefits and demand for STEM-intensive skills, it is less efficient at overall job creation compared to investments in other public sectors. A significant and growing global demand exists for high-tech skills within the defense industry, leading to pronounced skill gaps and shortages. These are exacerbated by an aging workforce, competition from the private sector, and evolving expectations from younger talent pools.

These issues can be addressed by increasing the allocation of the budget to the defense industry, by strategic interventions such as skill-based pay systems, modernized recruitment and retention strategies, robust education and training pipelines with strong STEM focuses, and targeted support for any transitions arising from shifts in spending priorities. This will mitigate labor shortages and skill deficiencies while simultaneously fostering human capital development and educational spillovers. Conversely, this approach raises concerns regarding the efficacy of such financial inflow, as without consideration of discussed interventions a great portion of the inflow may be allocated predominantly to higher wages rather than contributing to beneficial spillovers.

2.4. The Impact of Warfare on Economic Growth

Warfare represents one of the most profound shocks a national or global economy can experience, fundamentally altering the trajectory of economic development. Beyond the immediate and tragic human costs, conflicts trigger a cascade of economic consequences that range from the destruction of physical capital and infrastructure to the radical reallocation of resources, labor, and technological effort. This section of the literature review delves into the complex and often paradoxical relationship between warfare and economic growth. It will explore how armed conflicts, while inherently destructive in the short term, can also act as catalysts for long-term structural economic changes, drive certain types of technological innovation, and reshape the political and institutional frameworks that govern economic activity. By examining historical precedents and contemporary conflicts, this chapter aims to provide a nuanced understanding of the multifaceted economic impacts of war, setting the stage for analyzing current defense spending considering these transformative, and often devastating, historical experiences.

2.4.1. Short-Term Shocks and Long-Term Structural Changes

The economic consequences of warfare unfold across distinct temporal dimensions, where immediate disruptions often catalyze profound, long-term structural transformations. Historical analyses reveal recurring patterns in how economies absorb short-term shocks and adapt over decades, reshaping production systems, fiscal policies, and global trade networks.

Wars impose acute economic dislocations. World War II exemplifies this, with catastrophic damage to Europe’s transport networks reducing industrial output significantly in regions like Germany and France (CVCE 2025). The destruction paralyzed supply chains. Rationing and price controls, initially stabilizing, fueled black markets and exacerbated social inequalities (CVCE 2025; NPS 2023). In the United States, wartime production demands created consumer goods shortages, necessitating strict rationing via the Office of Price Administration, which successfully limited inflation despite surging demand (NPS 2023). Labor markets saw paradoxical shifts: U.S. unemployment plummeted to 1.9% by 1945 due to military recruitment and defense manufacturing (I&P 2015), while Europe faced layoffs as industries retooled. Women's workforce participation surged, with 6 million in manufacturing by 1943, a temporary shift laying groundwork for future social change (NPS 2023). Warfare also strains fiscal systems; U.S. public debt soared to 120% of GDP by 1945, financed by Victory Bonds and expanded income taxes (I&P 2015). Post-war Europe required Marshall Plan aid ($13 billion, 1948–1951) for currency stabilization and the initial rebuilding of infrastructure, showing how external financing can mitigate immediate post-conflict crises (CVCE 2025). Similarly, the ongoing Russia-Ukraine conflict has acted as a profound geopolitical shock, compelling even nations not directly involved in combat to re-evaluate long-standing fiscal and security policies. Germany, for instance, historically constrained by a constitutional 'debt brake' (Schuldenbremse) limiting government borrowing to 0.35% of GDP each year since the 2008 financial crisis, approved a landmark spending deal in March 2025 (Darling, 2025). This deal significantly loosens these borrowing limits, primarily to enable massive new investments in infrastructure and defense. This fiscal restructuring in Germany, driven by the 'changing security environment' in Europe and the US shifting its strategic priorities, illustrates how external shocks can force a re-evaluation of deeply entrenched domestic economic policies, even those with broad political popularity like the 'Schuldenbremse' (Darling, 2025).

Beyond these immediate disruptions, war-induced economic transformations lead to lasting structural changes, influencing resource allocation, debt management, trade patterns, and institutional frameworks over decades. Following World War II, the United States experienced a significant shift in resource allocation, moving from wartime production to fostering consumer-driven growth, partly by leveraging pent-up demand and integrating some wartime technological advancements, such as radar and jet propulsion, into civilian industries (NPS 2023). In stark contrast, the Soviet Union's intense Cold War focus on heavy industry and military production—estimated by the CIA to consume 15-17% of GNP versus 7% for the U.S. (Escudero 2023)—led to structural stagnation. This prioritization hampered civilian technological development, created chronic shortages, eroded public trust, and contributed to slowed GDP per capita growth (0.93% annually by the 1970s) and eventual economic collapse (Mazat 2015, p. 4, Table 1). Even Gorbachev's later attempts at demilitarization were insufficient to reverse this path dependency (Escudero 2023). Path dependencies can also create inefficiencies in market economies; the U.S. military-industrial complex, while a source of some technological developments, also diverted technical talent, potentially contributing to productivity gaps with Japan and Germany by the 1980s (Kliesen 1993). Conversely, some nations, like Finland with its post-WWII neutrality fostering investment in education and innovation (Abraham Escudero 2023), or South Korea which demonstrated a capacity to transform its economy in the decades following major conflict towards new industrial specializations (Abraham Escudero 2023), illustrate alternative long-term development paths influenced by post-war strategic choices. Germany's decision in March 2025 to exempt defense spending above 1% of GDP from its constitutional debt brake marks a major shift in resource allocation (Darling, 2025). Aimed at reviving the neglected military and meeting NATO budgeting requirements, this move will likely redefine Germany's industrial focus and leadership in European security (Darling, 2025). The change involves political challenges, requiring €500 billion in infrastructure spending, including €100 billion for climate goals, to achieve political consensus in a fragmented landscape, pushed by a caretaker government (Darling, 2025). This underscores how such shifts can be politically complex, even amid external imperatives like the war in Ukraine. The German case also highlights path dependency, where past underinvestment in defense, rooted in a post-WWII pacifist stance, now necessitates significant spending increases—€25-30 billion annually—to reach NATO's 2% GDP target, posing recruitment and budget oversight challenges (Darling, 2025). It illustrates how past choices create long-lasting fiscal and industrial challenges.

Long-term debt trajectories are also profoundly shaped by conflict. Japan’s post-war strategy of high savings and export growth allowed it to avoid sovereign debt crises. Greece, however, saw its post-Cold War military modernization contribute significantly to a debt-to-GDP ratio reaching 180% by 2015, exacerbating the Eurozone crisis (Bardakas et. al. 2023, Figure 1). The U.S. experience shows cyclical trends: the massive WWII debt (over 120% GDP) was gradually reduced, but the Reagan-era Cold War buildup, financed through debt and tax cuts, shifted the U.S. back from a creditor to a major debtor nation (Escudero 2023, I&P 2015). Trade patterns, too, are often reconfigured. The Marshall Plan was pivotal for Europe's immediate recovery and played a role in integrating Western Europe into a transatlantic economic framework, thereby influencing U.S. influence and U.S.-Europe trade (CVCE 2025). Furthermore, governments often institutionalize wartime economic measures, creating enduring structures. A lasting WWII effect in the U.S. was a more even income distribution (top decile's share falling from 45% pre-war to around 33% until the 1970s), which was arguably a key factor enabling the development of its advanced consumer economy (I&P 2015). The collapse of the Soviet Union exemplifies war's indirect structural consequences, leading to a "transformational recession" (GDP contractions of 20–50%) in former Eastern Bloc nations. Differing recovery speeds between nations pursuing "shock therapy" (Poland, Russia) versus gradual reforms (Hungary, Czech Republic) underscore the critical role of institutional adaptability in navigating post-conflict transitions (Berend 2019).

The economic consequences of warfare are demonstrably multifaceted, unfolding across both immediate and extended timeframes. The provided analysis illustrates that while wars invariably trigger acute short-term shocks – including devastating physical destruction (as seen in WWII Europe), significant resource diversion, labor market upheaval (U.S. vs. Europe WWII), and severe fiscal strain characterized by rapid debt accumulation (U.S. WWII debt) – these initial disruptions often serve as powerful catalysts for profound and enduring structural transformations.

Over the long run, economies adapt to these shocks, leading to significant shifts in resource allocation, industrial structure, debt management strategies, and international trade patterns. The text highlights contrasting post-conflict trajectories: the United States saw post-WWII conditions contribute to a consumer-driven boom, partly through the adaptation of wartime R&D, while the Soviet Union's protracted Cold War focus on military spending led to stagnation and eventual collapse (Mazat 2015; Escudero 2023). Similarly, Germany's 2025 fiscal overhaul in response to the Ukraine war (Darling, 2025) demonstrates a significant, contemporary example of a nation being forced by external security shocks to restructure its long-term economic and defense posture. Differing approaches to managing post-war economies (Japan vs. Greece) and navigating post-Soviet transitions (shock therapy vs. gradualism) underscore how policy choices and institutional adaptability shape long-term outcomes (Bardakas et. al. 2023; Berend 2019). Furthermore, wartime measures can become institutionalized, impacting factors like income distribution for decades (I&P 2015) and altering global economic relationships, as evidenced by the Marshall Plan's influence on transatlantic trade (CVCE 2025).

Ultimately, the economic legacy of conflict is not solely defined by the initial destruction or disruption. It is significantly shaped by how societies navigate the aftermath, manage fiscal burdens, reallocate resources, and adapt institutions. As historical patterns demonstrate, the capacity to channel short-term shocks into long-term, adaptive economic restructuring is crucial for post-conflict recovery and sustained prosperity.

2.4.2. Technological Innovation and Resource Reallocation

The intersection of warfare and economic development presents a paradoxical relationship where destruction often creates pathways for innovation and transformation. While wars devastate infrastructure and human capital, they simultaneously accelerate technological advancement and create opportunities for fundamental economic restructuring. Even in contemporary conflicts, such as the one in Ukraine, this pattern persists, with an 'increased demand for science and innovation from both the state and business. This includes military research, medicine, materials science, and artificial intelligence, among other industries that require scientists with their knowledge and competencies' (Haraschenko et al., 2024, p. 13).

Warfare has historically functioned as a powerful accelerator of technological innovation through its unique combination of urgent needs, concentrated resources, and the suspension of normal economic constraints. The imperative to achieve military objectives creates environments where rapid innovation becomes essential for survival and victory.

Large-scale wartime projects demonstrate how military necessity can drive technological breakthroughs. The Manhattan Project and the Whirlwind computer project exemplify how wartime environments foster innovation through interdisciplinary collaboration and resource concentration. These projects progressed empirically but followed rationally formulated hypotheses on strong scientific foundations and, critically, were pursued "at all costs" compared to peacetime commercial projects (Hughes, 1976). This removal of traditional economic constraints creates innovation ecosystems that would be difficult to replicate in normal market conditions. The urgency of military requirements also accelerates the transition from theoretical concepts to practical applications. During World War II, the U.S. carbon black industry underwent significant transformation through government-sponsored research and development, applying industrial research discoveries to fundamentally change its business model and adopt high-efficiency production methods that supported postwar expansions (Foord, 2021). This demonstrates how wartime pressures compress innovation timelines. Similarly, medical advancements driven by organizations like the Office of Scientific Research and Development (OSRD) during WWII led to lasting civilian applications such as mass-produced penicillin, vaccines, and new malaria treatments, jump-starting the U.S. innovation system (Gross & Sampat, 2023).

In the 21st century, efforts to stimulate defense innovation through dedicated funding mechanisms continue, often in response to new or re-emerging geopolitical threats. The European Defence Fund (EDF), initiated in 2017 with an annual investment of up to €1.5 billion in R&D, was designed by then President of the European Commission, Jean-Claude Juncker, to 'devise its own future defense technology' and make the EU security architecture more independent, particularly from the United States (Krenzer, 2025). While the EDF did correlate with a 'boost of production volume' (an average annual growth rate of 4.51% after 2017 compared to 1.73% before) and employment in the European defense industry, particularly for large companies like Leonardo, BAE Systems, and Rheinmetall, its impact on enhancing European *military capabilities* was limited. The 'mixed success' of the EDF highlights a critical distinction: while investment in R&D can spur industrial growth and technological development, its strategic utility depends on whether the resulting innovations are integrated into domestic military forces. In the EDF's case, much of the increased production was geared towards exports to non-European clients, with European militaries often sourcing equipment externally (Krenzer, 2025). This underscores that simply funding R&D is insufficient if procurement strategies and interoperability goals are not aligned.

Wars also necessitate rapid reallocation of resources and industrial capacity. Japan's struggling silk industry during the Pacific War exemplifies this, successfully pivoting from luxury goods to large-scale parachute production, converting silk into a critical military material (Melzer, 2020). Such adaptations illustrate how warfare forces industries to repurpose existing capabilities. The mobilization of industrial resources during wartime also reshapes labor markets and manufacturing processes. In the United States, labor dynamics significantly influenced military-industrial restructuring from World War II through subsequent conflicts, as armament firms sought to overcome constraints imposed by workers, contributing to a shift from mass mobilization to neoliberal war-making (Payne, 2023). The Russian invasion of Ukraine has triggered a more recent and significant attempt at resource reallocation within Europe towards its defense sector. The European Defence Industry Programme (EDIP), launched in response to exposed vulnerabilities and with projected annual investments of at least €500 billion, aims to 'boost production and "make Europe ready for war"' (Krenzer, 2025). This represents a substantial commitment to reorienting industrial capacity and financial resources towards addressing the continent's defense weaknesses, including enabling new aid packages to Ukraine.

The aftermath of warfare creates both immense challenges and unique opportunities for economic transformation through reconstruction efforts. Post-war reconstruction inevitably begins with rebuilding destroyed physical infrastructure, a process that often involves modernization and improvement rather than mere restoration. The effectiveness of local economic development correlates strongly with the active reconstruction of social infrastructure, including medical institutions, schools, and public services (Liashenko et.al. 2023), which serves as the foundation for broader economic recovery. Research on Ukrainian post-war prospects emphasizes that infrastructure reconstruction must be targeted and strategic, focusing limited resources on enterprises capable of quickly producing high-complexity products for international markets, recognizing that not all pre-war infrastructure merits restoration (Pustovoit, 2022).

Post-war periods often present rare opportunities for fundamental economic restructuring. The Republic of Korea's experience demonstrates how post-war recovery can lead to transformative economic development. After an initial focus on overcoming devastation (1953-1960), South Korea implemented policies fostering interaction between the state, business, and foreign aid to ensure sustained development, allowing for structural reforms that might have faced greater resistance otherwise (Nebrat, 2022). The concept of "reconstructive development" emerges where economic thinking shifts from mere restoration to transformative growth, which can occur even with zero or negative growth rates while still improving economic structures (Serogina et. al. 2023).

National economic policies play a decisive role in determining the trajectory and success of post-war recovery. Keynesian economics, advocating for a mixed economy with significant government intervention, emerged as a dominant policy framework during the post-war expansion (1945-1973), proving effective for managing the transition to peacetime economies in many Western nations (Bush, 2010). The institutional environment established by national policies significantly influences outcomes. Successful recovery in South Korea, for instance, highlights how institutional factors and economic mechanisms can be designed to leverage both domestic resources and international assistance, evolving policies from immediate humanitarian needs to sustainable development frameworks (Nebrat, 2022). Post-war reconstruction also offers opportunities for structural economic transformation through deliberate policy choices. Countries implementing comprehensive economic policies—including structural and institutional reforms—can significantly increase the impact of international aid (Nebrat, 2022), suggesting that reconstruction policy should aim beyond restoration to fundamental economic modernization. The effectiveness of such transformation depends on coherence between local development needs and national reconstruction priorities (Liashenko et. al. 2023).

Foreign aid constitutes a critical component of post-war recovery, particularly for nations with limited domestic resources. It can accelerate recovery when deployed strategically, as

Austria's post-war development via the Marshall Plan illustrates, laying foundations for long-term innovation. In South Korea, aid initially focused on immediate devastation before supporting broader economic initiatives (Nebrat, 2022). However, the relationship between aid and growth is not automatic. The legacy of war—damaged commercial networks, loss of trust, and weakened market institutions—creates persistent constraints that aid alone cannot overcome, making reconstruction surprisingly difficult even under favorable conditions (Brück et. al. 2000). The long-term effects of foreign aid depend largely on implementation and domestic policy. Aid policies should be modified for post-war economies to accelerate debt reduction and support small-scale private producers (Brück et. al. 2000). Aid effectiveness increases substantially when recipient countries implement sound fiscal, monetary, trade, institutional, and structural economic policies (Pustovoit, 2022), creating incentives for reform and ensuring resources contribute to sustainable development.

Successful post-war reconstruction requires deliberate strategies. It should actively incorporate technological innovations developed during conflict, as seen with the U.S. carbon black industry (Foord, 2021), to build more advanced economic structures. Effective reconstruction also balances immediate recovery needs with long-term transformation goals. In post-Korean War recovery, policies initially focused on overcoming devastation before shifting to broader development objectives (Nebrat, 2022). For contemporary scenarios, research suggests concentrating limited resources on restoring enterprises capable of quickly producing high-tech products for international markets rather than attempting comprehensive reconstruction (Pustovoit, 2022).

In conclusion, warfare's relationship with technological innovation and economic restructuring reveals a complex interplay of destruction and opportunity. While conflicts impose enormous costs, they simultaneously accelerate innovation, force resource reallocation, and create opportunities for economic transformation during reconstruction. The most successful post-war recoveries strategically leverage wartime innovations, implement coherent and evolving policy frameworks, target resources effectively, and integrate foreign aid with domestic reform. Understanding these dynamics is crucial for designing post-conflict recovery efforts that maximize transformation potential while mitigating the devastating legacies of violence.

2.4.3. The Political Economy of War and Peace

War is not merely a contest of arms; it is a profound catalyst for social, political, and economic transformation. Major conflicts, such as the ongoing Russia-Ukraine war in Europe, irrevocably alter the bedrock of nations, reshaping institutions, redrawing societal fault lines, and reconfiguring economic priorities. The end of conflicts, whether through decisive victory, negotiated settlement, or protracted stalemate, does not signify a return to a prior state. Instead, it introduces a multifaceted post-war setting, burdened with the inheritances of wartime destruction and policies, where the pursuit of long-term stability, peace, and prosperity becomes a formidable challenge. This chapter will explore how major wars, with a particular lens on the Russia-Ukraine conflict, alter the social and political structures of countries. It will examine how these changes, compounded by wartime economic policies, affect the feasibility of establishing durable peace and the intricate political economy that governs both the continuation of conflict and the arduous process of reconstruction.

Major wars act as a violent crucible, melting down and recasting the social and political structures of affected nations. The most immediate consequence is the "destruction of infrastructure, the collapse of state institutions and administrative capacity, a halt to investment activities... high inflation levels... a worsening of the trade balance, an increase in foreign indebtedness, and a decline in external aid flows" (Gudmundsson 2004, p. 67). This economic devastation has profound social implications, often leading to widespread displacement, the creation of refugee crises, and the erosion of human capital. In Ukraine, the systematic targeting of civilian infrastructure by Russian forces exemplifies this, aiming not only to achieve military objectives but also to cripple the state's ability to function and provide for its citizens, thereby reshaping the social fabric through displacement and hardship.

Beyond the physical, war deeply impacts social cohesion. Trust, a cornerstone of societal interaction and economic activity, becomes "one of the casualties of civil war" (Gudmundsson 2004, p. 69). The shared practical knowledge and informal institutions, or *metis*, that allow communities to function, and coordinate are disrupted or destroyed (Cowen and Coyne 2005, p. 36). This is evident in occupied Ukrainian territories where pre-existing local governance and community networks are dismantled or co-opted, and a new, often coercive, order is imposed.

Politically, wars can lead to state weakness or even collapse. As Mason (2007) notes, impoverished nations with weak states are particularly vulnerable to civil war, and the experience of war further erodes state capacity. In prolonged conflicts, formal institutions may be supplanted by alternative power structures. By contrast, Syria's prolonged civil war (2011–present) has resulted in a fragmented political landscape, where warlords and foreign-backed militias have supplanted formal institutions, exacerbating sectarian divisions and weakening state control (Brown 2018, p. 8). The emergence of such non-state actors or the significant weakening of the central state creates a condition of "dual sovereignty" (Mason 2007, p. 42), where competing entities vie for control and legitimacy, a potential trajectory for parts of Ukraine if the conflict becomes deeply entrenched and fragmented.

Wars also redefine identity and power dynamics. Ethno-nationalist sentiments can be inflamed, and current divisions deepened (Mason 2007; Fernando 2017). In Sri Lanka, the post-war reconstruction was aimed at "consolidating the military victory of the Sri Lankan state over the Liberation Tigers of Tamil Eelam (LTTE)... by totally dismantling the foundations of the Tamils as a nation" (Fernando 2017, p. 23). This involved a "development-security nexus" intrinsically linked to a "militarized development process" and the 'Sinhalacisation' of Tamil regions. Russia's rhetoric concerning Ukraine, denying its distinct national identity and aiming to absorb parts of its territory, mirrors this dynamic of conflict being used to impose a dominant ethno-nationalist vision and reconfigure political and demographic realities. The forced displacement of Ukrainians and the implantation of Russian administrative structures in occupied zones are stark examples of such structural alteration.

The economic policies adopted during wartime have lasting repercussions on the post-war environment. Governments typically reorient their economies towards military production, often leading to "high inflation levels... a worsening of the trade balance, [and] an increase in foreign indebtedness" (Gudmundsson 2004). Ukraine has experienced a massive contraction of its economy, coupled with reliance on international financial aid, while Russia has reconfigured its economy to sustain a prolonged war effort, facing unprecedented international sanctions designed to cripple its war-making capacity. These sanctions themselves represent a form of economic warfare, fundamentally altering Russia's integration into the global economy.

The concept of "military neoliberalism" (Schwartz 2011) highlights how twenty-first-century military interventions are often intertwined with ambitious neoliberal economic transformations in the host country. While this primarily describes interventions like those in Iraq and Afghanistan, where the military becomes a direct agent of economic restructuring, elements can be seen in the strategic aims of controlling economic assets in conflict zones. Russia's focus on Ukraine's industrial heartlands in the Donbas and agricultural regions in the south, as well as its control over Black Sea ports, suggests an aim to integrate these economic assets into its own sphere, fundamentally altering Ukraine's economic structure and sovereignty. Looking beyond immediate wartime expropriation, the long-term political economy of external involvement in conflicts like the Russia-Ukraine war can also be shaped by resource considerations. A future scenario is already affected by arrangements where continued defence and reconstruction aid is explicitly linked to access to a nation's natural wealth. An example is a recent 2025 deal between the US and Ukraine, wherein the US would share profits from the future sale of Ukraine's vast reserves of critical minerals like graphite, titanium, and lithium in return for ongoing investment in Ukraine's defence and reconstruction (BBC, 1 May 2025). Such an agreement, driven by the strategic value of these minerals for renewable energy and military technology, and explicitly framed by the US Treasury as a way to 'unlock Ukraine's growth assets' and address concerns over previous aid contributions. This illustrates how controlling and exploiting economic assets can become crucial in the political economy of prolonged conflicts and their aftermath. It involves not just military control but also long-term economic partnerships driven by resource access, especially amidst geopolitical competition for critical materials, like the US-China trade war. (BBC, 1 May 2025). Schwartz (2011) describes a "vicious cycle of pacification" where military efforts to impose new economic orders lead to immiseration and resistance, followed by further pacification (p. 231), a pattern potentially unfolding in Russian-occupied Ukrainian territories.

Furthermore, conflicts often give rise to "informal war economies" (Gudmundsson 2004), which can sustain belligerents but become obstacles to post-war reconstruction by fostering corruption and rent-seeking behavior. The control and exploitation of "lootable" resources like minerals or, in the Ukrainian case, agricultural products and industrial assets in occupied zones, can prolong conflict by providing financial means to warring parties (Mason 2007, p. 25; Gudmundsson 2004).

The capacity of major powers like the United States to engage in sustained support for nations in conflict, such as Ukraine, or to lead extensive post-war reconstruction efforts, is also influenced by their own domestic economic health and broader international economic policies. Significant protectionist measures, such as the 'Liberation Day' tariffs provided by a US administration in 2025, could have substantial negative impacts on the US economy itself, with projected GDP losses of 1.45% in a scenario with international retaliation (Winchester, 2025). Such economic self-harm could, in turn, constrain the fiscal capacity or political willingness of the US to undertake costly long-term foreign aid and reconstruction commitments. Moreover, a global trade war, as predicted by the implementation of such tariffs and subsequent retaliation (Winchester, 2025), would shrink the overall global economy. This harms global value chain, increasing internal costs for major of military industries, especially located in the U.S., and making multinational cooperation for complex tasks like Ukraine's reconstruction more challenging and potentially reducing the pool of available international resources.

The transition from war to peace is fraught with peril. Nations emerging from conflict are at a "grave risk of experiencing a relapse into renewed conflict" (Mason 2007, p. 41). The altered social and political structures, coupled with the devastated economy, create a tinderbox where grievances can easily reignite. The "development-security nexus" described by Fernando (2017, p. 23) often dominates post-war reconstruction, where aid and development are intertwined with the strategic goals of the victorious or dominant power, potentially at the expense of equitable recovery or addressing the root causes of conflict. This is a significant concern for Ukraine, where Western aid for reconstruction will inevitably be linked to geopolitical alignments and security considerations.

External actors play a crucial role, but their interventions are complex. Donor-led reconstruction efforts, as seen in Syria, face "legitimacy dilemmas, capacity dilemmas, and coordination problems" (Brown 2018). The intricate link between development, security, and donor interests in post-war scenarios is also starkly illustrated by a reported 2025 US-Ukraine agreement concerning Ukraine's natural resources (BBC, 1 May 2025). It exemplifies how the political economy of post-war reconstruction involves a negotiation of interests where the recipient nation’s sovereignty and resource control are balanced against the donor's strategic and economic objectives. Efforts to build counter-state capacity and legitimacy through service delivery often replicate traditional state-building tensions, even when the objective is different (Brown 2018). The challenge lies in balancing the imposition of external models with the need to cultivate local metis and ensure indigenous acceptance and trust (Cowen and Coyne 2005, p. 36). For Ukraine's reconstruction, this means avoiding a "one-size-fits-all" approach and instead developing "more strategic, more context-sensitive efforts" (Brown 2018).

Establishing a workable political order is paramount. This involves more than just rebuilding institutions; it requires creating a system where interactions can shift from "games of conflict" to "games of coordination" (Cowen and Coyne 2005, p. 32). This is particularly challenging when the war has ended in a decisive military victory that reinforces the dominance of one group, as in Sri Lanka, where the unitary state structure was consolidated, marginalizing Tamil aspirations for self-determination (Fernando 2017, p. 23). A similar dynamic could emerge if Russia were to achieve its maximalist aims in Ukraine, or conversely, if Ukraine's victory led to the marginalization of certain population groups.

The nature of the war's termination significantly influences peace durability. While military victories might seem decisive, Mason (2007) suggests that negotiated settlements, especially when supported by peacekeeping operations and power-sharing agreements, can sometimes offer a more sustainable path, though they too are fraught with challenges like spoilers and the difficulty of implementing disarmament (pp. 6, 45-46, 50-52). External actors' strategic planning influences the post-war economy. The 2025 US-Ukraine natural resources deal shows US dedication to Ukraine's economy, driven by access to critical minerals (BBC, 1 May 2025). Such agreements create long-term economic dependencies and influence the post-war environment. They demonstrate how major powers secure economic benefits in strategic regions, with the US deal also addressing past aid concerns and competing with China. External actors' roles in reconstruction depend on their domestic economic conditions and policies. For example, US protectionist trade policies forecasted under Trump's tariffs (Winchester, 2025) harm its GDP, weakening its long-term support for conflict regions like Ukraine. This underscores how trade policies affect foreign aid and strategic commitments. The "primacy of security factors in determining political trajectories" (Brown 2018) often means that even well-intentioned reconstruction efforts can be undermined if underlying security issues and power imbalances are not addressed.

Wartime economic policies cast long shadows. High military expenditure during conflict can divert resources from essential services and development (Gudmundsson 2004, p. 76). If a "military neoliberalism" approach has been taken, the "vicious cycle of pacification and immiseration" can create enduring humanitarian crises and resistance (Schwartz 2011). Rebuilding an economy shattered by war and distorted by wartime policies requires not just financial investment but also institutional reforms that promote equitable growth and opportunity, thereby raising the "opportunity costs of participation in renewed conflict" (Mason 2007, p. 69). The reconstruction of Ukraine will be a monumental task, requiring vast international aid, but its success will depend on whether it addresses the structural damage, fosters inclusive institutions, and avoids the pitfalls of externally imposed models that lack local legitimacy.

In summary, significant wars, such as the devastating conflict witnessed in Ukraine, are not transient events but profound historical ruptures that reshape the very foundations of societies. They dismantle and reconfigure social hierarchies, political authorities, and economic systems in ways that complicate any simple return to a pre-war status quo. The economic policies pursued during wartime, whether driven by immediate necessity, strategic opportunism, or ideological enthusiasm, deepen the implementation of these changes, creating complex legacies that shape the post-war landscape.

The political economy of post-war reconstruction is often a contested terrain, where the interests of internal factions, external powers, and international donors intersect, sometimes clashing with the needs and aspirations of the local population (Fernando 2017; Brown 2018). The path forward for a nation like Ukraine, or any country emerging from major conflict, involves navigating these treacherous waters, fostering inclusive political and economic institutions (Mason 2007), and ensuring that reconstruction efforts genuinely serve the long-term welfare of all its citizens, rather than becoming a new arena for conflict or external domination (Schwartz 2011; Cowen and Coyne 2005). The political economy of war dictates that its scars are deep; the political economy of peace demands wisdom, resources, and a commitment to addressing those scars comprehensively.

Chapter 3. Data and methodology

This chapter describes data science approach to analyzing the relationship between military spending and economic growth across NATO countries and key allies. Unlike traditional econometric approaches that have dominated this field, we employ advanced machine learning (ML) techniques to uncover complex patterns in the data that might otherwise remain hidden.

Traditional studies examining military expenditure effects on economic growth have typically relied on linear regression models, panel data analysis, or time series techniques with strict assumptions about functional relationships. For instance, recent research on NATO countries has employed panel cointegration tests to analyze military expenditures' impact on sustainable development (Tsitouras & Tsounis 2024; d'Agostino et. al. 2017; Dunne & Smith 2019), while others have used more conventional panel approaches to analyze macroeconomic variables affecting economic outcomes (Dunne & Tian 2016, Yuan et. al. 2023, Hou & Chen 2013). These methods, while valuable, often fail to capture complex nonlinearities and interaction effects that may characterize the military spending-growth relationship.

Our 'data science' approach leverages machine learning algorithms that can automatically detect complex patterns, nonlinearities, and interactions without requiring explicit specification of functional forms. This is particularly important for understanding military spending effects, where both positive spillovers (technological innovation) and negative effects (crowding out of productive investment) may operate simultaneously and vary across different contexts.

The superiority of this approach is demonstrated by recent research showing that machine learning models consistently outperform traditional econometric approaches in forecasting economic indicators. For instance, ML algorithms can predict economic indicators like GDP growth with greater precision than conventional methods (Haponik, 2024), leading to more reliable forecasts. Similarly, in a study of Chinese macroeconomic variables, the average forecast errors of machine learning models were generally lower than those of traditional econometric models (Yang et. al. 2024).

3.1. Data Description

	Variable	count	mean	std	min	25%	50%	75%	max
0	Year	2920.0	1.989565e+03	2.037211e+01	1949.000000	1.972000e+03	1.990000e+03	2.007000e+03	2.024000e+03
1	CPI	2264.0	6.848024e+01	5.577018e+01	0.000054	2.611352e+01	7.218997e+01	1.019112e+02	1.322884e+03
2	Capital formation	1989.0	2.369221e+01	4.834588e+00	4.452209	2.067264e+01	2.318424e+01	2.637568e+01	5.322203e+01
3	GDP per cap.	2187.0	2.573581e+00	4.379398e+00	-31.177519	8.510625e-01	2.593928e+00	4.653500e+00	4.784542e+01
4	Health expenditure	970.0	2.867665e+03	2.408884e+03	34.622330	8.273309e+02	2.162439e+03	4.647990e+03	1.243443e+04
5	Merchandise trade	2097.0	6.109981e+01	3.539173e+01	6.420058	3.685646e+01	5.237776e+01	7.826028e+01	2.327421e+02
6	Military_spending	2358.0	3.273244e+04	1.220610e+05	0.000000	1.295150e+03	4.851500e+03	1.463250e+04	1.031257e+06
7	Population	2688.0	2.537338e+07	4.531113e+07	175574.000000	3.159257e+06	8.543260e+06	3.386237e+07	3.349149e+08
8	Unemployment	1634.0	8.356089e+00	5.715682e+00	0.200000	4.688750e+00	6.906000e+00	1.021650e+01	3.880000e+01
9	Labour force	2198.0	5.886736e+01	7.904387e+00	32.720000	5.356454e+01	5.954255e+01	6.352950e+01	9.357000e+01
10	R&D	1070.0	1.569062e+00	9.698417e-01	0.015900	7.333475e-01	1.414500e+00	2.236538e+00	5.210810e+00
11	Educational attainment	1283.0	2.278222e+01	1.222878e+01	1.513240	1.252180e+01	2.126000e+01	3.150163e+01	6.803931e+01
12	Gini Index	1152.0	3.152173e+01	4.188371e+00	20.700000	2.820000e+01	3.189318e+01	3.440000e+01	4.440000e+01
13	Population_growth	2688.0	5.300174e-01	8.778181e-01	-8.078026	7.480518e-02	5.160519e-01	9.944351e-01	4.297652e+00
14	GDP_growth_cat	2920.0	1.296918e+00	7.790447e-01	0.000000	1.000000e+00	1.000000e+00	2.000000e+00	2.000000e+00
15	Farleft	2920.0	1.917808e-01	3.937690e-01	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	1.000000e+00
16	Farright	2920.0	5.068493e-02	2.193911e-01	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	1.000000e+00
17	Moderateleft	2920.0	2.452055e-01	4.302826e-01	0.000000	0.000000e+00	0.000000e+00	0.000000e+00	1.000000e+00
18	Moderateright	2920.0	5.123288e-01	4.999336e-01	0.000000	0.000000e+00	1.000000e+00	1.000000e+00	1.000000e+00

Table 1: Summary statistics of the input data

Our analysis focuses on NATO member countries and selected allies, providing a diverse sample of 40 economies with varying levels of military expenditure and economic development. Despite questionable level of development and weak domestic military industry the select of Balkan countries was included. As NATO members (Croatia, North Macedonia, Montenegro, Albania) or aspiring members (Bosnia and Herzegovina), these Balkan nations are integral to the European security architecture. Their defense spending patterns reflect NATO commitments and the collective response to the heightened threat environment stemming from the Ukraine war. Including them allows the model to capture a broader range of responses within the NATO alliance, particularly from newer members or those with historically different security postures. The study covers a multi-year period ranging from 1949 - 2022, capturing several economic cycles, geopolitical events, and variations in military spending patterns across a total of 2,920 country-year observations (Table 1). In doing so, we sought to address the requirements of our methodology, which necessitates a substantial number of observations, while remaining aligned with the primary objectives of our study in the context of the Ukraine-Russia conflict.

Our model includes a broad assortment of variables aimed at capturing the various effects outlined by Endogenous Growth Theories, the Augmented Solow Model, and Keynesian Demand Models, with the mechanism detailed in the next sub-chapter. The dataset exhibits significant variance across all indicators, reflecting a wide range of economic conditions from severe recessions to periods of "miracle" growth.

The dependent variable is economic growth, operationalized as the annual growth rate of GDP per capita, with data sourced from the World Bank. The raw data for this variable demonstrates the extreme volatility our model must account for, with annual growth rates ranging from a minimum of -31.2% during severe crises to a maximum of 47.8% in periods of rapid expansion.

The key independent variable is total military spending adjusted to constant U.S dollars based on 2023 year, obtained from the Stockholm International Peace Research Institute (SIPRI) military expenditure database. For the primary independent variable, military expenditure is measured in absolute, inflation-adjusted U.S. dollars (constant 2023). This methodological choice is deliberate and crucial for testing the specific economic theories under investigation. Unlike a percentage of GDP, which measures national burden, or a growth rate, which measures shifting priorities, absolute expenditure directly operationalizes the key causal mechanisms of interest: the size of the Keynesian demand injection, the quantity of real resources crowded out from the private sector, and the scale of investment available for potentially growth-enhancing R&D projects. This allows the model to move beyond analyzing policy intent to directly assessing economic impact, providing a more powerful and theoretically grounded test of the defense-growth nexus. The extreme skew in this variable, with a median spending of $4.85 billion but a mean of $32.7 billion and a maximum exceeding $1 trillion, underscores the dominance of a few large spenders.

To control for supply-side influences on economic performance, the analysis includes several variables: higher education enrollment ratios, gross fixed capital formation (as a percentage of GDP), population size, and research and development (R&D) expenditure (as a percentage of GDP) obtained from World Bank database. The labor force participation rate, and unemployment rate were obtained from the International Labour Organization (ILOSTAT). Notably, key supply-side variables such as R&D and Educational attainment have significantly fewer observations (1,070 and 1,283 respectively) than the full dataset, highlighting the presence of missing data and justifying the advanced imputation techniques discussed in our methodology later.

On the demand side, control variables (all acquired from the World Bank database) include public health expenditure (current health expenditure per capita in constant US dollars), the consumer confidence index (proxied by the consumer price index, with 2010 as the base year), and policy interest rates (real interest rate as a percentage).

Additionally, a set of external and structural variables is incorporated: merchandise trade (% of GDP), income inequality (measured by the Gini index), and political party ideology, coded categorically (e.g., left, right, center) acquisition of which will be discussed later. The diversity of economic structures in our sample is evident in variables like Merchandise trade, which ranges from a low of 6.4% to a high of 232.7% of GDP, capturing both relatively closed and extremely open economies. Our political variable also reveals that a moderate-right government was the most frequent ideology over the period, present in 51% of the observations.

3.2. Theoretical Framework

The methodology is guided by a unified theoretical framework that integrates multiple growth theories. It is posited that economic growth is jointly determined by both supply-side and demand-side factors that interact in nonlinear and threshold-dependent ways. Supply - Side and Demand-Side (Keynesian theory) Integration.

First, by the supply side the Augmented Solow Model's emphasis on factor accumulation is operationalized in our model through several key variables. Physical capital accumulation is primarily captured by Gross Fixed Capital Formation (% of GDP), reflecting investment in productive assets. The influence of borrowing costs on this accumulation is partly addressed by including Policy interest rates. As highlighted in our literature review (e.g., LR Section 2.1.1), the financing of defense expenditure can impact on these rates and, consequently, private investment. Human capital, a critical component of the augmented model, is proxied by Higher education enrollment ratios. The literature review chapters extensively discuss how defense spending can both divert resources from broader education and, conversely, stimulate specific skill development and human capital within defense-related industries. Population data is used for per capita normalizations and as a scale factor consistent with Solow frameworks. The diverse nature of our country sample (NATO and allies) allows for an implicit examination of convergence processes, although this is not the primary focus of the classification task. Second theory discussed by the supply side, Endogenous Growth Theories, underscore the role of internally generated technological progress, that are primarily addressed through the R&D expenditure as a percentage of GDP variable. As extensively reviewed (LR Sections 2.1.2, 2.3.1, 2.4.2), military spending is often R&D intensive and can be a significant source of technological spillovers, dual-use innovations (e.g., GPS, AI applications), and productivity gains, particularly in economies with high absorptive capacity and supportive institutional frameworks. Higher education enrollment ratios, representing human capital, is also critical here, as a skilled workforce is necessary to undertake and diffuse R&D. The interaction between military spending and these variables will be crucial for understanding if defense expenditure indeed fosters endogenous growth by stimulating innovation networks rather than merely acting as an exogenous demand shock. Our ML approach is particularly suited to capture the complex, potentially non-linear relationships between defense R&D, civilian R&D, and overall economic dynamism discussed in the literature."

By the demand side, the Keynesian perspective is examined by treating `Total military spending per capita` as a direct government fiscal injection capable of influencing aggregate demand. The beginning of the literature_review posits that such expenditures can have a multiplier effect, particularly in economies operating below full capacity, thereby boosting employment and output. Variables like `Unemployment` and `Labor force participation rate` provide context on resource utilization, while the `Consumer confidence index` serves as a broader indicator of prevailing aggregate demand conditions. We will explore if increased military spending correlates with higher growth, especially under conditions potentially indicative of economic slack, which would support Keynesian demand-stimulation arguments.

The critical debate between 'crowding-out' and 'spillover' effects of military spending, central to our literature review (LR Sections 2.1.1, 2.2.2), will be empirically investigated by examining the relationship between `Total military spending` and other key economic activities. Neoclassical theory suggests that higher military spending, potentially financed through borrowing that raises `Policy interest rates`, could crowd out productive private investment (proxied by `Gross Fixed Capital Formation`) and crucial public investments in areas like education (proxied by `Higher education enrollment ratios`) and health (proxied by `Public health expenditure as a percentage of GDP`). Conversely, positive relationships or positive interaction effects, particularly with `R&D expenditure`, could indicate Keynesian demand-side spillovers or Endogenous Growth-style technological spillovers. Our ML models are designed to identify these potentially complex and conditional effects, determining whether military expenditure acts as a net stimulus or a drag on other growth-enhancing sectors.

A key innovation in our approach is the explicit recognition of potential nonlinearity and interaction effects. By classifying economic growth into three distinct categories—low, medium, and high growth, we aim to explicitly ascertain the optimal level of defense expenditure conducive to moderate economic growth within the framework of contemporary warfare in the territories of present-day Western countries. Also utilizing available for some model's feature of importance validating for models' variables we will examine key stimuluses accepted as variables in our model, backed up by theoretical ground in our literature review, for economic growth. We hypothesize that moderate military spending might generate positive technological spillovers, while excessive spending may crowd out education or private capital investment. Similarly, the effect of human capital on growth might depend on levels of innovation or aggregate demand.

This aligns with research using Markov-switching models that characterize distinct growth regimes (stable growth, miracle catch-up, stagnation, and crisis) with transition probabilities determined by institutional quality (Jerzmanowski 2006). Our approach can identify similar regime-dependent relationships between military spending and economic growth.

3.3. Data Preprocessing

The raw, aggregated dataset, while comprehensive, requires several critical preprocessing steps to ensure its quality, integrity, and suitability for machine learning modeling. This section details the systematic approach taken to handle missing data, meaningful features, assess statistical properties, and prepare the data for the final analysis.

3.3.1. Initial Data Assessment and Missingness Analysis

A preliminary examination of the dataset revealed significant challenges related to missing data, which is common in longitudinal, multi-country datasets. To understand the extent and nature of this missingness, the missingno library for visualization was employed.

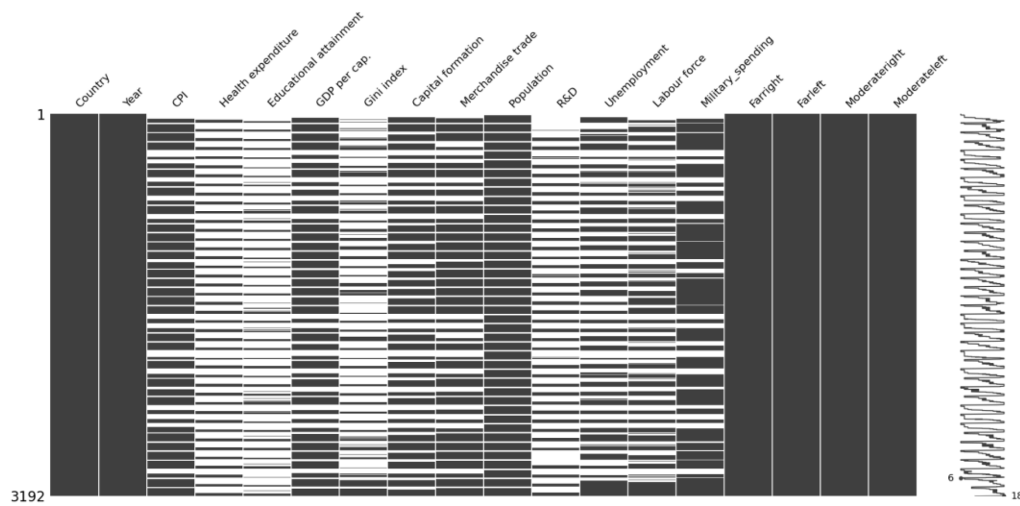

Figure 2: MSNO missingness frequency plot

As illustrated in Figure 2, the missingness is not random. The Government Ideology variables, which were artificially created for this study, are complete. However, several key indicators, including Capital formation, Merchandise trade, GDP per capita, and Military spending, exhibit clear patterns. This suggests that data is often missing for specific countries during particular time periods (e.g., before they joined an international organization or before they started collecting a specific type of data), a situation known as Missing Not at Random (MNAR). This pattern makes simple listwise deletion (removing rows with any missing value) an inappropriate strategy, as it would systematically remove certain countries or eras, introducing significant bias and drastically reducing the sample size.

To quantify which variables were most affected, a gap frequency plot was generated.

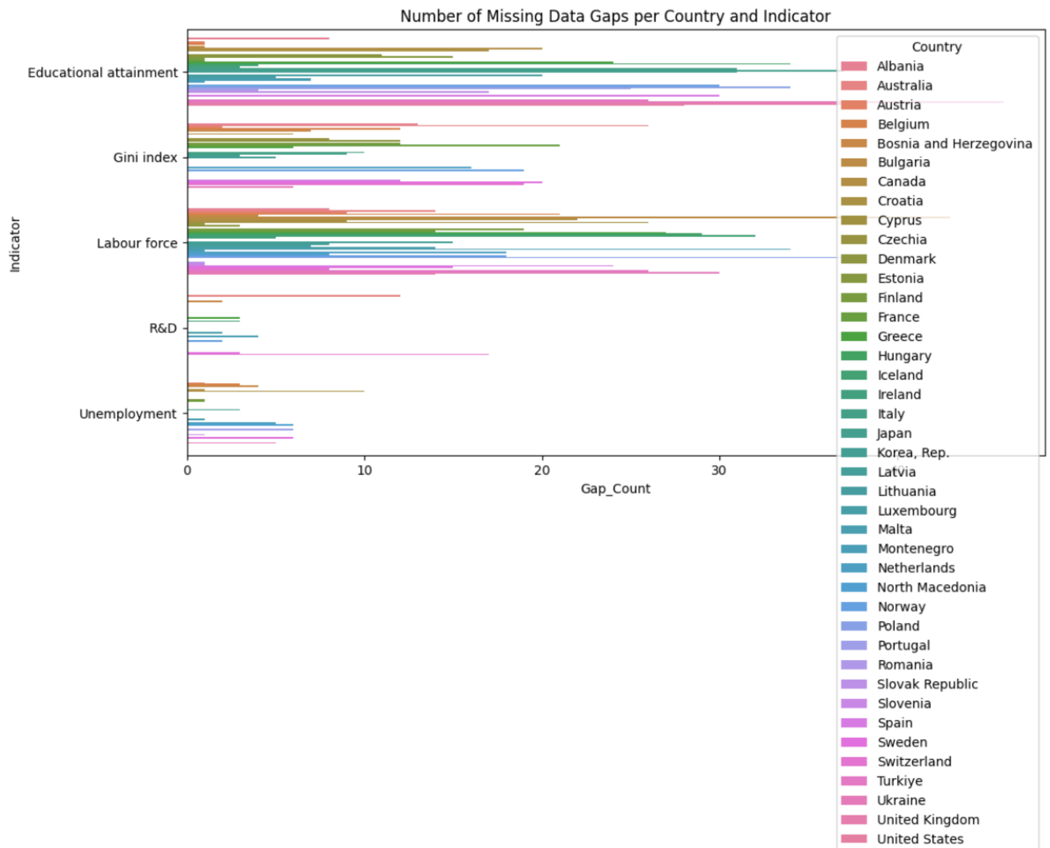

Figure 3: Data gaps frequency plot

Figure 3 confirms that indicators such as Educational attainment, Gini index, and Labour force contain the most substantial data gaps, further reinforcing the need for a sophisticated imputation strategy.

3.3.2. Advanced Missing Data Imputation

Given the time-series nature of the data and the non-random patterns of missingness, a two-stage advanced imputation process was implemented.

Firstly, Multiple Imputation by Chained Equations (MICE). For most variables with smaller, intermittent gaps, we employed the MICE algorithm, implemented via Scikit-learn's IterativeImputer. This technique is superior to simple mean or median imputation because it treats each feature with missing values as a function of the other features. It iteratively models and predicts the missing values by leveraging the correlations and relationships that exist across the entire dataset, thereby preserving the natural variance and structure of the data.

Secondly, following the automated imputation, a crucial validation step was performed to check for any potential biases or unrealistic imputed values. For a few specific cases (notably for Ukraine in certain years), the MICE algorithm produced results that were deemed economically implausible. In these isolated instances, a more conservative linear interpolation was used to fill the gap. This manual oversight ensures that the final imputed dataset is not only statistically sound but also grounded in economic reality.

A special case was Educational attainment. Due to its theoretical importance in growth models and the large number of missing observations, deleting rows would have severely compromised the dataset. Therefore, it was essential to impute this variable using the same rigorous MICE procedure to maintain a sufficient sample size for the "reduced model" analysis.

3.3.3. Creation of the Government Ideology Variable

To incorporate the political context into the analysis, a categorical Government Ideology variable was created to classify the ruling government of each country for each year of the study period (1990–2024). Given the complexity and scale of classifying over three decades of political history across 40 countries, a novel AI-assisted approach was employed, leveraging the analytical capabilities of a large language model (LLM), Perplexity AI. This method allowed for a systematic and scalable classification based on a synthesis of multiple data sources, providing a more robust alternative to manual coding.

The classification framework was developed to assign each country's ruling government to one of four ideological categories: Far Left (fl), Moderate Left (ml), Moderate Right (mr), or Far Right (fr). This process relied on an integrative analysis of several key data sources. Natural Language Processing (NLP) techniques were applied to party manifestos and legislative texts, enabling the model to detect keywords, policy positions, and rhetorical patterns indicative of left- or right-leaning ideologies, such as contrasts between terms like “social equity” and “fiscal discipline.” To validate and calibrate these classifications, the model's outputs were compared with established academic datasets, particularly the Chapel Hill Expert Survey (CHES) (Di Leo et. al. 2025), which offers standardized ideological ratings for European political parties. Additionally, annual government coalition data was incorporated, accounting for the composition of ruling parties or coalitions in each country and enabling the model to assess the prevailing ideological orientation of each government in a comprehensive and context-aware manner.

To ensure reliability, the AI-generated classifications were validated against expert survey data, achieving a strong Pearson correlation of **$\rho = 0.78$** with the CHES expert rankings (Di Leo et. al. 2025). This high degree of congruence confirms that the AI-assisted methodology produced results that are consistent with established political science research. While acknowledging the inherent risks of AI bias, particularly a potential overemphasis on U.S.-centric political frameworks, this validated and scalable approach enabled the creation of a unique and valuable longitudinal dataset on government ideology, allowing for a quantitative test of its influence on economic growth regimes.

3.3.4. Feature Engineering and Selection

With a complete dataset, the next step was to refine and create variables to better test our hypotheses. An initial correlation analysis (Figure 4) revealed a strong positive correlation between absolute Population and absolute Military_spending. This is largely a trivial relationship—larger countries tend to spend more in absolute terms. To create a more dynamically meaningful variable, Population was transformed into Population_growth, calculated as the annual percentage change. This new feature measures demographic dynamics rather than country size, providing a more relevant predictor for a growth model and resolving the multicollinearity issue.

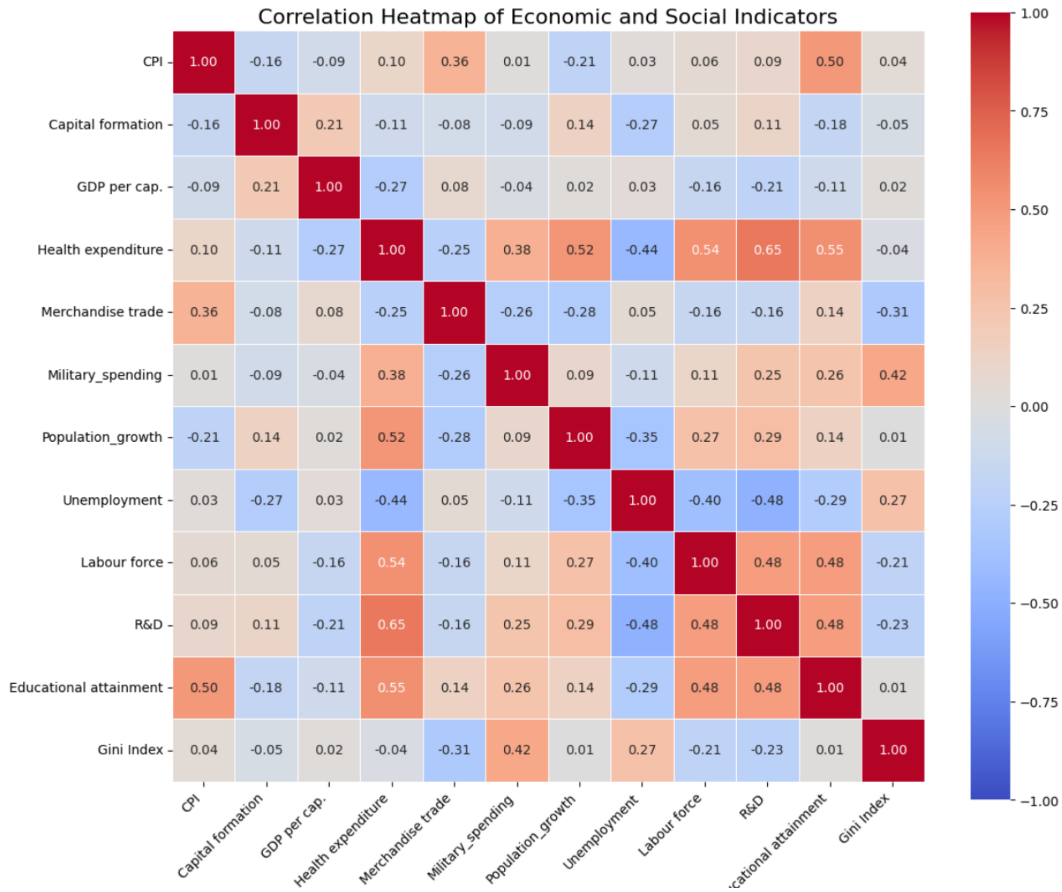

Figure 4: Correlation plot of initial data

The primary dependent variable, GDP per capita growth, was transformed into a categorical variable, GDP_growth_cat, with three distinct classes: Low, Medium, and High Growth. The specific thresholds and theoretical justification for this classification are detailed in the subsequent methodological framework section.

3.3.5. Multicollinearity Assessment

Before finalizing the feature set, we conducted a formal test for multicollinearity using the Variance Inflation Factor (VIF). Multicollinearity occurs when independent variables are highly correlated with each other, which can destabilize model coefficients and make them difficult to interpret.

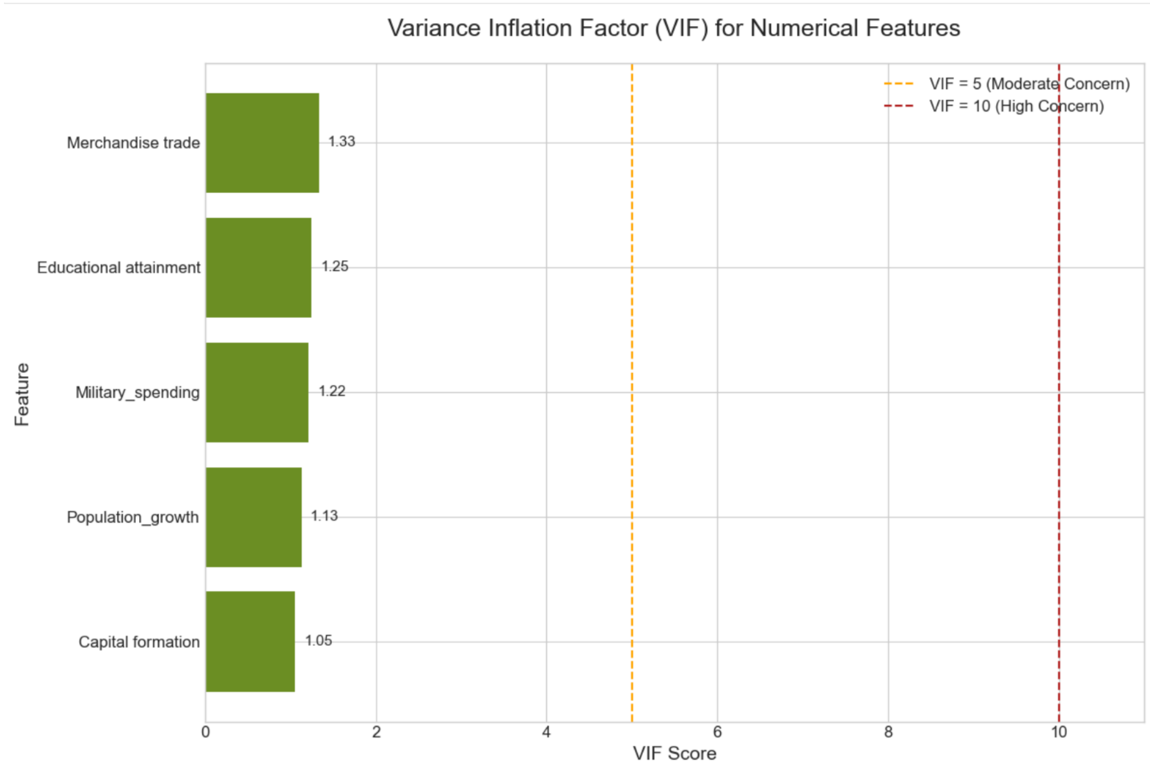

Figure 5: Variance Inflation Factor for numerical features

As shown in Figure 5, all numerical features in our model exhibit VIF scores well below the common cautionary threshold of 5, and far below the severe threshold of 10. This confirms that multicollinearity is not a concern among the selected predictors, ensuring the stability and interpretability of our models.

3.3.6. Final Data Preparation for Modeling

The final step before modeling is to standardize the numerical features. Machine learning algorithms, particularly those that rely on distance calculations or gradient descent (like Neural Networks and Logistic Regression), can be sensitive to the scale of input features. To address this, all numerical variables were scaled using Scikit-learn's StandardScaler, which transforms each feature to have a mean of zero and a unit variance. Critically, this scaling is performed *within* the cross-validation loop on the training data only, and the same scaling is then applied to the validation data. This strict separation prevents data leakage from the validation set into the training process, ensuring an unbiased evaluation of model performance.

Chapter 4. Current context analysis

Before addressing analysis of current context, as well as other parts of this paper, some key definitions must be explained. Key concept is a geopolitical distinction of countries, which allows to understand which countries would be a basis for analysis. Western geopolitical bloc in this context is a fundamental part of this work. Understanding this concept is key for current paper, because mainly countries from this geopolitical bloc are analyzed. Mainly distinction for this definition could be made for two historical periods: Cold War period and Post Cold War period.

The Cold War period could be defined from 1947 to 1991. Notable point in context of the so-called Western bloc was 1949, because it was a year when North Atlantic Treaty Organization (NATO) was formed. NATO is one of the most formalized definitions of Western bloc, because it is an institutionalized defensive alliance. NATO was opposed by Warsaw bloc, which crumbled in 1991 with the dissolution of the Soviet Union. However, it would be wrong to judge, that NATO was the only representation of Western bloc – in fact, some other countries, that weren't in NATO, could be defined as a part of a Western geopolitical pact. Mainly, those countries are in Pacific region – Japan, Republic of Korea, Australia and New Zealand. Japan historically belongs to Western bloc because of American occupation, which was a result of American victory in World War II on the Pacific. Republic of Korea could be counted as a part of this bloc because of big American influence after division of Korean peninsula in two parts. Australia and New Zealand cooperated with the United States and the Allies in wartime and continued such cooperation later (Geronik, 2024).

After the Cold War a system adapted, as well as new treaties emerged. First of all, it had been defined by an expansion of NATO, and, accordingly, of the Western bloc. Several expansions were made after the Cold War, mainly for Central and Eastern European countries. Mainly defined three waves of expansion:

first expansion in 1999: Czech Republic, Hungary and Poland,

second expansion in 2004: Bulgaria, Baltic countries (Estonia, Latvia and Lithuania) joined NATO, third expansion in 2009 with Croatia and Albania joining the Organization.

Although beyond this scope, several other countries (Montenegro and North Macedonia) also decided to join the NATO (Eichler, 2021). In 2023 and 2024 respectively, following Russian invasion on Ukraine, Finland and Sweden also joined the alliance (Särkkä, Ålander, Linnainmäki, & Pihlajamaa, 2024).

Notably, some Pacific alliances also were formalized like NATO. One of the most important alliances are AUKUS and American-Japanese-Korean trilateral pact (or simply Camp David Principles), which is successor of Quad+. AUKUS is an alliance between the United Kingdom, the United States and Australia, which was signed in September 2021 (Rees, 2025). Camp David Principles is a formalized alliance between the US, Japan and Republic of Korea (Stangarone, 2023). Both of these alliances (AUKUS and Camp David Principles) are formalization of Pacific part of Western bloc.

After understanding geopolitical definitions, that a lay as basis of this work, it would be consequential to see the current context for different countries and their military budgets. NATO impact and shared commitments would be discussed. For European part Germany, France and the United Kingdom would be analyzed, then the United States would be under scope of our analysis. Also, the European Union impact would be covered. Our analysis will also include impact on enterprises in the military industrial sector and some cross-cutting impact on the economy.

An important part of current defense spending portions is made by many political commitments of NATO member states. Most important commitments were made in 2014, during NATO Wales Summit, where members of Organization were committed to 2% of GDP military spending and 20% equipment spending goals. Though such commitments for some countries weren't fully fulfilled, because mainly commitment to spending targets were driven by several factors – e.g. "threat vulnerability", when member state has a shared border with potential threat for NATO or by "abatement cost", which is important in context of economic damage if 2% GDP target is reached (which is a case for Germany or France, as well as their fiscal policies). This divergence between NATO countries explain why full commitment were not fully realised (Becker, Poast and Haesebrouck, 2024).

Starting from Germany, which restrained for a long time from large increases of military spending, a change of paradigm could be marked. Chancellor Olaf Scholz announced so-called turning point in military spending policy (*Zeitenwende*) three days after Russian invasion on Ukraine **(Tian et. al. 2023)**. German government decided to implement several measures, recognizing changing geopolitical landscape in Europe and in the world (Olsson, 2025):

establishing a €100 billion defense fund (*Sondervermögen*) in order to improve Bundeswehr fighting capability; this measure increased defense budget to 2.1% of German GDP in 2024, from 1.5% in 2021,

committing to 2% GDP of military spending through 2027, established by NATO,

procuring defensive equipment (e.g. F-35 jet fighters, CH-47F Chinook helicopters)

It is quite visible, that German defense spending policy change, marked by *Zeitenwende* has a key focus – mainly it was directed towards categories, that was heavily underinvested and are in need for Germany – mainly equipment. It should be noted, that change in this approach highlights very important challenge – even though equipment modernization is very important part of efforts, funding for *Bundeswehr* personnel, as well as operations and maintenance (O&M) infrastructure might be viable to increase readiness capability of German forces.

Industrial impact for German companies due to *Zeitenwende* was also significant. One of main examples is Rheinmetall, German defensive enterprise. Revenue of company increased by 40% year-on-year in 2023. Rheinmetall consequently expanding his military capabilities, for example by opening new shell factories to meet according to NATO targets of production or by developing new designs of military vehicles. Other German firms in military industrial complex had similar experiences. Due to fiscal expansion, approximately 20% of the workforce was added to the sector in two years. To be competitive, German military enterprises shifted their investments into Research&Development projects, mainly in drone countermeasures, directed-energy weapons or artificial intelligence systems. Activity in this sector caused some supply-sided bottlenecks, particularly in raw materials and in explosives **(Tian et. al. 2023)**.

France also went through some transformations due to changing geopolitical context. French budget maintained 2% GDP goal, which was in align with NATO guidelines. New geopolitical challenges were serious for French policymakers: President of the Republic, Emmanuel Macron declared "war economy" to show seriousness of the situation. Mainly

France diverted military spending funds to support some strategic areas in its military industrial complex. For example, it allocated the portion of budget to modernization of nuclear arsenal with new third-gen SSBNs and ASMP-A missiles. Additionally, French policymakers focused on European defense integration, by funding Future Combat Air System to €4.2 billion annually, supporting domestic companies (Dassault and Airbus), that were leading the project (Machi, 2022).

As well as in German case, French policy made a clear strategic choice – to maintain high-end equipment and modernize it. In contrast with countries that prioritize mainly O&M investment, French policymakers decided to allocate their funding into such projects as Future Combat Air Systems or by modernizing nuclear arsenal – even if 2% GDP target was not always achieved – which is a big distinction in contrast with NATO members that may concentrate on more low-end parts of its arsenal – like personnel or O&M (Becker et. al. 2022).

French industry experienced similar problems as a German one, with some problems being more important: mainly, supply chain bottlenecks, tied to integration of civil enterprises into economic activity of military industrial complex. For example, French company Safran had problems with receiving deliveries of turbine blades with waits of 18 months due to commercial aerospace companies, that were competing for foundry capacities. Main contributors of increased spending were Airbus (which had 27.7% of revenue increase, by new orders for military air transportation aircraft or IRIS-T air defense project) and Thales (which revenue increased of 13.8%, mainly due to CAESAR howitzers procurement and cybersecurity solutions) (Airbus, 2023; Thales, 2024).

It is worth to note, that significant growth in revenue for such enterprises as Thales or Rheinmetall is a direct consequence of highly important investments in operations and maintenance equipment. Surge of demand in ammunition introduce a focus to not only support own national forces, but also with a need to support allies. Core component of O&M were neglected for a big time, which is a showcase of Becker et. al. thesis (2022) that argued for critical, but often overlooked component of a collective defense readiness.

It is also worth to note, that France and Germany are not only contributors to defense industry, because of several initiatives launched on level of European Union. The European Commission governs the European Defense Fund with amount of €7.3 billion for 2021-2027.

In 2024 the European Commission invested through funds in more than 60 projects, which brought total collaboration of the EU in defense R&D capabilities to €4 billion since existence of such budget. Fund has a significant impact on the European R&D in the defense sector (European Commission, 2024).

The European Union also supports many different initiatives that facilitate European defense. Examples of such initiatives include EDIRPA (European Defense Industry Reinforcement through Common Procurement Act) which improves coordination for cross-border defense projects and provides financial instruments for Member States to get access to European defense products (European Commision, 2024).

ASAP (Act in Support of Ammunition Production) is another example, where the European Commission used common budget in order to stimulate different areas of ammunition production, for example explosives, missiles or powder production (European Commision, 2024).

The EU coordinated PESCO (Permanent Structured Cooperation) project, which helped Member States launch commitments for new defensive projects with each other, mainly for cutting-edge technologies (like energy weapons) (European Council, 2017).

Another example of benefit of common European initiatives is SAFE (Strategic Autonomous Fund for Europe), which provided €150 billion in loans for Member States in order to realize urgent defense investments. Loans were structured on favorable terms for Member States, offering long duration (maximum for 45 years). What is also important, is that SAFE aimed to boost European production – components of countries outside the EU were limited to 35% (Lungungu, 2025).

In broader context, defense spending of the EU increased significantly, representing 30% growth for a three-year period (2021-2024). Defense investments had a big portion of this part: almost 31% of all budgets are defense investments, with consequential increase. Projections show that defensive funds under disposal of the European Commission can be furtherly increased to more than €100 billion by 2027. This demonstrates the commitment of the common European authorities to further improve the domestic defense sector, with accounting mainly on innovative sectors, which are in main scope of the European Commission and its defensive spendings frameworks (European Defence Agency, 2023).

For countries of Western bloc that are outside the European Union, the United Kingdom defense spending experienced some stagnation, however declarations of the policymakers of this country show ambitious targets on way to increase military spending. UK commitment mainly represented by increasing defense spending to 2.5% GDP by 2027 and 3% by 2034. Mainly United Kingdom prioritize its missile capabilities through defense budget (Foley, Brooke-Holland, & Mills, 2025).

The United Kingdom strategic choices in this context are quite clear – even though UK is not a country with high "abatement costs", it decided to prioritize relatively high-end equipment, which is quite similar to French strategy, as well as a step to alignment with the US priorities. However, there is a consensus in literature, that overemphasis on equipment category without a proper spending in O&M category may lead to a "bonsai army", which means possessing advanced armament but lacking enough power to realize prolonged operations.

Main beneficiary of British military industrial complex was BAE Systems, which had remarkable growth of revenue of 22.5% in 2024. British defense giant benefited through supply of M777 howitzers, along with increased demand of armored vehicles and naval systems (Investegate, 2024).

The United States of America are the country with the biggest defense budget (and spending) on the world, which makes their position quite notable. The US defense budget grew sequentially, increasing from $742 billion in 2021 to $886 billion in 2024. What is also important is that defense spending of the US is technically not limited since 2021, because of the expiration of Budget Control Act. Projections for 2026 shows, that United States military budget can approach $1 trillion, which is very significant amount. Similarly, the US used these funds to several military priorities – like modernization of nuclear arsenal or developing new military equipment, investing in R&D; as well as to geopolitical priorities – by launching several initiatives and programs to help Ukraine (Cohen, 2025).

In industrial sense, main contributors and beneficiaries were biggest firms of military industrial complex of the United States, for example, Lockheed Martin or Northrop Grumman. Lockheed Martin was the biggest defense contractor and had an increase in revenue of 15.1% in 2024. Operating profit was especially spectacular for the Missiles and Fire Control segment of enterprise, delivering 50% increase, mainly due to the procurement of supplies for such systems as HIMARS. Drone revenues of Lockheed grew by 45% year-over year. Northtrop Grumman accomplished 15% growth in revenue due to increasing demand of various missile systems, even when experiencing problems with B-21 stealth bomber project. Overall defense sector in the United States had a increased employment growth (by approximately 7.3%) while 800.000 positions were engaged in defense industry (Shetti & Stone, 2025; Northrop Grumman, 2024).

To conclude, the current increase of Western bloc defense spending is more than just a reaction to a single geopolitical event, but a chain of culmination of political commitments that were created in 2014. Each country in this context shaped its policy based on “threat vulnerability” or “abatement costs” (Becker, Poast & Haesebrouck, 2024). Analysis shows that burden-sharing of defense for NATO has complex and varied landscape, which does not allow to distinct allies between main spenders and, so called “free riders”. Member states are making clear strategic choices with its defense spending: either prioritization of long-term equipment modernization, operational readiness through O&M investment or either by fostering personnel (Becker et. al. 2022). Understanding these dynamics are crucial for assessing the true capabilities of Western bloc and NATO in particular.

Chapter 5. Methodological Framework

5.1. Target variable creation

Our methodology combines traditional econometric techniques with advanced machine learning methods to provide a comprehensive analysis of military spending effects on economic growth. A cornerstone of this approach is the careful classification of economic growth to enable nuanced analysis.

A crucial step in our analysis is the transformation of the continuous GDP per capita growth rates into discrete classes. Rather than relying on dataset-specific relative percentiles, which can shift with the sample period, we adopt an approach grounded in established economic growth literature. Recent work on growth regimes, notably by Michał Jerzmanowski (2006), demonstrates that economies transition between distinct states—stagnation, stable growth, crisis, and "miracle" catch-up—each characterized by its own long-run average growth rate. Jerzmanowski's Markov-switching analysis identifies four principal regimes with the following approximate steady-state growth rates:

- Stagnation: Long-run growth ≈ 0 percent per year.
- Stable Growth: Long-run growth ≈ 2 percent per year.
- Crisis: Characterized by large volatility around zero, but not used here for defining a distinct mean for classification boundaries due to its shock-driven nature.
- Miracle Growth: Long-run growth ≈ 6 percent per year.

By collapsing these empirically identified regimes into three broad classes and placing thresholds approximately midway between the distinct positive long-run growth means, we can define absolute cut-points for low, medium, and high growth that are more meaningful and consistent across different historical periods and economic contexts. Based on Jerzmanowski's findings for positive growth regimes, we establish two primary thresholds by averaging the long-run growth rates of adjacent positive growth regimes. The threshold between Stagnation (≈ 0%) and Stable Growth (≈ 2%) is (0% + 2%) / 2 = 1%. The threshold between Stable Growth (≈ 2%) and Miracle Growth (≈ 6%) is (2% + 6%) / 2 = 4%.

This derivation leads to the following absolute growth classifications:

- Low Growth: Annual GDP per capita growth ≤1%
- Medium Growth: 1% < Annual GDP per capita growth ≤ 4%
- High Growth: Annual GDP per capita growth > 4%

These thresholds are not arbitrary; they reflect meaningful economic transitions. Growth below 1% often signifies underperformance or stagnation, even by mid-twentieth-century developed economy standards. Growth exceeding 4% typically captures periods of exceptional catch-up, convergence, or economic "miracles." This classification approach, anchored in the empirically derived regime means from Jerzmanowski's work, allows us to identify different growth patterns and analyze the factors that differentiate between them with greater historical consistency and policy relevance than purely relative percentile-based methods.

5.2. Addressing Class Imbalance with SMOTE-ENN

A common challenge in classification problems is class imbalance, which occurs when the number of observations is not equally distributed among the outcome categories. This is a critical issue to address, as machine learning models trained on imbalanced data tend to become biased, favoring the majority class and performing poorly on the minority classes that are often of greater interest.

Our analysis confirms that our dataset exhibits a moderate class imbalance. Figure 6 provides a clear visualization of this distribution across our three defined economic growth regimes.

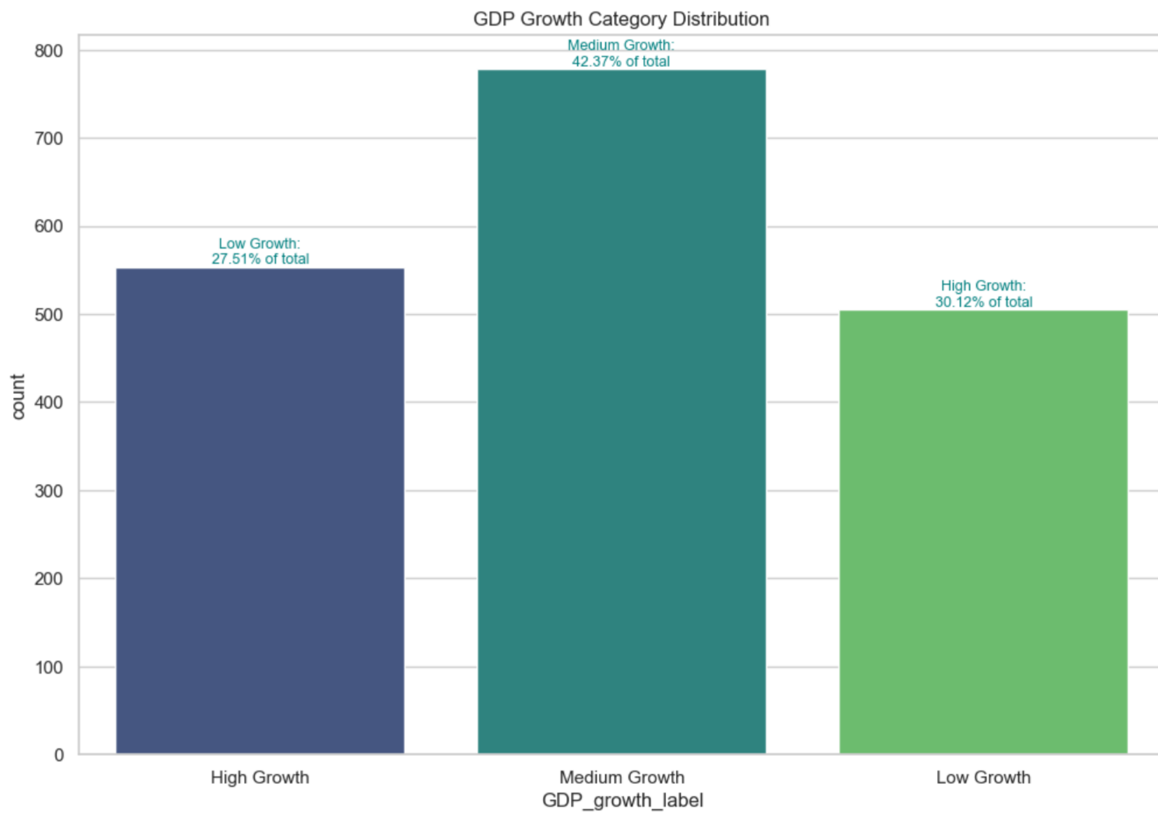

Figure 6: GDP Growth category distribution

The 'Medium Growth' category (1% < Growth ≤ 4%) forms the majority class, accounting for 42.37% of the total observations. In contrast, the 'High Growth' (> 4%) and 'Low Growth' (≤ 1%) categories represent minority classes, at 27.51% and 30.12% respectively. Without correction, a predictive model would see more examples of 'Medium Growth' and would likely achieve high accuracy simply by defaulting to this prediction, while failing to learn the distinct patterns that define high or low growth periods.

To rectify this and ensure our model is robust, we implement the Synthetic Minority Over-sampling Technique (SMOTE) combined with Edited Nearest Neighbors (ENN). This hybrid resampling method is a sophisticated solution that both creates new, synthetic data points for the 'High' and 'Low Growth' classes to balance the dataset, and simultaneously "cleans" the data by removing noisy observations that could confuse the model. As demonstrated in recent research, SMOTE-ENN can significantly enhance the performance of machine learning models in imbalanced datasets by generating new, synthetic instances while removing noisy data (Bounab et. al. 2024).

5.3. Traditional Econometric Approach: Logit Model

As a baseline and to maintain comparability with existing literature, we first employ a multinomial logit model to classify countries into different growth regimes. The logit model estimates the probability of a country experiencing a particular growth regime as a function of military spending and other control variables:

$$P(Y_i = j) = \frac{e^{B_j X_i}}{\sum_{k=1}^{3} e^{B_k X_i}}$$

where Y_i is the growth regime of country i , $X_i$is a vector of explanatory variables including military spending and controls, and B_j is a vector of coefficients for regime j.

This approach allows us to identify significant predictors of different growth regimes and estimate the marginal effects of military spending on the probability of experiencing high, medium, or low growth.

5.4. Advanced Machine Learning Approaches

To delve deeper into the potentially complex, nonlinear relationships and interaction effects inherent in the military spending-economic growth nexus—dynamics that might not be fully captured by the multinomial logit model—we complement our econometric analysis with several advanced machine learning approaches. These methods are chosen for their ability to learn intricate patterns from data without pre-specifying functional forms, aiming to improve both predictive accuracy and our understanding of the underlying mechanisms, as emphasized in general machine learning principles (e.g., Francois-Lavet et al., 2018, Ch. 2 & 7).

We first employ ensemble methods, which combine multiple learning algorithms to obtain better predictive performance than could be obtained from any of the constituent learning algorithms alone. Random Forests, a bagging technique, construct a multitude of decision trees during training and output the class that is the mode of the classes (classification) or mean prediction (regression) of the individual trees. Each tree in the forest is built on a bootstrap sample of the data, and at each node, only a random subset of features is considered for splitting. This process helps to reduce variance and overfitting, leading to improved generalization (Breiman, 2001). The algorithm proceeds by: 1. Creating multiple bootstrap samples from the original dataset. 2. For each sample, growing a decision tree, with feature selection for splits randomized at each node. 3. Aggregating the predictions of all trees (e.g., by majority vote for classification) to predict new data.

Furthermore, we implement Neural Networks, specifically deep learning approaches using multilayer perceptron (MLP) networks. Deep learning has shown significant promise in economic modeling due to its capacity to learn hierarchical representations and model highly complex, non-linear relationships directly from data (Tuncsiper, 2023; Purva et al., 2023; Francois-Lavet et al., 2018, Sec. 2.3). Our neural network architecture is designed to classify countries into the identified growth regimes and typically consists of: an input layer corresponding to our features (military spending, economic controls); one or more hidden layers with Rectified Linear Unit (ReLU) activation functions to introduce non-linearity and learn increasingly abstract feature representations; and an output layer with a softmax activation function to produce probabilities for each of the multi-class growth regimes. To enhance generalization and combat overfitting—a key concern in complex models (Francois-Lavet et al., 2018, Sec. 2.1)—we incorporate dropout layers to improve training stability and model robustness. As demonstrated in economic growth modeling for Turkey, such deep learning MLP networks can achieve high degrees of accuracy when properly configured (Tuncsiper, 2023).

Finally, recognizing that no single modeling paradigm is universally superior, and following emerging trends in economic modeling (Woloszyn & Bukowski, 2025), we also explore Hybrid Approaches, gaining crucial insights from both non-linear machine learning model and Generalized Linear Model (GLM). Such methods seek to combine the strengths of traditional econometric models (like our logit model, which offers interpretability, and a baseline grounded in economic theory) with the flexibility and predictive power of machine learning techniques. The development of artificial intelligence in economic modeling increasingly points toward such synergistic methods, aiming to achieve more robust and nuanced insights into complex phenomena like the interplay between defense expenditure and economic growth.

5.5. Model Evaluation and Selection

To ensure a robust and reliable assessment of our models, we employ a rigorous evaluation framework. This process begins with data splitting, where the full dataset is divided into a training set (comprising 70% of the data) and a testing set (the remaining 30%). Stratification is applied during this split to ensure that the class distributions of economic growth regimes (low, medium, high) are representatively maintained in both subsets, which is crucial for unbiased model training and evaluation.

Following the initial split, k-fold cross-validation is utilized exclusively on the training set. This technique is instrumental for two primary purposes: robust hyperparameter tuning and assessing model stability (Francois-Lavet et al., 2018, Sec. 9.2; AIST Guideline, Sec. 1.7.7). By systematically training and validating the models on different folds of the training data, we can identify optimal hyperparameter configurations—using either grid search or random search techniques—that yield the best generalization performance on unseen portions of the training data, thereby minimizing the risk of overfitting.

The performance of all models is then meticulously evaluated on the held-out testing set using multiple metrics to provide a comprehensive understanding of their predictive capabilities. These metrics include overall Accuracy (the proportion of correctly classified instances), as well as class-specific performance measures such as ROC-AUC and the F1-score to understand how well the model performs for each distinct economic growth regime. A Confusion Matrix is also generated to provide a detailed breakdown of correct and incorrect classifications, offering insights into specific error patterns. This aligns with the AIST guidelines' emphasis on ensuring model "correctness" (AIST Guideline, Sec. 1.7.6, 7.6).

Ultimately, the model selection process is guided by a combination of factors: the empirical predictive performance as indicated by the chosen metrics, the interpretability of the model's outputs, and its overall robustness and stability as assessed through the cross-validation and testing procedures.

Beyond simply evaluating predictive power, a key advantage of our combined econometric and machine learning approach is the ability to assess the importance and interpretability of different variables in determining economic growth regimes. To achieve a comprehensive understanding, we employ a trio of established techniques, moving from a model's internal metrics to more robust, model-agnostic evaluations.

The most direct method, provided by tree-based models like Random Forests, is the built-in feature importance. This score is typically calculated as the "mean decrease in impurity" (e.g., Gini impurity). In simple terms, features that are more effective at splitting the data into pure, homogeneous groups (e.g., cleanly separating "High Growth" from "Low Growth" countries) are given a higher importance score. While fast to compute, this method can be biased, sometimes inflating the importance of continuous or high-cardinality features.

To address this potential bias and provide a more reliable, performance-based measure, we also implement permutation importance. This technique is more intuitive and model-agnostic. It works by first measuring the model's performance on a dataset. Then, it randomly shuffles the values of a single feature and measures the performance again. The more the performance drops after shuffling, the more important that feature was to the model's predictions. This method directly links a feature's importance to its impact on predictive accuracy, making it a more robust indicator than the built-in score.

Finally, to achieve the deepest level of interpretability, we utilize SHAP (SHapley Additive exPlanations) Values. Grounded in game-theoretic principles, SHAP values provide consistent and locally accurate attributions for each feature's contribution to a specific prediction (Jabeur et. al. 2021). Unlike the other methods which only tell us *that* a feature is important, SHAP can tell us *how* a feature impacts the prediction (e.g., whether a high value for Capital formation pushes the prediction towards "High Growth" or "Low Growth"). This method has been successfully applied in fields like environmental economics for interpreting complex model findings, and we anticipate its utility in elucidating the drivers of economic growth regimes with unparalleled detail. By triangulating the results from these three distinct methods, our analysis gains significant robustness and confidence in its conclusions.

To further understand the marginal effect of individual variables on predicted outcomes, we use Partial Dependence Plots (PDPs). These plots visualize how the model's prediction for a specific growth regime changes as a particular variable's value is varied, while averaging over the effects of all other variables, thus isolating the variable's impact. Finally, we explicitly investigate Interaction Effects, particularly focusing on how the impact of military spending might be conditional upon other economic or institutional factors. This involves using specialized techniques suitable for machine learning models to identify and quantify significant interactions between variables, moving beyond the additive assumptions of simpler models

5.6. Methodological Advantages and Expected Contributions

Our methodological approach, which integrates traditional econometrics with advanced machine learning techniques, offers several important advantages for analyzing the intricate relationship between military spending and economic growth. A primary benefit is the capacity of machine learning to capture complex nonlinear relationships that may be overlooked by conventional linear models. As evidenced in recent research on forecasting country-specific GDP growth (Silva et al., 2024), machine learning models excel at identifying intricate patterns in economic data, potentially revealing nuances in the defense-growth nexus that traditional approaches might miss. This ability to model non-linearities is crucial, as the economic impact of defense spending is unlikely to be uniformly linear across all contexts and spending levels.

Furthermore, our data-driven methodology is well-suited for identifying potential threshold effects and regime-dependent relationships. We can explore whether there is specific "tipping points" at which the influence of military spending on economic growth shifts, perhaps from positive to negative or vice-versa. This aligns conceptually with findings from the Markov-switching approach to economic growth, such as Jerzmanowski (2006), which empirically demonstrated that economies transition between distinct growth regimes (e.g., stagnation, stable growth, miracle catch-up) with differing dynamics. Our models can potentially uncover how military spending interacts with these regimes or influences the probability of transitioning between them; an aspect significantly highlighted by Jerzmanowski (2006) concerning the role of institutional quality.This leads to another key advantage: the ability to systematically explore interaction effects. Our models allow for a multi-dimensional analysis of how the impact of military spending is contingent upon other critical factors such as human capital, technological readiness, and institutional quality. Given Jerzmanowski's (2006) findings that institutional quality, for instance, significantly affects how countries transition between growth regimes, and Akusta's (2024) further emphasis on this, understanding these interactions is paramount for a comprehensive analysis. Machine learning techniques are particularly adept at uncovering such conditional relationships without requiring them to be pre-specified.Beyond deeper explanatory insights, the employed machine learning models are expected to offer enhanced predictive power. This improved forecasting capability can be invaluable for policy simulation and for anticipating the economic consequences of different defense expenditure scenarios. Research in forecasting macroeconomic variables, such as that by Yang et al. (2024) for Chinese data, has often shown that machine learning models can produce lower forecast errors compared to traditional econometric approaches, leading to more reliable predictions of future economic trajectories under varying defense budget allocations.Ultimately, the nuanced understanding derived from this comprehensive methodological framework is expected to yield significant policy implications. By moving beyond simplistic linear assumptions and identifying how the economic effects of military spending vary across different contexts, growth regimes, and interaction with other national characteristics, our research aims to inform more targeted and effective policy recommendations. This can assist policymakers in developing more sophisticated strategies for balancing national security imperatives with broader economic growth objectives, potentially identifying optimal levels and compositions of defense spending conducive to sustainable development.

5.7. Conclusion

The methodological framework detailed in this study marks a deliberate and substantial departure from the singular, often linear approaches that have traditionally shaped research on the defense-growth nexus. Rather than claiming that a "data science approach" is inherently superior, this work argues for a synergistic integration of theoretically grounded econometrics, rigorous data preparation, and advanced machine learning techniques as essential for disentangling the complex relationship between military expenditure and economic performance. This integrated methodology is purposefully designed to address the limitations of earlier research and to produce insights that are not only more robust but also contextually aware and policy-relevant.

Central to this approach is the careful specification of models informed by established economic theory. In contrast to purely data-driven exercises, the selection of variables and the overall analytical framework draw directly from the conceptual foundations of the Augmented Solow Model, Endogenous Growth Theories, and Keynesian Demand Models. This ensures that machine learning models are applied within a coherent theoretical structure rather than in isolation, enabling the testing of complex, competing hypotheses. For example, the models can explore whether military spending generates ‘crowding-out’ effects by displacing productive investment, or whether it produces ‘spillover’ benefits through enhanced capital formation, technological development, or human capital accumulation.

Recognizing that the reliability of any model depends critically on the quality of its inputs, this study implements a meticulous data preparation process. Advanced imputation techniques, notably Multiple Imputation by Chained Equations (MICE), are employed to address the pervasive problem of non-random missing data, thereby preserving both the integrity and the statistical power of a unique multi-country, longitudinal dataset. The construction of the target variable also reflects a theoretically informed approach, drawing from Jerzmanowski’s (2006) work on growth regimes rather than relying on arbitrary statistical partitions. This classification into 'Low', 'Medium', and 'High' growth categories lends conceptual weight and relevance to the subsequent analysis. Furthermore, by applying SMOTE-ENN to address class imbalances, the methodology ensures that models are capable of accurately identifying and learning from minority classes, which are often of greatest importance for policy considerations.

To balance predictive power with interpretability, a hybrid modeling strategy is adopted. The multinomial logit model serves as a critical econometric benchmark, offering interpretable coefficients that remain comparable with those from conventional studies. Alongside this, more sophisticated machine learning methods, including ensemble approaches such as Random Forests and deep learning models like Neural Networks, are introduced for their superior ability to capture complex patterns and improve predictive accuracy. This dual strategy enables the identification of whether statistically significant relationships exist, while also providing a foundation for deeper analysis into why those relationships hold.

A defining feature of the methodology is its commitment to moving beyond prediction towards meaningful explanation. By integrating multiple interpretability techniques—ranging from built-in feature importance measures and model-agnostic permutation importance to the nuanced, game-theory-based SHAP values—the analysis systematically addresses the often-cited "black box" problem associated with machine learning. This multi-layered approach makes it possible to not only rank the most influential drivers of economic growth but also to visualize their marginal effects through Partial Dependence Plots. Critically, it reveals the interaction effects that characterize contemporary economic systems, enabling the exploration of questions such as whether the impact of military spending on growth varies according to a country's level of human capital or trade openness.

The overall objective of this comprehensive methodology is to foster a more nuanced understanding of the defense-growth relationship, one that moves beyond simplistic, one-size-fits-all conclusions. By identifying the non-linearities, thresholds, and contextual factors that shape the relationship between defense expenditure and economic performance, this research aims to offer policymakers a sophisticated, evidence-based toolkit. The intended contribution is to deliver targeted, actionable insights capable of helping NATO members and allied states navigate the delicate balance between maintaining national security and promoting sustainable economic prosperity in a geopolitically complex world.

Chapter 6. Predictive Modeling and Results

6.1. Model Performance and Selection

Following the data preprocessing, this phase of the analysis shifts to the core objective: empirically determining the most effective and robust model for classifying economic growth regimes. To achieve this, a comparative evaluation of three distinct modeling paradigms—a traditional Multinomial Logistic Regression, an ensemble-based Random Forest, and a deep learning Neural Network—was conducted. The evaluation was structured as a comprehensive, two-stage process.

First, a rigorous 5-fold stratified cross-validation was performed on the training data. This allowed for an unbiased assessment of each model's predictive power and stability, using key metrics like the Macro F1-Score and ROC AUC. The goal of this stage was to identify a single "champion" model that demonstrates the best overall performance.

Second, to ensure the findings were not model-dependent, a cross-model feature importance analysis was conducted. This involved comparing the feature importance scores (derived from coefficients, permutation, and SHAP values) generated by all three models during the cross-validation loop. This methodological triangulation serves to validate the robustness of the identified economic drivers, ensuring that the key conclusions are based on a consensus across different analytical approaches. This process is detailed below, beginning with the model selection, followed by the feature importance analysis.

6.1.1. Model Selection via Cross-Validation

To empirically determine the most effective modeling approach for classifying economic growth regimes, a rigorous 5-fold stratified cross-validation was performed. This process evaluated the performance and stability of three distinct models: a traditional Multinomial Logistic Regression (LOGREG), an ensemble-based Random Forest (RF), and a deep learning Neural Network (NN). The average performance across the five folds for each model is summarized in Table 3.

	Accuracy	**Macro F1-Score**	**Macro ROC AUC**
LOGREG	0.4720 ± 0.0336	0.4721 ± 0.0337	0.6575 ± 0.0201
RF	0.5089 ± 0.0191	0.5013 ± 0.0152	0.6786 ± 0.0142
NN	0.4945 ± 0.0457	0.4938 ± 0.0444	0.6746 ± 0.0290

Table 2: Summary table of cross-validation results

The results presented in Table 3 clearly indicate that the Random Forest model is the superior analytical tool for this research problem. It consistently outperformed the other models across all three key evaluation metrics. The Random Forest achieved the highest mean Macro F1-Score (0.5013), demonstrating the best balance of precision and recall for classifying the different growth categories. Similarly, its top-ranking Macro ROC AUC score (0.6786) signifies the strongest discriminative power, meaning it was most capable of correctly distinguishing between the low, medium, and high growth regimes.

Crucially, the Random Forest also exhibited the greatest stability, as evidenced by its consistently low standard deviation across all metrics (e.g., ±0.0152 for F1-Score). This low variance indicates a robust model that has learned generalizable patterns from the data, rather than overfitting to the noise of specific training splits. In contrast, while the Neural Network showed competitive performance, its significantly higher standard deviation (±0.0444 for F1-Score) suggests a more volatile and less reliable model.

The Multinomial Logistic Regression served as an important linear baseline. The fact that both non-linear models (Random Forest and Neural Network) substantially outperformed it confirms the initial hypothesis that the relationships between the predictor variables and economic growth are complex and non-linear, justifying the use of advanced machine learning techniques.

Given its superior predictive performance and demonstrated stability, the Random Forest model was selected as the final, definitive model for all subsequent in-depth analysis, including the calculation of final feature importances and the generation of Partial Dependence Plots.

6.1.2. Assessing Robustness Through Cross-Model Feature Importance

To assess the robustness of the identified growth drivers, a comparative analysis of feature importance was conducted across the three cross-validated models: Logistic Regression, Random Forest, and Neural Network (see Table 2). This comparison yields several critical insights into the underlying economic and political dynamics.

	Logistic Regression			**Random Forest**			**Neural Network**	
	Coef	**Perm**	**Shap**	**Builtin**	**Perm**	**Shap**	**Perm**	**Shap**
Population_growth	0.2002	0.0313	0.1442	0.1986	0.0621	0.0548	0.0589	0.2186
Military_spending	0.1240	0.0196	0.0409	0.1938	0.0516	0.0618	0.0161	0.0625

	Logistic Regression			Random Forest			Neural Network	
	Coef	**Perm**	**Shap**	**Builtin**	**Perm**	**Shap**	**Perm**	**Shap**
Educational attainment	0.1815	0.0498	0.1499	0.1917	0.0400	0.0502	0.0452	0.2890
Capital formation	0.2085	0.0428	0.1591	0.1850	0.0318	0.0518	0.0313	0.2590
Merchandise trade	0.1453	0.0390	0.1120	0.1780	0.0390	0.0379	0.0448	0.1978
Farleft	0.0786	0.0054	0.0227	0.0059	0.0024	0.0028	0.0080	0.0427
Farright	0.1766	0.0148	0.0758	0.0167	0.0086	0.0137	0.0120	0.0828
Moderateleft	0.0567	0.0186	0.0535	0.0149	-0.0003	0.0093	0.0273	0.0693
Moderateright	0.0408	-0.0012	0.0401	0.0154	0.0001	0.0091	0.0173	0.0996

Table 3: Feature Importance values across 3 models

The analysis reveals a striking and consistent pattern across all models: core economic and demographic variables overwhelmingly dominate as the most important predictors of growth. Capital formation, educational attainment, population growth, and merchandise trade consistently emerge as the top-tier factors driving outcomes. This is particularly evident in the most stable models, such as the Random Forest and Neural Network, where the SHAP values for these features are consistently higher than for all others. The Neural Network, in particular, assigns substantial importance to educational attainment (SHAP: 0.2890) and capital formation (SHAP: 0.2590), underscoring the critical roles of a skilled workforce and productive investment as foundational pillars of growth in its learned representation. The strong agreement across diverse model architectures provides compelling, data-driven support for the primacy of Neoclassical and Endogenous Growth theories.

While military spending — the primary variable of interest in this study — is consistently identified as a predictor, it occupies a position of moderate, secondary importance. In the Random Forest model, its SHAP value (0.0618) places it clearly below the core economic drivers but above the political variables. The Neural Network model corroborates this result (SHAP: 0.0625). This finding is crucial for the central research question: although military spending plays a meaningful role in the models' predictions, its influence is demonstrably smaller than that of fundamental economic health. This lends empirical support to a nuanced interpretation — defense spending is neither a guaranteed engine of growth nor a negligible cost, but rather a contributing factor whose effects depend on the broader economic environment.

Political ideology, in contrast, registers the lowest importance scores across nearly all methods and models. Variables representing ideological positions (Farleft, Farright, Moderateleft, Moderateright) consistently show minimal predictive value. In the robust Random Forest model, their SHAP values are an order of magnitude smaller than even military spending. While the Neural Network shows slightly higher sensitivity to these features, particularly to Moderateright (0.0996), their importance remains well below that of the top economic variables. This suggests that while the political context may shape the environment for certain policies, the direct, measurable impact of a government's ideological label on predicting growth regimes is limited compared to the tangible effects of investment, education, and trade.

The comparison of model behavior also yields methodological insights. Logistic Regression displays relatively high coefficient values for several features, yet its low permutation importance scores (all below 0.05, not shown in the table) confirm its overall weak predictive power. The Random Forest model offers a balanced view, while the Neural Network produces a spikier representation, assigning very high importance to a select few top features, likely reflecting its capacity to capture complex, non-linear relationships. Notably, the consistent feature hierarchy established by the more sophisticated Random Forest and Neural Network models enhances the credibility of these conclusions.

In sum, this cross-model analysis establishes a clear and robust hierarchy of influence. The primary drivers of economic growth are investments in capital and human resources. Military spending, while measurable in its effects, holds a secondary position, and the ideological orientation of the government functions more as an aesthetic feature than a decisive force. The metaphor is apt: economic growth travels on a road built by capital and education, with defense spending as a vehicle whose speed is constrained by the road's quality, and political ideology as the color of the car — a visible attribute, but not one that determines the journey's success.

6.2. Final Model Evaluation on Holdout Data

Having identified the Random Forest as the most robust and stable model through cross-validation in the previous section, the final step in the evaluation process is to assess its performance on a completely unseen holdout test set. This serves two critical purposes: first, to provide a final, unbiased measure of the model's predictive accuracy, and second, to conduct a definitive feature importance analysis to understand the key drivers of its predictions.

To this end, the final Random Forest model was retrained on the full, resampled training dataset before being applied to the 20% holdout data. This ensures the model learns from the maximum available information before its ultimate test.

The final model demonstrated strong and consistent performance on the holdout set, confirming its ability to generalize to new data. It achieved an Accuracy of 0.5136, a Macro F1-Score of 0.5099, and a Macro ROC AUC of 0.7144. These results are consistent with the cross-validation scores, providing a reliable foundation for the subsequent interpretability analysis.

6.2.1. Detailed Performance Analysis: The Confusion Matrix

While the aggregate performance metrics provide a valuable top-level summary, a deeper understanding of the model's behavior requires a more granular analysis of its classification decisions. The confusion matrix, presented in Figure 7, offers this detailed view by breaking down every prediction made on the holdout test set, revealing the model's specific strengths and weaknesses.

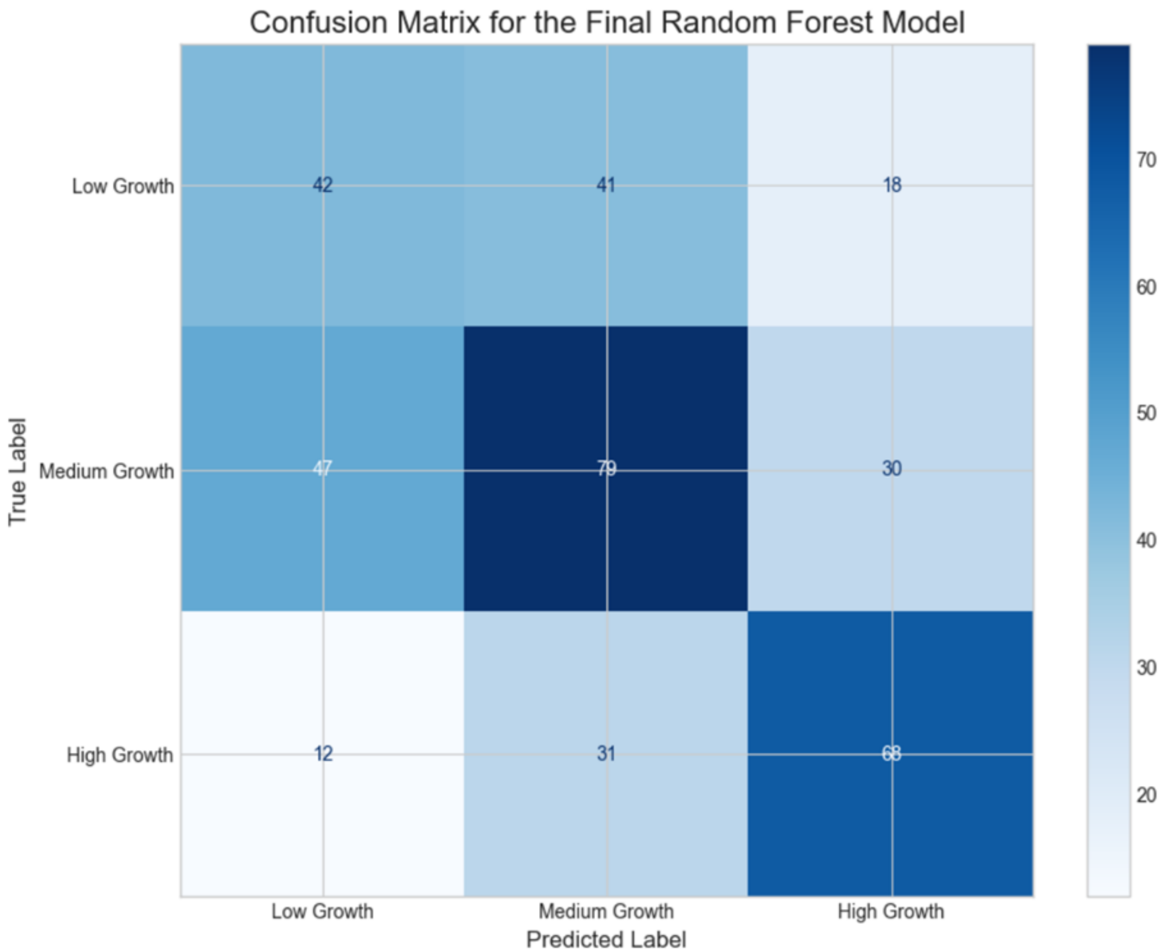

Figure 7: Confusion matrix for the final Random Forest model

The analysis of the confusion matrix reveals several important insights about the model's behavior and performance. First, the matrix shows that the model has successfully learned a meaningful signal from the data. This is evident from the strong diagonal dominance, with values of 42, 79, and 68 for the three growth categories, indicating that the model's most frequent prediction for each class is the correct one. As a result, its performance is notably better than a random baseline. Importantly, the model's mistakes are not arbitrary; it rarely makes extreme errors. For example, it only misclassified a "High Growth" country as "Low Growth" 12 times out of 111 cases. This pattern suggests the model has effectively internalized the ordinal nature of the growth categories, understanding the progression from Low to Medium to High.

The matrix also highlights varied performance across the different classes. The model is particularly effective at identifying "High Growth" economies, correctly classifying 61.3% of all actual high-growth cases. This indicates that the available features are relatively well-suited for capturing the dynamics behind rapid economic acceleration. In contrast, the model struggles most with identifying "Low Growth" economies, achieving a recall of only 41.6%. This disparity suggests that the transition from stagnation to modest, stable growth may be influenced by subtler, less easily captured factors.

A notable limitation of the model lies in its difficulty distinguishing between adjacent growth categories. The majority of its errors occur in predictions involving neighboring classes, as reflected in the substantial off-diagonal values between 'Low' and 'Medium' (41 and 47) and between 'Medium' and 'High' (30 and 31). This implies that while the model captures the general direction of economic growth, it often lacks the precision to reliably differentiate between cases that sit near the thresholds, such as economies growing at 0.8% versus those growing at 1.2%.

Additionally, the model exhibits a tendency to gravitate towards the central category, "Medium Growth," making it the most common prediction overall. This conservative drift toward the mean is typical for classifiers handling ordinal data under uncertainty. When the signals are ambiguous or insufficiently strong to support a confident prediction of an extreme outcome, the model defaults to the middle category. This behavior helps explain many of the errors involving adjacent classes.

In sum, the confusion matrix for the final Random Forest model offers valuable insights beyond what a single accuracy score could provide. It confirms that the model’s predictions are meaningfully better than random and that it has successfully learned the ordinal structure of economic growth, avoiding extreme misclassifications. Its main shortcoming lies in differentiating between adjacent growth categories, especially in definitively identifying 'Low Growth' economies. This underscores the model’s primary utility as an explanatory tool for understanding the underlying drivers of economic growth, rather than as a highly precise forecasting mechanism.

6.3. Definitive Feature Importance Analysis

While the cross-model comparison provided a general consensus, we now turn to our best-performing final Random Forest model for a precise and definitive interpretation. This "deep dive," using multiple importance metrics on completely unseen data, provides the final hierarchy of factors driving economic growth regimes. The results are summarized in Figure 8.

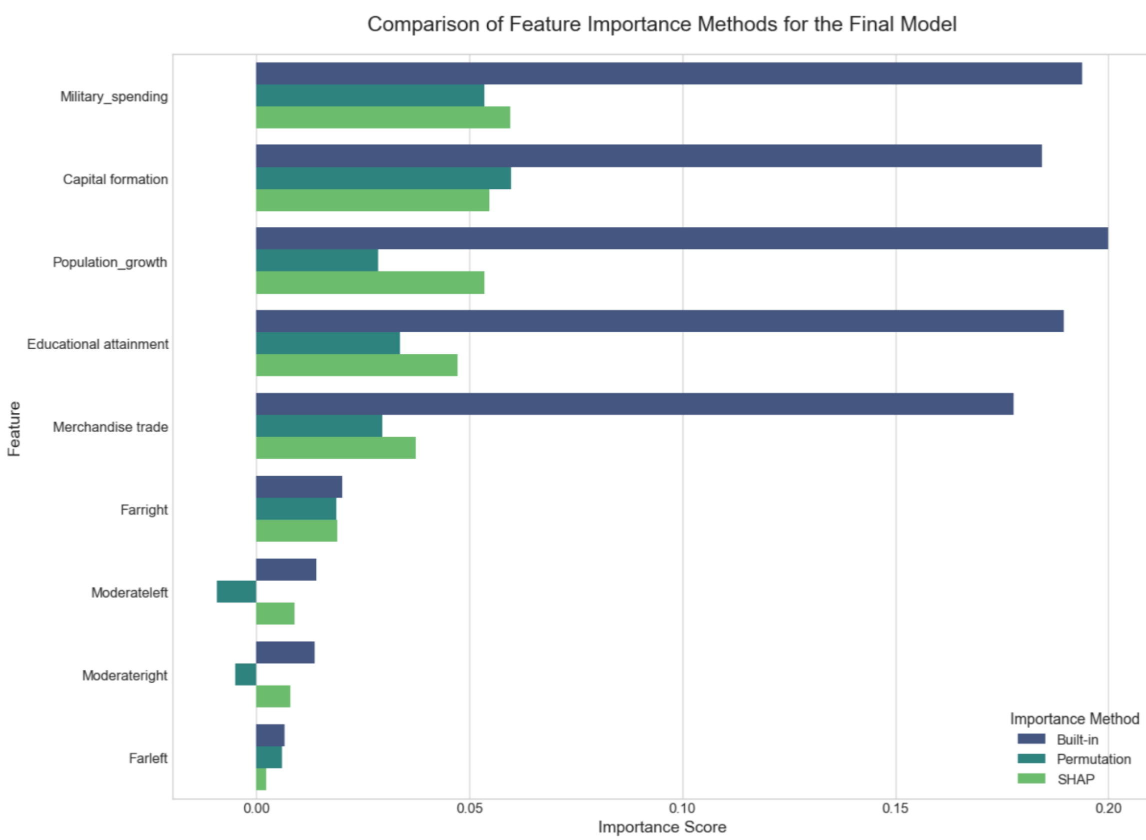

Figure 8: Final Feature Importance Summary

The final analysis reveals a top tier of five critical predictors that far outweigh the others in influence. According to the most robust metrics (Permutation and SHAP), Capital

Formation and Military Spending are the most influential features. The SHAP analysis places Military Spending at the top (SHAP value: 0.0596), while Permutation Importance, which directly measures the impact on model performance, ranks Capital Formation as number one (Permutation Importance: 0.0598). This confirms that both variables are of primary importance.

Closely following this leading pair are Population Growth, Educational Attainment, and Merchandise Trade. These five variables form a distinct group of core economic drivers. The magnitude of their importance is significant; for example, the SHAP value for Military Spending is more than three times larger than that of the most important political variable, Farright (0.0191).

A clear and significant drop-off in importance occurs after these top five economic variables. The political ideology features consistently register the lowest scores. This finding, now confirmed on holdout data, provides definitive evidence that in this model's framework, fundamental economic activities are far more predictive of growth regimes than a government's ideological label.

Notably, while the "Built-in" importance metric (based on Gini impurity) assigns high and relatively similar scores to all top five economic features, the more reliable performance-based metrics—Permutation and SHAP—provide a more nuanced and credible ranking, clearly distinguishing the primary drivers from the secondary ones.

In conclusion, the final evaluation on holdout data not only validates the Random Forest model's predictive power but also provides a definitive hierarchy of influence. The results cement the conclusion that a country's economic destiny, as predicted by this model, is overwhelmingly shaped by its investment in physical and human capital, its demographic trends, and its level of defense expenditure. This quantitative ranking sets the stage for the final step of our analysis: a qualitative exploration of how these key features influence growth, which will be examined through the use of Partial Dependence Plots.

6.4. Understanding the Relationships: Partial Dependence Plots

Having established the key predictors of economic growth regimes in the previous section, we now turn to visualizing how these variables influence the model's predictions. To achieve this, we utilize Partial Dependence Plots (PDPs). A PDP illustrates the marginal effect of a single feature on the predicted outcome of the machine learning model, while averaging out the effects of all other features in the model. This technique allows us to isolate and understand the relationship between a variable of interest and the probability of a country entering a specific growth regime.

6.4.1. The Central Variable: Military Spending and its Impact on All Growth Regimes

Given that military spending is the central variable of this thesis, its effect was analyzed for all three growth categories to understand the full spectrum of its predicted impact. The relationship, as shown in Figure 9, is notably non-linear and differs significantly across the growth regimes, revealing both the costs of defense expenditure and the conditions under which positive economic spillovers may occur.

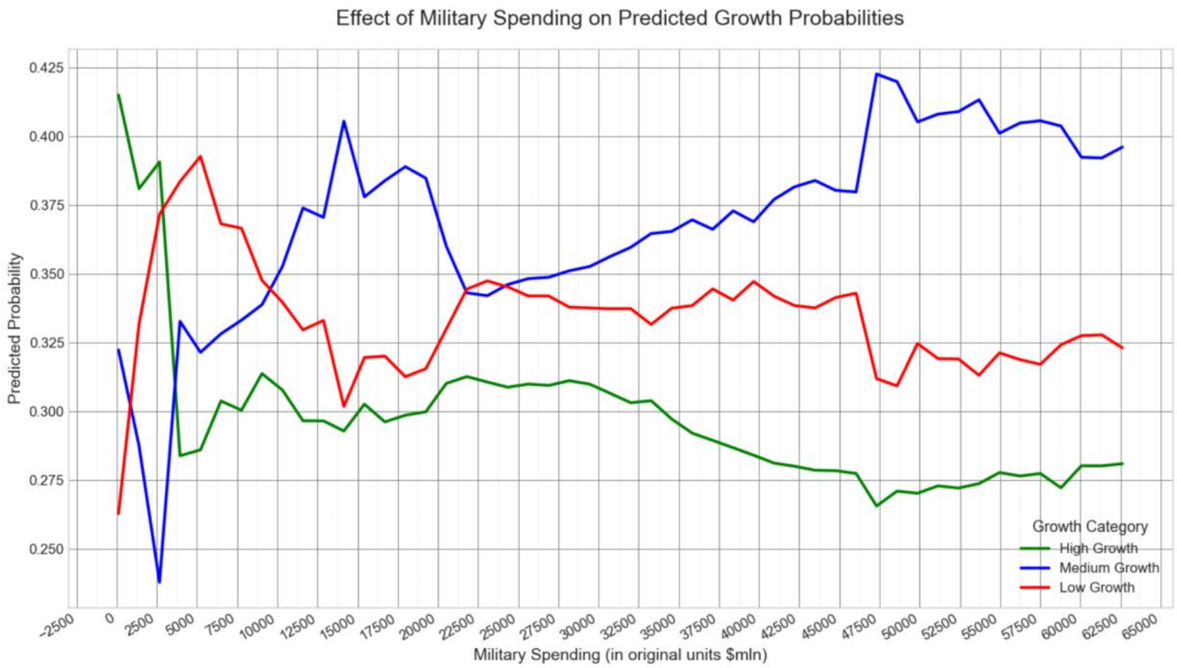

Figure 9: Effect of Military Spending on Predicted Growth Probabilities

The model suggests that initial increases in military spending significantly reduce a country's chances of achieving high growth. As spending rises from zero to approximately $4 billion, the probability of entering a high-growth regime drops sharply from 0.41 to 0.28. Beyond this point, the relationship becomes less clear, with a modest recovery followed by another decline at very high spending levels, particularly above $30 billion.

At the same time, the likelihood of falling into a low-growth regime increases steeply with initial increases in military expenditure. However, this trend reverses as spending moves from approximately $5 billion to $15 billion, where the probability of low growth actually decreases. This is a crucial finding, suggesting that moving from a very low to a moderate level of defense spending may provide enough economic stimulus or security to help an economy avoid a low-growth trap.

The association with medium-growth outcomes provides the clearest evidence of potential positive effects. Following an initial sharp decline, the probability of being in a medium-growth category begins to rise substantially, peaking when military spending reaches approximately $15 billion. This suggests the model has identified a "sweet spot" where defense expenditure, perhaps through a combination of demand stimulus and industrial base effects, is most conducive to sustaining stable, medium-paced economic growth.

Overall, the model captures a complex dynamic. While initial increases in spending appear to be a drag on high-growth potential, moderate levels of expenditure are associated with two positive outcomes: a reduced risk of economic stagnation and a higher probability of achieving stable, medium growth. This indicates that positive spillovers, while perhaps not strong enough to catalyze a high-growth "miracle," are a measurable factor at certain levels of investment.

6.4.2. The Economic Engine: Capital Formation

The model's interpretation of Capital Formation aligns perfectly with its high ranking in the feature importance analysis. As shown in Figure 10, the model reveals a strong, positive, and largely monotonic relationship between investment and the probability of high growth.

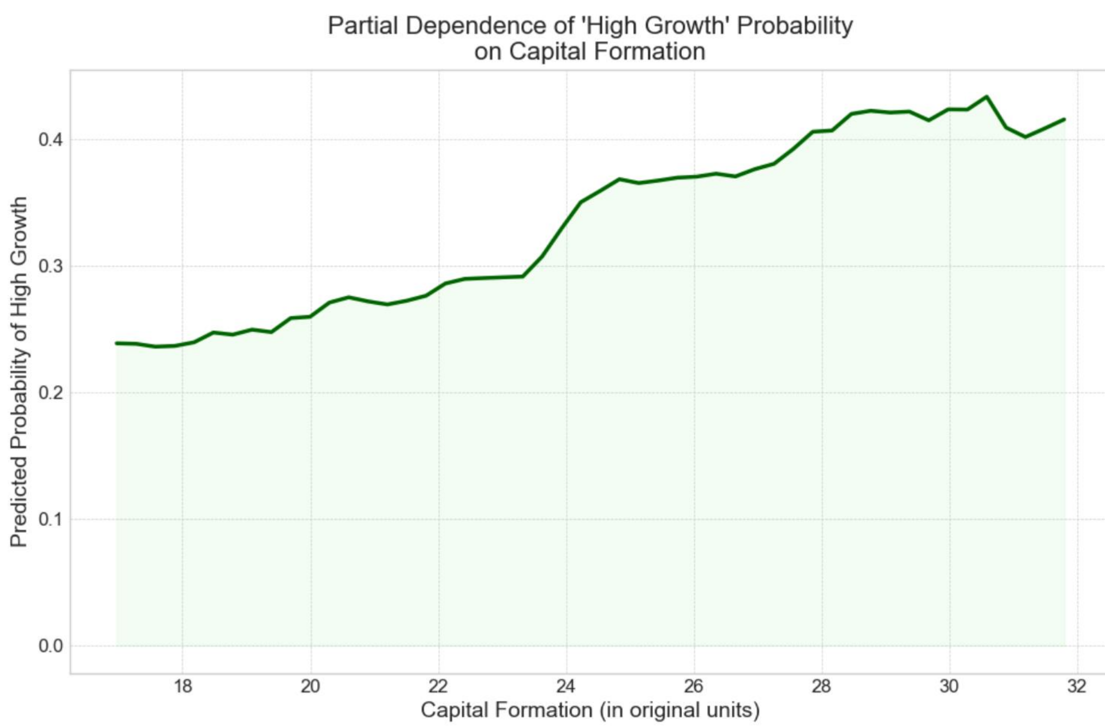

Figure 10: PDP of High Growth probability on Capital Formation (% of GDP)

As the share of GDP dedicated to capital formation increases from 23% to 31%, the predicted probability of a country entering a high-growth regime nearly doubles, rising from 0.25 to a peak of 0.45. This finding underscores that the model considers sustained investment in productive capacity to be a primary driver of strong economic performance.

6.4.3. The Role of Human Capital: Educational Attainment

The relationship between educational attainment and growth regimes is complex, as shown in Figure 11. Contrary to a simple linear expectation, higher levels of education are not always associated with a higher probability of high growth.

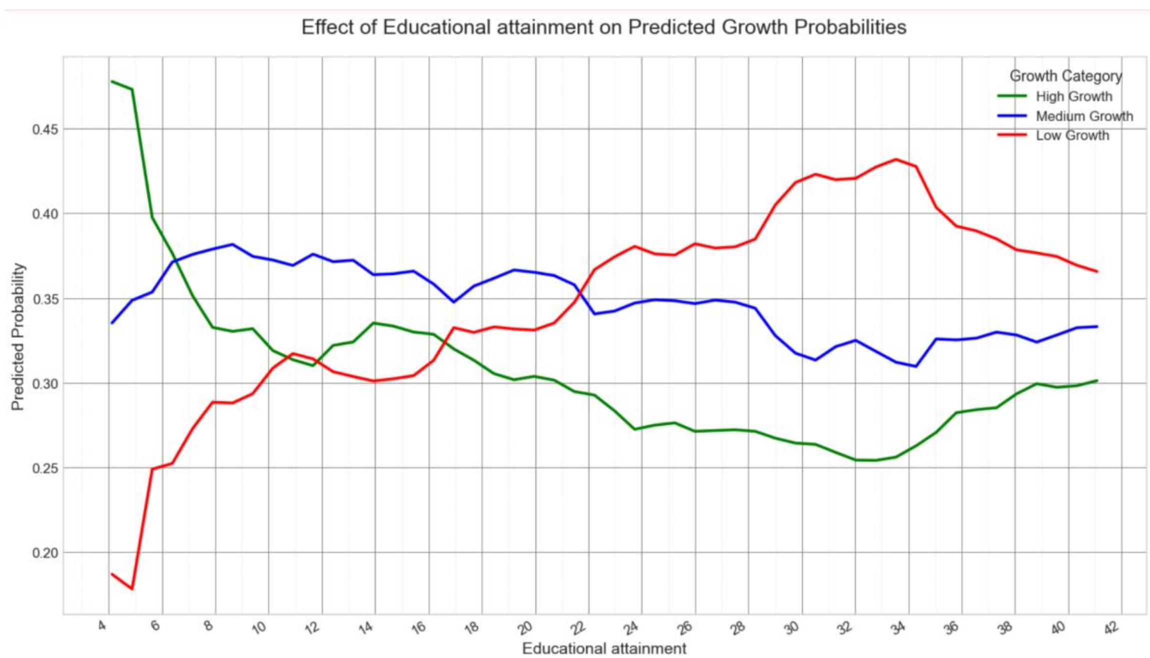

Figure 11: Effect of Educational attainment on Predicted Growth Probabilities

The probability of "High Growth" is highest at the lowest levels of educational attainment, dropping sharply from 0.47 to 0.33 as the attainment rate increases from 4% to 8%. Conversely, the probability of "Low Growth" trends upwards as education levels increase. The probability of "Medium Growth" remains relatively stable across all education levels. This counter-intuitive finding suggests the model is likely capturing the "low-base effect," where countries with lower initial human capital have greater potential for rapid catch-up growth.

6.4.4. Demographic and External Factors: Population Growth and Trade

The model identified both population dynamics and trade openness as important secondary predictors.

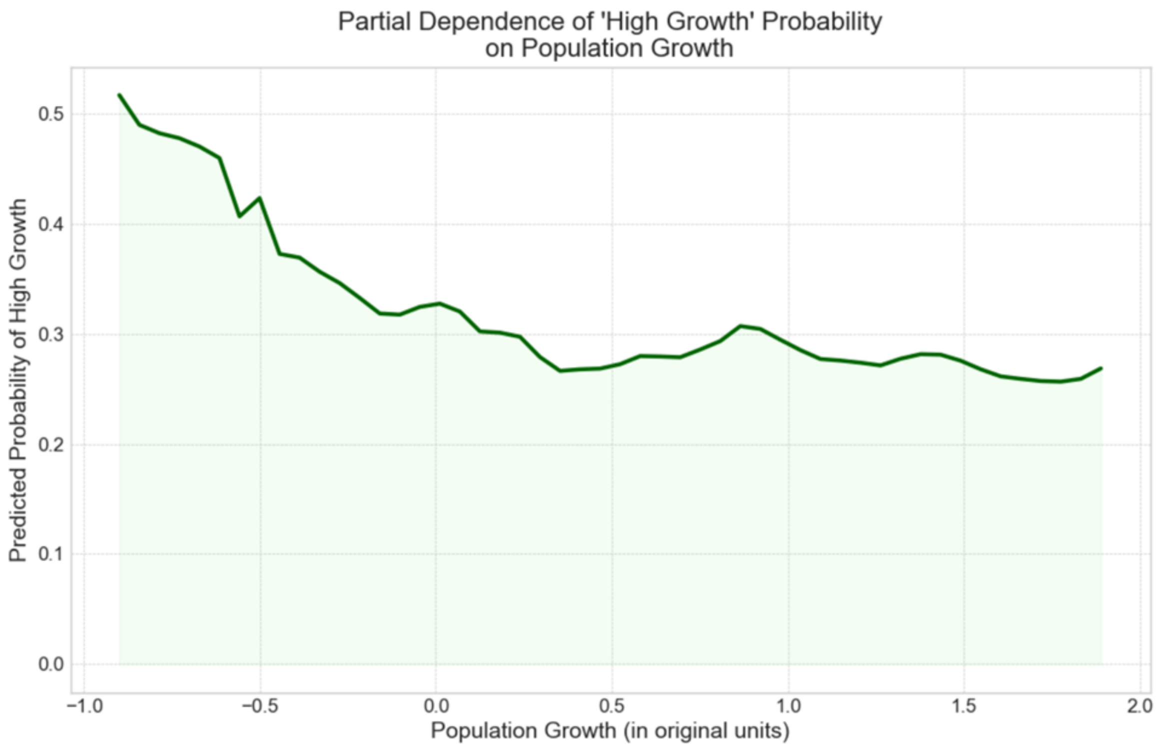

Figure 12: PDP of High Growth probability on Population growth.

The PDP in Figure 12 shows a clear and consistent negative relationship between population growth and the probability of achieving a high-growth regime. As population growth increases from -0.8% to 1.8%, the probability of high growth is more than halved, falling from 0.5 to approximately 0.28.

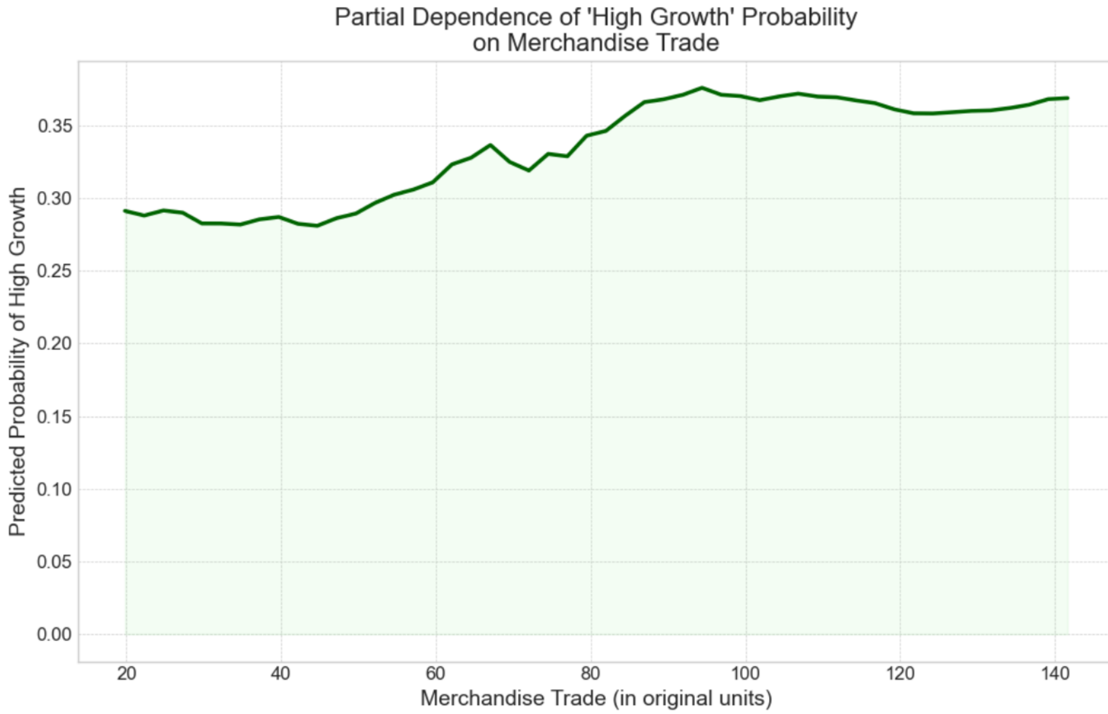

Figure 13: PDP of High Growth probability on Merchandise trade (% of GDP).

As seen in Figure 13, trade openness has a modest but positive effect. As trade as a percentage of GDP increases, the probability of high growth gently rises from 0.29 to a plateau of around 0.38, indicating that greater integration into the global economy is associated with better growth prospects.

6.4.5. The Influence of Political Ideology: The Far-Right Variable

To explore the influence of the political context, we now turn to the most significant of the ideology variables as identified in the feature importance analysis: the Farright dummy variable.

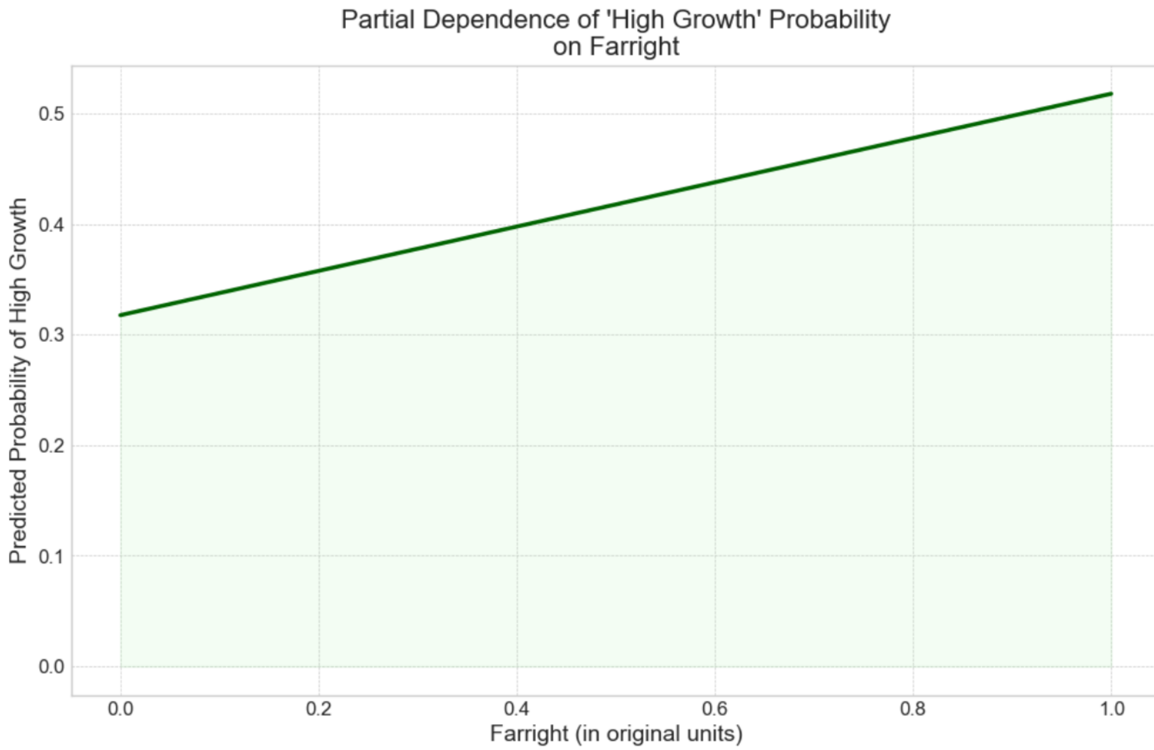

Figure 14: PDP of High Growth probability on 'Farright 'ideology variable

Unlike the continuous variables analyzed previously, this plot compares the model's average prediction across two discrete states: when a far-right government is not in power (value 0) and when it is (value 1).

The model reveals a notable positive association. The predicted probability of a country entering a "High Growth" regime is approximately 0.3 when a far-right government is not in power. This probability increases significantly to around 0.5 when a far-right government is in power.

This result does not imply causation but indicates that, within the patterns learned by the model from the historical data, the presence of a far-right government is a condition more frequently associated with high-growth periods than its absence. This intriguing finding will be explored further in the context of economic and political theory in the subsequent discussion chapter.

6.4.6. The Interaction Effect: Military Spending in the Context of Education

To move beyond individual variable effects, a 2-Way PDP was generated to explore the interaction between Military Spending and Educational Attainment. This plot, shown in Figure 15, offers a much deeper and more nuanced understanding of the model's logic, specifically highlighting how a country's human capital can mediate the economic impact of its defense spending.

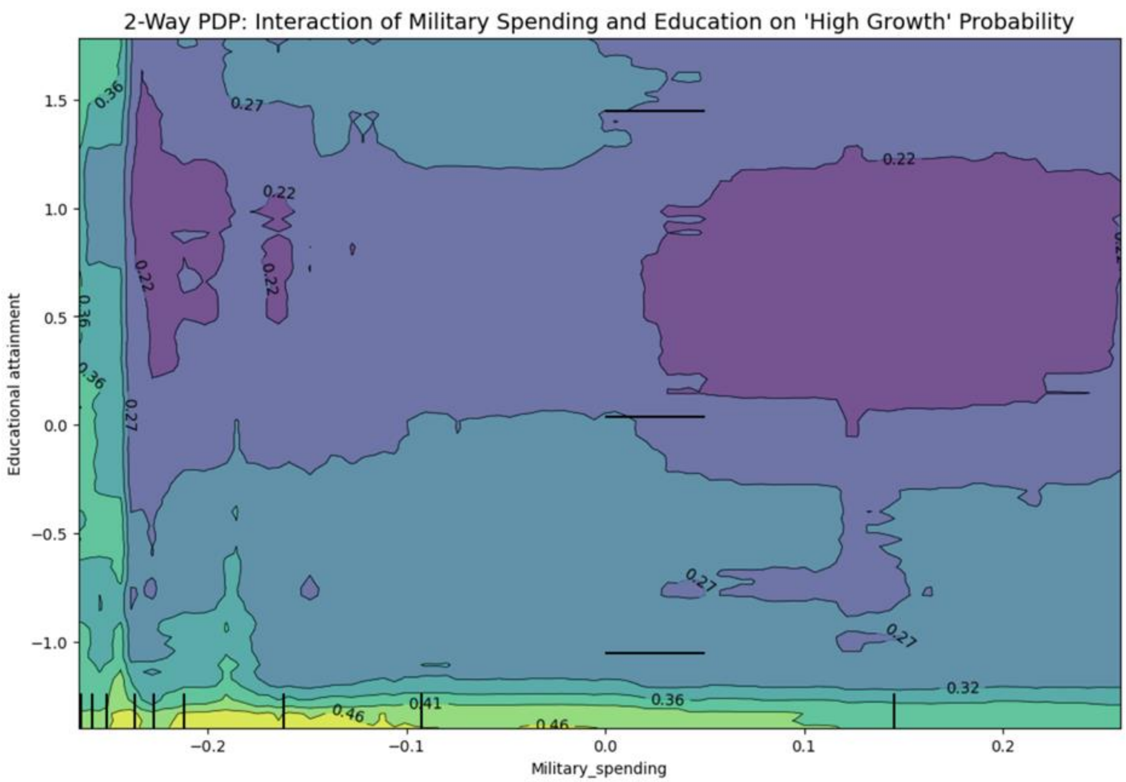

Figure 15: 2-Way PDP Interaction of Military spending and Educational attainment on High Growth probability.

This interaction plot reveals several critical findings. The model predicts the highest probability of being in a "High Growth" category (the bright yellow areas) for countries that have both low military spending and low educational attainment. This strongly suggests the model captures a specific economic scenario: developing countries that are not burdened by heavy defense expenditure are most likely to experience rapid catch-up growth from a low economic base.

There is also the universal negative impact of initial spending increase. The plot clearly shows that regardless of a country's level of educational attainment (moving from left to right along any horizontal line), the initial effect of increasing military spending is a sharp decrease in the probability of high growth (the color shifts from yellow to green/blue). This reinforces the finding from the 1-way PDP that initial defense outlays are seen by the model as a significant hindrance to high-growth prospects.

While the overall effect of increased spending is negative, the plot's true insight lies in the changing relationship. For countries with low educational attainment (bottom of the plot), the negative impact of military spending is severe and sustained. However, for countries with high educational attainment (top of the plot), the negative slope is noticeably less steep. This suggests that a highly educated workforce mitigates the negative economic consequences of defense spending. A more educated population may be better equipped to absorb technological spillovers from the defense sector, translate military R&D into civilian innovation, and fill the high-skill jobs created by the defense industry. In this way, human capital acts as a crucial enabling factor, allowing an economy to realize positive spillovers that would otherwise be lost.

In conclusion, these Partial Dependence Plots transform the abstract feature importance scores into a clear, visual narrative of the model's logic. They reveal that the path to a "High Growth" regime is not driven by a single factor, but by a complex interplay of conditions. The model identifies a powerful "catch-up" dynamic, where the highest probability of high growth is found in developing nations with low initial Educational Attainment and a minimal Military Spending burden. For more developed economies, sustained Capital Formation is a clear positive driver. Crucially, the plots demonstrate that increasing military spending consistently appears as a drag on the probability of achieving high growth, an effect that is most pronounced at initial levels of expenditure. This detailed, visual evidence provides the foundation for the theoretical discussion that will follow.

6.5. Complementary Econometric Analysis

To complement the machine learning analysis and assess the statistical significance of each predictor from a classical econometric standpoint, a Multinomial Logistic Regression model was fitted to the same reduced dataset. This approach allows us to quantify how each variable affects the odds of a country experiencing a "Medium" or "High" growth regime relative to a baseline of "Low" growth. This provides a different, yet complementary, layer of insight to the predictive focus of the Random Forest.

The model was fitted with the "Low Growth" category (0) serving as the reference level. The resulting coefficients therefore represent the change in log-odds for a country being in the "Medium" or "High" growth categories relative to this baseline. The overall model fit, while modest with a Pseudo R-squared of 0.078, is highly significant, with a Log-Likelihood Ratio p-value of 2.41e-56, confirming that the included variables collectively provide significant explanatory power.

6.5.1. Drivers of Medium Growth vs. Low Growth

The first part of the analysis examines the factors that increase the likelihood of a country achieving a stable, medium-growth outcome instead of remaining in a low-growth state. The results are summarized in the Table 5.

```
--- Statsmodels Multinomial Logit Summary ---
                          MNLogit Regression Results
==============================================================================
Dep. Variable:        GDP_growth_cat   No. Observations:                 1836
Model:                       MNLogit   Df Residuals:                     1818
Method:                          MLE   Df Model:                           16
Date:               Fri, 11 Jul 2025   Pseudo R-squ.:                 0.07809
Time:                       00:40:18   Log-Likelihood:                -1828.6
converged:                      True   LL-Null:                       -1983.4
Covariance Type:           nonrobust   LLR p-value:                 2.410e-56
==========================================================================================
      GDP_growth_cat=1       coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------------
const                      0.4658      0.062      7.557      0.000       0.345       0.587
Population_growth          0.0407      0.066      0.614      0.539      -0.089       0.170
Military_spending          0.2320      0.062      3.727      0.000       0.110       0.354
Educational attainment    -0.2867      0.062     -4.589      0.000      -0.409      -0.164
Capital formation          0.1671      0.063      2.646      0.008       0.043       0.291
Merchandise trade          0.1962      0.071      2.753      0.006       0.057       0.336
Farleft                   -0.1979        nan        nan        nan         nan         nan
Farright                  -0.1985        nan        nan        nan         nan         nan
Moderateleft               0.1141        nan        nan        nan         nan         nan
Moderateright              0.0264        nan        nan        nan         nan         nan
------------------------------------------------------------------------------------------
      GDP_growth_cat=2       coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------------------
const                      0.0080      0.069      0.115      0.908      -0.128       0.144
Population_growth         -0.3959      0.075     -5.270      0.000      -0.543      -0.249
Military_spending          0.0597      0.115      0.518      0.604      -0.166       0.285
Educational attainment    -0.5372      0.079     -6.771      0.000      -0.693      -0.382
Capital formation          0.5052      0.070      7.222      0.000       0.368       0.642
Merchandise trade          0.3734      0.078      4.795      0.000       0.221       0.526
Farleft                   -0.1916   6.85e+05    -2.8e-07      1.000   -1.34e+06    1.34e+06
Farright                   0.2892   1.07e+06    2.69e-07      1.000   -2.11e+06    2.11e+06
Moderateleft           -7.45e-05   2.47e+06   -3.02e-11      1.000   -4.83e+06    4.83e+06
Moderateright             -0.0702   2.56e+06   -2.74e-08      1.000   -5.01e+06    5.01e+06
==========================================================================================
```

Table 4: Multinomial logistic regression summary

The analysis reveals several important findings. Notably, military spending emerges as a distinctive factor in this model. A one-unit increase in military expenditure significantly raises the log-odds of a country falling into the "Medium Growth" category relative to "Low Growth" ($p < 0.001$). This indicates that while military spending may not directly drive high economic growth, it appears to play a meaningful role in helping economies transition from stagnation to more stable, moderate growth.

Consistent with expectations, both capital formation and merchandise trade are positive and statistically significant predictors. Greater investment and deeper participation in global trade improve the likelihood of a country moving from low to medium growth, reinforcing the importance of core economic fundamentals.

An intriguing and somewhat counter-intuitive result concerns educational attainment. The analysis finds a significant negative relationship between higher levels of education and the odds of being in the medium-growth category compared to low growth. This likely reflects a "low-base effect," as suggested by the partial dependence plots, where countries starting with lower levels of human capital experience faster, catch-up growth that enables them to escape stagnation more readily than those already further along in educational development.

6.5.2. Drivers of High Growth vs. Low Growth

The second part of a summary compares the "High Growth" regime to the "Low Growth" baseline, identifying the factors associated with economic acceleration.

The comparison reveals several important insights. Military Spending does not emerge as a statistically significant predictor ($p = 0.604$) for distinguishing between "High Growth" and "Low Growth" outcomes. This is a notable contrast to earlier findings where Military Spending appeared to help economies escape stagnation. Here, however, it lacks the statistical power to propel an economy into a sustained high-growth phase.

In contrast, Capital Formation stands out as the strongest positive predictor, with a large and highly significant coefficient. This result confirms, with considerable robustness, that high levels of investment are essential for achieving high growth.

Additionally, Population Growth now appears as a significant negative predictor. This suggests that rapid increases in population may dilute per-capita economic gains, making it less likely for an economy to transition into a high-growth phase.

6.5.3. A Note on Political Ideology Variables

The statistical output for the political ideology variables (Farleft, Farright, etc.) shows nan (Not a Number) for their standard errors and p-values. This is not an error, but a result of perfect multicollinearity. Because these four variables are dummy indicators that are mutually exclusive and exhaustive (a country must fall into one and only one category), one variable can be perfectly predicted by the other three. The model cannot estimate their individual effects independently. While this prevents a direct interpretation of their statistical significance from this model, it does not invalidate the coefficients or significance tests of the other variables.

6.5.4. Synthesis of Econometric Findings

The multinomial logistic regression provides a nuanced and statistically grounded perspective that complements the machine learning analysis. It confirms that core economic fundamentals like Capital Formation and Merchandise Trade are robust and significant drivers of positive economic outcomes.

Most importantly, it offers a specific, interpretable role for Military Spending. The analysis strongly suggests that defense expenditure is not a catalyst for "High Growth" miracles. Instead, its statistically significant impact is found in the transition from low to medium growth. This finding provides an empirical basis for a more sophisticated view: defense spending may act as a stabilizing force or a demand-side stimulus that helps lift economies out of stagnation, even if it lacks the power to unlock top-tier economic performance

Chapter 7. Discussion: Interpreting the Drivers of Economic Growth Regimes

Having established the empirical results and predictive performance of the models in the preceding chapter, this chapter now turns to the crucial task of interpretation. The goal is to move beyond the statistical outputs and to deconstruct the findings, placing them within the broader academic discourse surrounding the defense-growth nexus. Where Chapter 5 answered what the most important predictors are, this chapter seeks to explain why they are important and how they influence economic outcomes.

By synthesizing empirical evidence from our machine learning models with the established economic theories outlined in the literature review—from Neoclassical and Keynesian perspectives to Endogenous Growth and political economy frameworks—this discussion aims to address the central controversies in the field. We will explore the non-linear and conditional relationships revealed by the Partial Dependence Plots to offer a nuanced, data-driven perspective on the complex interplay between military spending, economic fundamentals, and political context. This chapter will first recapitulate the key empirical findings to set the stage, then delve into a detailed analysis of the primary growth drivers, culminating in a synthesized understanding of the modern "guns vs. butter" debate.

7.1. Recapitulation of Key Findings

Before delving into a theoretical interpretation, it is essential to first summarize the core empirical conclusions derived from our comparative modeling process. This process was designed not only to find the most accurate model but also to ensure the robustness of the findings regarding which factors are most influential in determining a country's economic growth regime.

The first key outcome was the selection of a definitive model for analysis. The rigorous 5-fold cross-validation process demonstrated that the Random Forest model was the superior analytical tool, achieving the highest mean performance across all key metrics, including a Macro F1-Score of 0.5013 and a Macro ROC AUC of 0.6786. Crucially, it also exhibited the lowest variance in its performance, indicating a stable and generalizable model that has learned true underlying patterns rather than noise in the training data.

The second, and most central, finding comes from the feature importance analysis. Across all three tested models (Random Forest, Neural Network, and Logistic Regression), a clear and consistent hierarchy of influence emerged. The analysis revealed that core economic and demographic variables—specifically Capital Formation, Educational Attainment, Population Growth, and Military Spending—are the dominant predictors of whether a country will experience a low, medium, or high growth outcome. This consensus across different model architectures provides strong evidence for the primacy of these fundamental factors.

A significant secondary finding was the limited direct predictive power of political ideology. In a striking contrast to the economic variables, the categorical features representing the government's position on the political spectrum consistently registered the lowest importance scores across all models and all importance metrics (SHAP, Permutation, and Built-in).

These findings provide a clear hierarchy of influence, but the relationships themselves, particularly for military spending, are complex and non-linear. The following sections will deconstruct these relationships, connecting our empirical results back to the established theoretical debates.

7.2. The Foundational Pillars of Growth: Validating Economic Orthodoxy

Before delving into the central variable of military spending, it is crucial to analyze the other top-tier predictors identified by the Random Forest model. These variables, representing core economic fundamentals, provide the essential context in which defense spending operates and serve to validate our model against established economic theory. The model's independent discovery of these relationships underscores its ability to learn and represent sound economic principles.

The model's interpretation of Capital Formation serves as a powerful validation of its economic coherence. The Partial Dependence Plot (Figure 9) reveals a strong, positive, and almost monotonic relationship between the rate of investment and the probability of achieving high growth. As the share of GDP dedicated to capital formation increases from 23% to a peak of 31%, the predicted probability of a country entering a high-growth regime nearly doubles. This finding provides robust, data-driven support for the central tenet of the Neoclassical and Augmented Solow growth models discussed in our literature review (Section 1.1.1). The model has independently learned that sustained investment in productive capacity—the very essence of capital accumulation—is a foundational prerequisite for an economy to transition into a high-growth regime.

In contrast to the straightforward interpretation of capital formation, the relationship between Educational Attainment and high growth is more complex and seemingly paradoxical. As shown in the Partial Dependence Plot (Figure 10), the model associates the highest probability of a "High Growth" outcome with the lowest levels of educational attainment.

This counter-intuitive result should not be interpreted as evidence that education is detrimental to growth. Instead, it strongly suggests the model has captured a distinct and powerful economic phenomenon: the "low-base" or "convergence" effect. The model identifies a regime characteristic of developing nations where economies with the lowest initial levels of human capital have the greatest potential for rapid, "catch-up" growth. For these countries, even marginal improvements in education and technology can yield massive percentage gains in productivity, catapulting them into a high-growth phase. This aligns with the principles of Endogenous Growth theory (Section 1.1.2), which emphasizes the role of human capital and knowledge. While the theory posits that high human capital sustains long-run innovation in developed economies, our model reveals the other side of the coin: the explosive growth potential unlocked when human capital begins to accumulate from a very low starting point. The Random Forest model, by not being constrained to linear assumptions, has successfully identified this non-linear, regime-dependent reality often missed by traditional econometric models.

Finally, the model identifies both demographic and external factors as important secondary predictors. The clear negative relationship between Population Growth and the probability of a high-growth regime (Figure 11) points towards a "demographic drag" on per-capita prosperity. The model suggests that in periods of rapid population expansion, gains in total economic output are often diluted, making it more challenging to achieve the high rates of per-capita growth that define our top category. Conversely, Merchandise Trade shows a modest but consistently positive relationship with high growth (Figure 12), lending support to theories of trade-led growth and indicating that greater integration into the global economy is associated with improved prospects for strong economic performance.

7.3. Deconstructing the "Guns vs. Butter" Debate: A Data-Driven Synthesis

The central "guns vs. butter" debate, which pits the potential for defense spending to act as an economic stimulus against its risk of diverting essential resources, lies at the heart of this research. Rather than providing a simple verdict in favor of one paradigm, our multi-model analysis offers a more nuanced, data-driven synthesis. The findings suggest that the economic impact of military spending is not uniform; instead, it is highly conditional, varying significantly depending on a country's initial economic state and its underlying structural capacity.

Our analysis begins not with the pursuit of high growth, but with the challenge of overcoming economic stagnation. A unique insight from the Multinomial Logistic Regression model (Chapter 5.5) revealed that while military spending was not a statistically significant predictor of achieving *high* growth, it was a highly significant positive predictor ($p < 0.001$) for moving a country from a "Low Growth" to a "Medium Growth" regime. This suggests that moderate defense expenditure may act as a Keynesian-style demand stimulus, as theorized by Benoit (1973). By injecting government funds into the economy for personnel and procurement, such spending may provide a baseline of industrial activity and employment that helps economies escape a low-growth trap, a finding that aligns with the Keynesian arguments detailed in our literature review (Section 1.1.1).

However, helping an economy escape stagnation is a different challenge than propelling it to high growth. Here, our more powerful Random Forest model provides a contrasting perspective. The Partial Dependence Plot for the "High Growth" category (Figure 8) shows that the initial increases in military spending are strongly associated with a decrease in the probability of achieving a high-growth outcome. This finding aligns perfectly with the Neoclassical "crowding-out" hypothesis (Section 1.1.1), which posits that defense spending diverts scarce financial and human resources from more productive private and public investments—such as infrastructure and civilian innovation—that are necessary for rapid economic acceleration.

These two seemingly contradictory findings—that military spending helps escape low growth but hinders high growth—are not mutually exclusive. They point to a complex, non-linear reality that is clarified when we consider the interaction between military spending and a nation's human capital. The 2-Way Partial Dependence Plot (Figure 14), which visualizes this interaction, offers the model's most sophisticated insight. It reveals that the negative "crowding-out" effect of military spending on high growth is significantly mitigated in countries with high educational attainment. While the initial negative slope is present for all countries, it is noticeably less severe for those with a more educated populace.

This provides powerful empirical support for the Endogenous Growth theory concepts discussed in our literature review (Section 1.1.2), particularly the idea of "absorptive capacity" (Cohen & Levinthal, 1989). A highly educated workforce, rich in scientists, engineers, and technicians, is better equipped to absorb technological spillovers from the defense sector, translate military R&D into civilian innovation, and fill the high-skill jobs created by the defense industry. In this context, human capital acts as a crucial enabling factor, allowing an economy to realize positive spillovers that would otherwise be lost and turning a potential economic drag into a more manageable cost.

Therefore, the "guns vs. butter" trade-off is not a fixed choice. Our model suggests the answer is conditional: the economic cost of "guns" is substantially lower, and the potential for positive spillovers higher, in nations that have already made significant investments in "books".

7.4. The Political Dimension: Ideology as a Secondary Influence

A central hypothesis in political economy is that a government's ideological orientation shapes its economic policies and, consequently, its growth trajectory. However, a consistent and striking finding from our empirical analysis is the limited direct predictive power of political ideology compared to fundamental economic variables. Across all three models—Logistic Regression, Random Forest, and Neural Network—and using multiple importance metrics, the dummy variables representing government ideology (Farleft, Farright, Moderateleft, Moderateright) consistently registered the lowest importance scores. The SHAP values for these variables in our final Random Forest model, for instance, were an order of magnitude smaller than those for the top economic predictors.

This overall finding suggests that when it comes to predicting a country's economic growth regime, the tangible effects of investment, education, trade, and defense spending far outweigh the direct influence of a government's placement on a left-right spectrum.

Despite this general trend, the Partial Dependence Plot for the Farright variable (Figure 13) did reveal one intriguing finding. While political ideology as a whole was a weak predictor, the model found a notable positive association between the presence of a far-right government and the probability of a country being in the "High Growth" category. The plot shows the predicted probability of high growth increasing from approximately 0.3 when a far-right government is not in power to around 0.5 when it is.

It is crucial to emphasize that this result does not imply a causal link whereby far-right governance directly creates high growth. Instead, it indicates that, within the historical patterns of our dataset, the presence of far-right governments may have coincided with other conditions that were also conducive to growth. This aligns with the Political Economy literature discussed in Section 1.2, which suggests that specific institutional contexts and policy choices, rather than broad ideological labels, are what truly shape economic outcomes. For instance, these periods of far-right governance might have been characterized by policies of economic deregulation, nationalist industrial policy focused on specific sectors, or responses to particular security threats that also spurred economic activity.

Ultimately, the analysis of the political dimension reinforces a core conclusion of this study: fundamentals prevail over ideology. While the political context undoubtedly creates the environment in which economic policy is made—a theme explored by Wagner's Law and theories of the military-industrial complex (Section 1.2) our model demonstrates that the direct, measurable impact of a government's ideological label is secondary. The path to a specific growth regime appears to be less about which party is in power and more about the concrete, and often politically constrained, decisions made regarding investment in physical capital, human capital, and national defense.

Chapter 8. Conclusions

The relationship between defense expenditure and economic growth represents one of the most enduring and debated topics in modern political economy. For decades, the academic discourse has been framed by a central, often inconclusive, "guns vs. butter" dichotomy, pitting the Keynesian view of military spending as a productive stimulus against the Neoclassical perspective of it as an economic drain that crowds out more productive investment. This thesis sought to bring new clarity to this long-standing debate by moving beyond the constraints of traditional linear models, which often fail to capture the nuanced realities of this complex relationship.

To achieve this, this study employed a unique and comprehensive methodological framework, integrating advanced machine learning techniques with classical econometric analysis. By applying models such as Random Forests and Neural Networks alongside a Multinomial Logistic Regression, this research was explicitly designed to capture the non-linearities, threshold effects, and complex interaction effects that characterize the defense-growth nexus. This approach was applied to a rich, longitudinal dataset spanning over seven decades and encompassing a diverse sample of 40 NATO and allied nations, allowing for a robust and generalizable analysis.

This concluding chapter serves to synthesize the principal findings of this extensive inquiry. It will begin by summarizing the key empirical results derived from the predictive modeling process. It will then proceed to discuss the theoretical and policy implications of these findings, connecting them back to the established literature and offering actionable insights for policymakers. Finally, the chapter will acknowledge the study's limitations and propose promising avenues for future research, ultimately offering a more sophisticated and contextually aware answer to the fundamental question of how defense spending truly shapes economic prosperity.

8.1. Re-evaluating the "Guns vs. Butter" Nexus

The comprehensive modeling process detailed in Chapter 5, which integrated a traditional econometric model with more advanced machine learning techniques, yielded several key empirical findings that provide a multi-faceted answer to the central research question. These results, validated through a rigorous cross-model and cross-validation framework, can be summarized into five principal conclusions.

First, the analysis established a clear hierarchy of influence among the factors that predict economic growth regimes. The most striking and consistent finding across all models is the paramount importance of core economic and demographic fundamentals. Variables such as Capital Formation, Educational Attainment, and Population Growth consistently emerged as the most powerful drivers of economic outcomes, confirming their foundational role in shaping a nation's growth trajectory.

Second, the primary variable of this study, Military Spending, was consistently identified as a significant but secondary predictor. While its influence on growth regimes is measurable and robust across all models, its predictive power is demonstrably smaller than that of the top-tier economic fundamentals. This positions defense expenditure not as a primary engine of growth, but as a significant contributing factor whose effects must be understood within the broader economic context.

Third, a significant secondary finding was the limited direct predictive impact of political ideology. In a stark contrast to the economic variables, the categorical features representing a government's position on the political spectrum consistently registered the lowest importance scores. This suggests that while ideology may shape the policy environment, its direct predictive power on growth regimes is far weaker than that of tangible economic activities and endowments.

Fourth, the analysis revealed a non-linear and regime-dependent reality for the impact of military spending. The effect of defense expenditure is not monolithic. The Multinomial Logistic Regression model showed that it plays a statistically significant stabilizing role, increasing the odds of an economy transitioning from a low to a medium growth state. However, the Partial Dependence Plots from the more powerful Random Forest model showed that these same initial increases in spending act as a hindrance to achieving high growth. This dual finding is crucial, suggesting that military spending can help economies escape stagnation but may inhibit their ability to achieve top-tier performance.

Finally, the analysis uncovered the conditional nature of the "guns vs. butter" trade-off. The 2-Way Partial Dependence Plot (Figure 14) delivered the most sophisticated insight of the study: the negative impact of military spending on the probability of high growth is significantly mitigated by higher levels of educational attainment. This strongly suggests that human capital acts as a crucial "absorptive capacity," allowing an economy to better translate defense-related activities into broader economic benefits and reducing the opportunity cost of security investments.

8.2. Theoretical Implications and Contribution to the Literature

The empirical results of this research, derived from a hybrid machine learning and econometric approach, do not merely provide a predictive model; they offer a data-driven intervention into the long-standing theoretical debates surrounding the defense-growth nexus. By moving beyond linear assumptions and capturing complex, conditional relationships, this study makes several key contributions to the existing literature.

8.2.1. A Data-Driven Synthesis of Neoclassical and Keynesian Views

The findings of this research do not offer a simple vindication of either the Neoclassical or Keynesian perspective on military spending. Instead, they provide a powerful data-driven synthesis, suggesting that both theories hold partial truth, with their relevance depending on a country's specific economic context and growth regime.

The Multinomial Logistic Regression model (Chapter 5.5) offers compelling support for the Keynesian demand-side stimulus argument in a specific context. The analysis revealed that while military spending was not a statistically significant predictor of achieving high growth, it was a highly significant positive predictor ($p < 0.001$) for moving a country from a "Low Growth" to a "Medium Growth" regime. This suggests that, consistent with the Benoit Hypothesis (Benoit, 1973), moderate defense expenditure may act as a stabilizing force or a Keynesian stimulus that helps economies escape stagnation, likely by boosting aggregate demand and industrial activity.

However, helping an economy escape stagnation is a different challenge than propelling it to a high-growth phase. Here, the more powerful Random Forest model provides a contrasting perspective that aligns with the Neoclassical "crowding-out" hypothesis. The Partial Dependence Plot for the "High Growth" category (Figure 8) clearly shows that initial increases in military spending are strongly associated with a decrease in the probability of achieving high growth. This supports the Neoclassical view that defense spending, particularly at higher levels, diverts scarce financial, physical, and human resources from more productive private and public investments that are essential for rapid economic acceleration.

These seemingly contradictory findings are reconciled when viewed through a regime-dependent lens. The models collectively suggest that military spending can be a tool to fight recession and stagnation (a Keynesian view) but becomes a hindrance when the goal is to achieve top-tier growth (a Neoclassical view).

8.2.2. Empirical Validation of Endogenous Growth Theory

Perhaps the most significant theoretical contribution of this study lies in its empirical validation of key tenets from Endogenous Growth theory. While the Neoclassical and Keynesian debate centers on if military spending helps or hurts, Endogenous Growth theory asks how and under what conditions. The interaction effect between military spending and education provides a direct and powerful answer.

The 2-Way Partial Dependence Plot (Figure 14) reveals that the negative "crowding-out" effect of military spending on high growth is significantly mitigated in countries with high educational attainment. This provides powerful, empirical support for the concept of "absorptive capacity" (Cohen & Levinthal, 1989). A highly educated workforce, rich in scientists, engineers, and technicians, is better equipped to absorb technological spillovers from the defense sector, translate military R&D into civilian innovation, and fill the high-skill jobs created by the defense industry. The model demonstrates that the economic spillovers from defense are not automatic; they require a high level of human capital to be realized.

This finding moves the debate beyond a simple trade-off. It offers a data-driven mechanism explaining why some countries might benefit from defense investment while others do not. The economic cost of "guns" is not fixed; it is conditional upon a nation's prior investment in "books."

8.2.3. Nuancing the Political Economy Framework

Finally, this research nuances the traditional Political Economy framework by demonstrating the limited direct predictive power of government ideology relative to economic fundamentals. The consistent finding that variables like Capital Formation and Educational Attainment are far more important predictors than Farleft or Farright challenges simplistic models that directly link a ruling party's label to a specific growth outcome.

This does not invalidate the theories of Wagner's Law or the Military-Industrial Complex. Rather, it refines their role. These theories are excellent at explaining the political and institutional pressures that might lead a government to choose a certain level of defense spending. However, our model shows that once that decision is made, the subsequent economic outcome is more heavily determined by the tangible fundamentals of the economy—its investment rate, its human capital, its trade openness—than by the ideological label of the government that made the decision.

The model effectively separates the political decision-making process from the subsequent economic mechanics. It suggests that while ideology shapes the policy environment, the path to a specific growth regime is ultimately paved with the concrete results of investment and education, regardless of the government's stated political affiliation.

8.3. Concluding Remarks and Recommendations

The empirical findings of this thesis offer several significant and actionable implications for policymakers navigating the complex relationship between national security and economic prosperity. First, the analysis strongly suggests that a singular focus on meeting spending targets, such as NATO's 2% of GDP benchmark, is an insufficient policy paradigm. Our models demonstrate that the economic consequences of defense expenditure are not fixed but are highly conditional on a nation's underlying economic structure and human capital base. This empowers finance and defense ministries to engage in a more sophisticated dialogue, framing defense budgets not as a simple line-item cost but as a strategic investment whose economic return varies with context.

Second, and perhaps the most crucial policy insight, is the existence of a "dual dividend" from investing in human capital. Our analysis shows that a highly educated populace is a foundational pillar of economic growth on its own. Critically, it also acts as a powerful mitigator of the "crowding-out" effect of military spending. This suggests that investments in education, R&D, and high-skill training provide a dual benefit: they are the most reliable path to sustainable prosperity and they lower the economic opportunity cost of necessary defense investments by increasing the economy's "absorptive capacity." For developing or aspiring NATO nations, this offers a clear policy prescription. The model indicates that the negative impact of defense spending is most acute in economies with lower human capital. The imperative, therefore, is not necessarily to delay security investments but to pursue them in parallel with aggressive investments in education and productive capacity to avoid hindering their "catch-up growth" potential.

While these policy implications provide a clear path forward, they must be considered within the context of the study's inherent limitations. It is important to reiterate that the models employed, while capable of identifying complex predictive relationships and correlations, cannot definitively establish causation. The findings represent strong, data-driven patterns, but the causal arrows remain a subject for further, more targeted econometric study. Furthermore, the analysis is constrained by data granularity. Future research could achieve deeper insights by disaggregating the monolithic Military Spending variable into its components (e.g., personnel, R&D, procurement) to analyze if different types of expenditure yield different economic effects. Similarly, the political and institutional variables, while novel, could be enhanced in future work by moving beyond broad ideological labels to incorporate more granular data on institutional quality, political stability, or specific fiscal policies.

Acknowledging these limitations, the central message of this research remains robust and clear. The long-standing "guns vs. butter" debate, this study argues, has often been framed around a false dichotomy. The findings here suggest it is not a simple choice of one over the other, but a complex challenge of timing, context, and synergy. The question is not if a nation should invest in defense, but how it can do so while fostering the very economic vitality that underpins its long-term strength.

Ultimately, this thesis demonstrates that sustainable national security in the 21st century cannot be divorced from economic prosperity. The most secure and resilient nations will be those that understand that investments in their people and their productive capacity are not a diversion from security, but the very foundation upon which it is built.

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