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GOVERNMENT EXPENDITURE COMPOSITION AND ECONOMIC GROWTH: EVIDENCE FROM PANEL DATA ANALYSIS

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Abstract

The question of whether the composition of government spending or the overall level of government spending is more important for economic growth has direct implications for the design of fiscal policy, but disaggregated panel evidence for groups of economically diverse countries is limited. This study estimates the long and short run growth effects of three functional expenditure categories: education (COFOG 09), defense (COFOG 02), and environmental protection (COFOG 05) across a balanced panel of eight countries (Australia, Austria, Belgium, Bulgaria, Colombia, Croatia, Czechia, and Denmark) for the period 2007–2025. The Pooled Mean Group ARDL estimator of Pesaran, Shin, and Smith (1999) is applied to 152 country-year observations and confirmed cross-sectional dependence (CD = 5.92, $p < 0.001$), a large positive long-run elasticity of defense spending with respect to real GDP growth of 2.27, and a negative long-run coefficient of −3.13 for education spending that is statistically significant is analyzed. Environmental protection expenditure is not statistically significant for both time horizons. In the short run, the contemporaneous coefficient of education spending is the largest at 42.64 and is consistent with demand-side stimulus that wears off over time. An error correction term of −0.99 indicates that the annual reversion to the long-run equilibrium is close to 100%. The Dumitrescu–Hurlin panel causality reveals a unidirectional causal relationship between defense spending and output growth, and between education allocation and defense budgeting. These findings contradict the supply-side theory of public education spending in already high-spending economies and suggest strong defense spending growth-enhancing effects via technological and security spillovers in NATO-aligned settings. Policy implications for fiscal rebalancing and expenditure efficiency are mentioned.

Keywords: Government expenditure, Economic growth, Defense spending, Panel study

JEL Classification: *H50, H52, H56, O40, C33*

INTRODUCTION

The debate on whether government expenditure stimulates or limits economic growth has preoccupied economists since Barro (1990) theoretically showed that productive government expenditure can be used to maintain growth in an endogenous model, and since Aschauer (1989) initial empirical evidence that government capital is an important source of private productivity. But the aggregate spending question of how much government is too much, is not as productive today as the compositional one: does it make any difference whether a government spends on schools, soldiers, or cleaner air? According to Devarajan, Swaroop, and Zou (1996), theoretically productive expenditure categories can be growth-retarding when they form too big a part of the budget. Kneller, Bleaney, and Gemmell (1999) showed for OECD countries that the mix of productive and non-productive expenditure, not just the level determines the fiscal-growth outcome.

Gemmell, Kneller, and Sanz (2016) confirmed the significance of expenditure composition in the determination of the level of long-run GDP in a wide panel of OECD economies (Sahnoune & Lagoune, 2024; Sosvilla-Rivero et al., 2025). Although this consensus is increasingly accepted, the

question is still open as to panels that combine high-income OECD economies with upper-middle-income emerging markets, and the specific functional areas of defense, education, and environmental protection that are both at the same time under pressure due to post-pandemic fiscal consolidation and geopolitical realignment (Vo et al., 2026). There are three categories which are at the center of the current fiscal debates. It is assumed that education spending accumulates human capital and increases long-run productivity (Barro, 1990), but empirical evidence on already high-spending OECD economies are less clear than theory suggests (Afonso and Jalles, 2014). The renewed focus on defense spending is being driven by the reaction of NATO members to post 2022 geopolitical pressure; the question of whether this spending crowds out productive private activity or creates growth by providing technological spillovers and security is a pressing policy issue (Alptekin and Levine, 2012; Emmanouilidis and Karpetis, 2022). The growth rate of environmental protection spending is high in the context of national green transition commitments, and the growth impacts are empirically under-researched due to the limited time series of available COFOG function 05 (Yilmaz, 2025). Aggregate spending regressions do not provide any answers to these questions; they require disaggregated functional analysis in a panel model that can be cross-country heterogeneous.

This paper fills that gap with annual data of Australia, Austria, Belgium, Bulgaria, Colombia, Croatia, Czechia, and Denmark 2007-2025. The choice is a truly heterogeneous panel that covers high-income OECD economies, more recent European Union member states, and an upper-middle-income Latin American economy. Such breadth examines the extent to which expenditure-growth correlations found in purely Western European panels are more generalizable. The time window reflects the contraction of the Global Financial Crisis, ten years of fiscal tightening, the COVID-19 pandemic fiscal stimulus, and the post-2022 increase in European defense spending, times of different and changing expenditure composition in all eight countries. The study has four objectives. It estimates, first, the long-run pooled and short-run heterogeneous growth elasticities of three disaggregated functional expenditure categories such as education, defense and environmental protection, over a panel of eight countries over 2007 to 2025. Second, it uses the PMG-ARDL model directly to explain the mixed integration orders (I(0) and I(1)) in the data and to explain cross-sectional dependence due to common global shocks. Third, it is a close approximation of the directional causal form of the expenditure-growth relationship with Dumitrescu-Hurlin panel causality tests which distinguishes between real fiscal causes and passive growth correlates. Fourth, it has policy implications of fiscal rebalancing in economies under concurrent pressure to consolidate budgets, fulfil defense commitments and finance green transition expenditures.

LITERATURE REVIEW

Expenditure Composition and Growth

The hypothesis that the composition of government spending is more important in determining its growth effect than its aggregate level has received a large body of empirical evidence since Devarajan, Swaroop, and Zou (1996) reported that even theoretically productive functional categories can become growth-retarding when they already have a large budget share. Easterly and Rebelo (1993) demonstrated in a large cross-section that transport and communication investment is always associated with growth, and more general fiscal categories are specification sensitive. This was formalised by Kneller, Bleaney and Gemmell (1999) on behalf of 22 OECD countries and it was shown that productive expenditure increases growth when funded by non-distortionary taxes and that exclusion of any budget category gives biased estimates- a fact that

has led to the simultaneous estimation of all three functional categories in this study. According to the data on environmental protection expenditure of the general government provided by Eurostat (2025), the average general government expenditure on COFOG 05 in 2023 is 0.8 per cent of GDP across the EU member states, with a large cross-country variation 0.2-1.5 percent of GDP. Gemmell, Kneller and Sanz (2016) extended the OECD evidence by using panel cointegration techniques, which also revealed that the long-run GDP-level effects of expenditure composition are economically significant. More recent studies have applied more suitable heterogeneous panel estimators that consider cross-sectional dependence and mixed integration orders of modern fiscal data.

Education Spending and Growth

The theoretical argument in support of education spending as a long-run growth driver is based on human capital accumulation and the productivity improvements that ensue due to a more skilled workforce (Barro, 1990). The result of Bose, Haque, and Osborn (2007), in the case of developing economies, is that education is the only functional category that has a strong positive growth effect when the budget constraint is imposed appropriately. This observation is in line with the perception that returns to education expenditure are greatest where the level of investment is low. The data on the high-income OECD and EU economies, however, is pointing in another direction. The authors discovered positive effects of education in OECD subsamples but negative or insignificant effects in larger cross-country panels (Afonso and Jalles (2014). Sosvilla-Rivero et al. (2025) affirmed that the effects of education spending are small and varied among EU countries. The most consistent explanation is the saturation mechanism proposed by Devarajan et al. (1996), in which further budgetary increases have a sharply decreasing marginal returns and can crowd out more efficient private providers of education, as is the case in Australia, Belgium, and Denmark. Their findings provide a convenient comparative benchmark to the developing-economy panels: education, health, and agricultural spending have positive long-run impacts in the lower-income setting, whereas defense spending is negative with the opposite trend to that of our eight-country panel. This difference confirms the hypothesis of income-level heterogeneity: the direction of the defense-growth effect changes to the opposite as the institutional and technological capacity grows.

Defense Spending and Growth

A meta-analysis of 32 empirical studies by Alptekin and Levine (2012) revealed a real but minor net positive impact of military spending on growth, and that the impact is highly sensitive to the inclusion of country heterogeneity in the model. Dunne and Tian (2015) verified in 106 countries that the defense-growth correlation is income-dependent: positive in high-income economies with developed defense R&D, and negative or zero in low-income ones. The same conclusion was supported by Emmanouilidis and Karpetis (2022), and Saba and Ngepah (2022), who claim that by combining countries with varying institutional capacity, it becomes difficult to identify true positive effects that are present in high-capacity defense establishments. The study that is closest to our sample is Dimitriou, Goulas, Kallandranis, and Drakos (2025). They analyse 141 NATO and non-NATO countries over 1992-2020 using spectral panel analysis and frequency-domain Granger causality and find that military spending boosts economic growth in NATO member states but not in non-NATO alliances like the SCO and CSTO. This dichotomy is ascribed to the technology spillover and security provision channels that are active in the NATO institutional framework. Our eight panel countries are six of the eight NATO members Australia is a partner country; Austria is a neutral security partner; the positive long-run defense coefficient of 2.27 here

is thus consistent with the NATO-member subgroup findings of Dimitriou et al. (2025) causal path LDEF to GDP supports their frequency-domain causality findings. The channels of transmission between defense expenditure and output in high-income, NATO-oriented economies include R&D spillovers of military technology to civilian sectors; dual-use infrastructure that lowers the cost of logistics in the private sector; security provision that lowers the political risk premium on long-term investment; and Keynesian multiplier effects of defense employment and procurement.

Environmental Expenditure and Growth

The systematic panel evidence on government spending on environmental protection and economic growth is less than that on education or defense, in part due to the fact that COFOG function 05 data of similar quality to national accounts were not readily available until the late 2000s. According to Gemmell, Kneller, and Sanz (2016), the effects of expenditure composition are most easily observed in categories that can be classified as either productive or consumptive; environmental spending is theoretically in the middle of the spectrum where ambiguity is likely to occur. Regulatory and compliance short-run costs are offset by long-run productivity gains of natural capital conservation and green innovation, and the net sign depends on the position of each country in the ranking of its socially optimal level of environmental expenditure. Ratombo and Mongale (2025) studied 16 SADC countries during 2000=2022 with the PMG-ARDL estimator, which is also used here to determine the joint effect of governance quality and government expenditure on economic growth. They find that the long-run growth impact of aggregate government spending is positive but depends on the level of governance. In the case of environmental spending in particular, they see statistically non-significant effects in the full SADC panel, which they attribute to the small proportion of environmental protection in overall budgets (less than one percent of GDP in most members) and the limited time series.

METHODOLOGY

The panel of eight countries analyzed, such as Australia, Austria, Belgium, Bulgaria, Colombia, Croatia, Czechia, and Denmark, over 2007-2025, results in 152 country-year observations (N = 8, T = 19). The initial year indicates the availability of COFOG functional expenditure data at adequate cross-country coverage; the final year continues the panel with the post-pandemic fiscal expansion and the 2022-2025 European defense review. Government spending by COFOG data are based on Eurostat data on the European countries and the OECD Government Finance Statistics on Australia. The growth rates of real GDP are based on World Development Indicators by the World Bank. The dependent variable (GDP) is the annual real GDP growth rate, which is in percentage. The three independent variables are natural-log-transformed real government expenditure per capita under COFOG function 09 (education, LEDU), COFOG function 02 (defense, LDEF), and COFOG function 05 (environmental protection, LENVI). Log transformation eliminates cross-country heterogeneity of scale and enables the coefficients to be interpreted as semi-elasticities, the percentage-point change in GDP growth in response to a one-percentage point increase in the corresponding expenditure category. All three regressors have variance inflation factors less than 1.5 (maximum = 1.496), which means that there is no multicollinearity issue.

Cross-Sectional Dependence

The test of cross-sectional dependence is conducted with Pesaran (2021) CD test on model residuals in the estimation window 2007-2024 that is common to both. Exposure to common

global shocks, the European sovereign debt crisis, COVID-19, global commodity price cycles and the post-2022 geopolitical shift are common to all eight economies, and thus a large CD statistic is anticipated and empirically significant to take care of before moving on to panel unit root and cointegration tests, which assume cross-sectional independence.

Panel Unit Root Tests

Three complementary tests at the level and first differences are used to test unit root properties, Levin, Lin and Chu (2002) test (LLC), which assumes a common unit root process; Im, Pesaran and Shin (2003) test (IPS), which allows heterogeneous autoregressive coefficients; and Fisher-type ADF test of Maddala and Wu (1999), which sums country level p-values to an asymptotic chi-squared statistic. The Schwarz Information Criterion is used to choose lag lengths; intercept-only specification is employed everywhere.

Cointegration and Lag Selection

Pedroni (1999) panel cointegration tests determine the existence of a long-run equilibrium relationship between the panel variables. The test has four within-dimension statistics (Panel v, Panel ρ, Panel PP, Panel ADF), and three between-dimension statistics (Group rho, Group PP, Group ADF); the inference is based mainly on the PP and ADF statistics, which are not powerless under the sample dimensions available. The ARDL (p,q,q,q), with p,q 1,2, are compared on the Schwarz Information Criterion on a shared 2009-onwards sample; the ARDL (2,1,1,1), preferred by the BIC, is continued.

PMG-ARDL Estimation

The Pooled Mean Group estimator of Pesaran, Shin, and Smith (1999) is based on the error correction representation:

$$\Delta GDP_{it} = \varphi_i \, (GDP_{i,t-1} - \theta' X_{it}) + \Sigma_j \, \delta_{ij} \, \Delta X_{i,t-j} + \varepsilon_{it}$$

where φ_i is the country-specific error correction coefficient, and θ is the pooled long-run slope imposition that must be equal across countries, and δ_{ij} is country-specific short-run dynamics. The long-run homogeneity constraint is compared to the mean-group estimator of Pesaran and Smith (1995) through a Hausman test. Standard errors are HAC-robust. Pooled residuals are tested using Breusch Godfrey, BreuschP agan and Ramsey RESET tests; CUSUM plots are used to test parameter stability.

Panel Granger Causality

Directional causality is estimated by the heterogeneous non-causality (HNC) model of Dumitrescu and Hurlin (2012) which averages country-specific Wald statistics to a W-bar statistic and normalizes it to a Z-bar under the asymptotic normal distribution. The heterogeneous lag structures is allowed by this test, cross-sectional dependence and unbalanced data, unlike standard panel Granger tests are also implementable, which assume a common causality structure.

RESULTS AND DISCUSSION

Table 1. Descriptive Statistics

Variable	Definition	Mean	Std. Dev.	Min	Max
GDP	Real GDP growth rate (%)	1.545	3.093	−8.510	13.654

LEDU	Log education expenditure (COFOG 09)	2.393	0.150	2.056	2.833
LDEF	Log defense expenditure (COFOG 02)	0.913	0.441	0.066	1.782
LENVI	Log environmental protection expenditure (COFOG 05)	0.431	0.439	−0.368	1.165

Note: expenditure variables are in natural logs of real per capita spending in constant USD. COFOG = Classification of Functions of Government.

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Table 2. Correlation Analysis

	GDP	**LEDU**	**LDEF**	**LENVI**
GDP	1.0000	-0.0799	0.1270	0.1033
LEDU	-0.0799	1.0000	0.5434	0.2594
LDEF	0.1270	0.5434	1.0000	0.3253
LENVI	0.1033	0.2594	0.3253	1.0000

Note: GDP correlates weakly with all three variables in the model

Table 3. Variance Inflation Factors

Variable	**VIF**
LEDU	1.435
LDEF	1.496
LENVI	1.131

Note: All VIF values are below the conventional threshold of 10 suggesting absense of multicollinearity among the variables

Table 3. Pesaran (2021) Cross-Sectional Dependence Test

N	**Common Years (T)**	**Avg. Pairwise Corr.**	**CD Statistic**	**p-value**
8	16	0.280	5.920	0.000***

*Note: *** $p < 0.01$.*

The CD test statistic 5.92 ($p < 0.001$), confirming substantial cross-sectional dependence with an average pairwise residual correlation of 0.28. Standard panel inference based on cross-sectional independence would be unreliable in this case.

Table 3. Panel Unit Root Tests

Variable	IPS Stat	IPS p	MW-Fisher	MW p	LLC Stat	LLC p	Order
GDP	-5.012	0.000	175.559	0.000	-5.012	0.000	I(0)
LEDU	-1.500	0.627	13.803	0.613	-1.500	0.067	I(1)
LDEF	-1.702	0.375	18.910	0.273	-1.702	0.044	I(1)
LENVI	-2.989	0.000	60.989	0.000	-2.989	0.001	I(0)
ΔLEDU	-6.154	0.000	190.003	0.000	—	—	I(0)
ΔLDEF	-4.636	0.000	151.029	0.000	—	—	I(0)

Note: Tests include intercept only; lag lengths by SIC. IPS = Im-Pesaran-Shin; MW = Maddala-Wu Fisher ADF; LLC = Levin-Lin-Chu. Δ denotes first differences.

The panel unit root results are reported in table 3. GDP growth and environmental protection expenditure are stationary at level and IPS and Maddala-Wu Fisher statistics reject at the 1% level. Education expenditure and defense expenditure are non-stationary at level in both statistics but stationary at first difference. This mixed integration order I(0) and I(1) is a strong characteristic of fiscal panels spanning structural change periods and is fully compatible with the ARDL bounds approach.

Table 4. ARDL Lag Order Selection

Specification	Parameters (k)	Log-Likelihood	AIC	BIC
ARDL(1,1,1,1)	43	−287.116	660.232	785.158
ARDL(2,1,1,1) *	51	−266.680	635.359	783.528
ARDL(1,2,2,2)	67	−261.221	656.441	851.095
ARDL(2,2,2,2)	75	−239.383	628.765	846.661

*Note: * BIC-preferred specification carried forward to PMG-ARDL estimation.*

Table 4 compares the four candidate ARDL specifications. The Bayesian Information Criterion picks ARDL(2,1,1,1), which introduces two lags of GDP and one lag of each expenditure category. The AIC favors ARDL (2,2,2,2) at with the 24 extra parameters on a 135-observation common sample; the BIC penalty outweighs the log-likelihood gain.

Table 5. Cointegration Test

Statistic	Value	p-value	Statistic	Value	p-value
Panel v	−1.398	0.919	Group ρ	0.496	0.690
Panel ρ	−0.699	0.242	Group PP	−13.547	0.000***
Panel PP	−7.975	0.000***	Group ADF	−7.257	0.000***
Panel ADF	−5.736	0.000***			

*Note: indicating significance = *** $p < 0.01$*

Table 5 presents Pedroni (1999) statistics. Panel PP (−7.975), Panel ADF (−5.736), Group PP (−13.547), and Group ADF (−7.257). The Panel rho and Group rho are not rejected, as they are known to have low power when T is small. The PP and ADF evidence strongly indicate that there is a long-run cointegrating relationship between the four panel variables.

5.3 PMG-ARDL Estimates

Table 6. PMG-ARDL

Variable	Coefficient	Std. Error	t-Statistic	p-value	Sig.

	Long-Run Pooled Coefficients				
LDEF	2.271	0.419	5.415	0.000	***
LEDU	−3.125	1.450	−2.156	0.033	**
LENVI	0.036	0.276	0.131	0.896	
Constant	7.228	3.418	2.115	0.036	**
	Short-Run Mean-Group Coefficients				
COINTEQ	−0.991	0.149	−6.669	0.000	***
D(LEDU)	4.621	10.822	4.085	0.044	**
D(LEDU(−1))	6.639	11.623	0.571	0.569	
D(LEDU(−2))	3.409	4.187	0.814	0.417	
D(LDEF)	2.838	2.453	1.157	0.250	
D(LDEF(−1))	−2.526	3.441	−0.734	0.464	
D(LENVI)	4.435	3.444	1.288	0.200	
D(LENVI(−1))	−5.954	4.757	−1.252	0.213	

*Note: *** p < 0.01, ** p < 0.05, * p < 0.10. COINTEQ = error correction term. HAC-robust standard errors. PMG with fixed lags (deplags=1, reglags=2 difference lags per regressor) specification.*

The PMG-ARDL results are shown in Table 6. The Hausman test fails to reject the long-run homogeneity restriction, which proves that PMG is more desirable than the unrestricted mean-group estimator. Long-run coefficients are shared among all the eight countries; short-run coefficients are country-specific averages.

Table 9. Estimates of Long-Run Mean Group (MG) and Hausman Test of Slope Homogeneity

Variable	**PMG Coeff.**	**PMG SE**	**MG Coeff.**	**MG SE**	**t-stat**	**p-value**
Long-Run Variables						
LDEF	2.271***	0.419	4.763	9.998	0.476	0.648
LEDU	−3.125**	1.450	−18.901	13.625	−1.387	0.208
LENVI	0.036	0.276	−1.364	4.300	−0.317	0.760
Hausman Test	$\chi^2(3) = 1.525$		p-value = 0.677			
Decision	Fail to reject H_0: Long-run slopes homogeneous → PMG preferred					

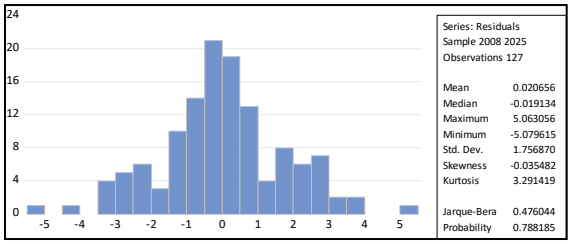
The Mean Group output below are obtained from country relevant error-correction ARDL regressions. The large standard errors presents the dimension available per country in the short run after lag adjustment. The individual estimates with high variance is a known property of MG in small samples of panels. The pooled PMG constraint is supported by the Hausman test statistic. Note: *** $p < 0.01$, ** $p < 0.05$ for sample: 2010–2025, N × T = 127. The estimates of MG obtained from country specific EC-ARDL regressions with one lag of each first difference. The standard errors for High MG present T = 15–16 per country.
Hausman H_0: long-run slopes are homogeneous across countries. Rejection prefer the model of MG; failure to reject supports PMG estimations.

Diagnostic Tests
The three residual diagnostics are all passed at the five-percent level (Table 7). The Breusch-Godfrey LM value of first-order serial correlation (2.057, p=0.152) does not reject the null hypothesis of no serial correlation. The Breusch-Pagan test of heteroskedasticity (8.435, p=0.088) and the Ramsey RESET test of misspecification of the functional form (2.230, p=0.112) also pass. CUSUM stability plots ensure the stability of parameters over the sample.

Table 7. Model Diagnostic Tests (Pooled Residuals, ARDL (2,1,1,1))

Test	Null Hypothesis	Statistic	p-value
Breusch–Godfrey	No serial correlation	2.057	0.152
Breusch–Pagan	Homoskedasticity	8.435	0.088
Ramsey RESET	Correct functional form	2.230	0.112

Note: All tests applied at the 5% significance level.



CUSUM stability plots ensure the stability of parameters over the sample, indicating the stability across the sample.

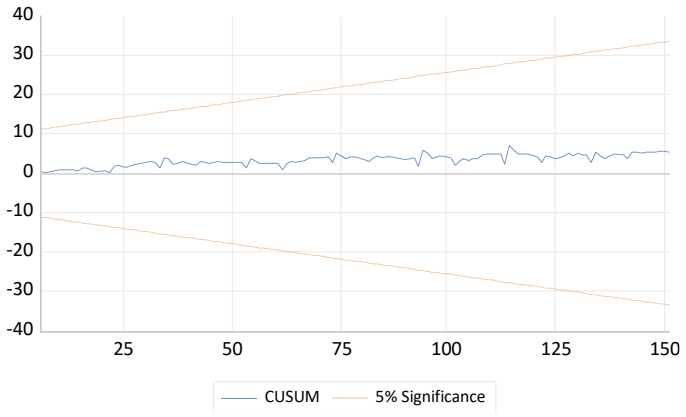


Figure 2: Cusum Test

Panel Granger Causality

The Dumitrescu Hurlin (2012) statistics of all twelve directional pairings are reported in Table 8. The most significant result is LDEF → GDP (Z-bar = 7.496, p < 0.001): defense spending Granger-causes output growth. The reverse channel (GDP to LDEF) is statistically insignificant (p=0.924), which excludes the reverse-causality explanation that wealthier economies merely spend more on defense. The second important direction is LEDU → LDEF (Z-bar = 3.412, p = 0.001): education spending Granger-causes defense allocation. Neither education nor environmental spending Granger-causes GDP in this panel.

Table 8. Dumitrescu–Hurlin (2012) Panel Granger Causality Tests

Direction (X → Y)	W-bar	Z-bar	p-value	
LDEF → GDP	3.425	2.016	0.044	**
LEDU → GDP	1.709	−0.412	0.680	
LENVI → GDP	2.954	1.349	0.178	
GDP → LEDU	2.952	1.347	0.178	
LDEF → LEDU	1.695	−0.431	0.667	
LENVI → LEDU	2.486	0.687	0.492	
GDP → LDEF	2.198	0.280	0.779	
LEDU → LDEF	4.532	3.580	0.000	***
LENVI → LDEF	2.733	1.036	0.300	
GDP → LENVI	1.705	−0.418	0.676	
LEDU → LENVI	3.344	1.901	0.057	*
LDEF → LENVI	2.707	1.000	0.317	

*Note: *** p < 0.01. W-bar = average Wald statistic across countries; Z-bar = standardized statistic under asymptotic N(0,1). Null: X does not Granger-cause Y in any individual country.*

Discussion

Above mentioned results presents four levels, the relationships of long-run pooled equilibrium, the short-run mean-group dynamics, the speed of adjustment to equilibrium, and the causal structure directionas. Each level has its own policy interpretation, which is elaborated below, based on the theoretical framework of Section 2 and placed in the context of the recent empirical literature. The highest and most accurately estimated long-run effect in the model is the defense spending coefficient of 2.271 (p < 0.001). One percent of real per capita defense spending increases the long-run equilibrium by 2.27 percentage points of annual GDP growth, assuming education and environmental spending. Dumitrescu Hurlin causality test proves that the direction is between defense spending and output (Z-bar=7.496, p=0.001) and not the opposite. This eliminates the most widespread confound in defense-growth studies, which is that richer economies merely spend more on defense, and indicates a real productive process. This interpretation is also supported by the fact that the reverse causal path (GDP = 0.924) is absent.

Dimitriou, Goulas, Kallandranis, and Drakos (2025) discovered that military spending boosts growth in the NATO alliance in particular, which they attribute to technology spillovers and security-provision externalities that are not present or weaker in non-NATO alliances. We have a NATO-majority composition in our panel (Australia as a partner country, Austria as a neutral partner, and six full or candidate NATO members); the positive and causally-based growth channel is thus consistent with their alliance-conditioned growth channel. In the particular post-2022 scenario where multiple panel members started to accelerate defense budgets far beyond

the two-percent-of-GDP level, the long-run elasticity of 2.27 suggests that the fiscal costs of rearmament can be partially counterbalanced by growth returns that act through the same spillover mechanisms.

The sampled economies theoretically have three transmission channels that are operative. OECD members have a long history of R&D spillovers of military technology into civilian sectors (Alptekin and Levine, 2012). Dual-use defense infrastructure, such as ports, communications, road networks constructed or maintained using defense funds, lowers the logistics expenses of the private sector. And security provision, which Barro (1990) considered as a productive input in the production of the private sector, reduces the risk premium on long-run capital allocation, especially considering the high geopolitical uncertainty in the post-2022 period that is captured at the end of our panel. Gök and Ünluoglu (2026) affirm the existence of positive direct impact of military spending on GDP per capita in EU panel and the positive spillover effects that work through trade and investment connections among EU member states. They discover that the defense-growth effect is positive and significant in the EU panel but negative in the African Union panel, which they explain by the institutional quality and technology absorption capacity. This cross-context difference supports the NATO/institutional channel interpretation: the growth payoff to defense expenditure is not omnipresent but is concentrated in high-capacity economies with allied security arrangements, which are exactly the nations that are dominant in our panel.

The education result requires a close disaggregation over time periods. The pooled coefficient is, in the long run, -3.125 ($p=0.033$): the higher the budget shares of higher education, the lower the equilibrium GDP growth in this panel. The modern first-difference coefficient D(LEDU) is 42.644 ($p = 0.003$): a one-year rise in education expenditure produces a strong positive growth impulse. The short-run lagged terms D(LEDU(−1)) and D(LEDU(−2)) are not statistically significant ($p=0.569$ and $p=0.417$ respectively), which proves that the positive short-run effect is not persistent and is only observed in the year of impact. This deviation is indicative of two different mechanisms. The demand-side, short-run impact is positive: the government spending on education is high, the employment is high, and wage payments to teachers and administrative personnel constitute a significant portion of the employment. Any growth is rapidly converted into aggregate demand via the public sector wage bill and related private expenditure. This channel does not need any enhancement in the quality of education or human capital accumulation; it works in the usual Keynesian multiplier processes. The negative effect in the long-run is the supply side. Human capital growth is not based on the amount of expenditure but on the efficiency of such expenditure in terms of creating quantifiable skills and aligning graduates to productive jobs.

In the case of the high-income members of this panel (Australia, Austria, Belgium, Denmark), the current level of spending on public education is already above five percent of GDP. This is precisely what the Devarajan et al. (1996) saturation mechanism predicts: when initial shares are high, further expenditure will be on the downward-sloping side of the marginal product curve. Similar negative or insignificant long-run education effects were found in OECD subsamples by Afonso and Jalles (2014). Gemmell, Kneller, and Sanz (2016) affirm that the effect of productive expenditure is greatest when the expenditure is less than the optimal share, which means that the sign reversal at high shares is in line with their theoretical model. The comparison to Sisay, Ali, and Ferede (2024) is educative. In their Ethiopia ARDL study, a country where the education expenditure is nowhere near saturation, the education expenditure has a strong positive long-run

impact on economic growth, which is in line with the early-stage human capital accumulation theory. Their article explains the reversal of the sign in the short run (negative short-run education coefficient in Ethiopia), which they explain by fiscal crowding out in a resource-constrained environment. Combined with our findings, positive short-run, negative long-run in the higher-income panel, these two studies define a developmental gradient: the growth dividend of public education spending is greatest in low-income economies where returns to human capital are not yet exhausted and the short-run fiscal stimulus channel is most powerful in high-income economies with fiscal space and a large workforce in the public education sector. This gradient has direct implications on the manner in which education budget expansions are to be assessed in various income settings.

CONCLUSION

In line with the findings, this study concludes that education expenditure produces counteracting effects over time: a substantial demand-side boost in the short run and a statistically significant negative long-run impact, which is in line with diminishing returns in economies where the amount spent on public education is already high. The growth effect of the environmental protection expenditure is not detectable during the sample period. The policy implications depend on the fiscal situation that these economies are experiencing. In the case of EU and NATO members simultaneously consolidating fiscal positions and increasing defense commitments, the evidence here implies a better trade-off than is usually thought: redistribution of resources to defense out of expenditure categories with low or negative long-run growth returns is not likely to impair output, and may actually improve it in the long run through the defense-growth channel identified here. The long-run education coefficient is negative, it does not imply that education budgets should be reduced, but it is an indication that further increases in spending without structural changes to tie outlays to quantifiable skill gains will not produce the human capital growth dividend that theory suggests. Efficiency benefits, such as competitive provision, funding with outcome provisions, and lower administrative costs, are most important factors at this stage of development than budget expansion.

The pooled long-run coefficients can overstate the defense effect and understate the education return in the case of the upper-middle-income panel members (Bulgaria, Colombia, Croatia) where education spending as a share of GDP is lower and defense sectors are smaller. These conclusions were limited by three factors. The panel covers just eight countries in 19 years; an extended time dimension would enhance the strength of the environmental expenditure tests. The constraint in PMG homogeneity is suitable in the average but masks within-panel variance that would be detected with a large N. And institutional quality controls are not part of the model, so the defense-growth channel cannot be neatly disentangled that both may be indicative of underlying governance strength. Future research ought to expand the analysis to a broader cross-section, include quality-adjusted measures of education spending, and examine non-linear threshold effects in the education-growth relationship by income groups.

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