ASSESSING THE IMPACT OF PUBLIC SPENDING ON SCIENCE AND TECHNOLOGY TO PROMOTE INNOVATION IN VIETNAM AND POLICY RECOMMENDATIONS

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Abstract:
In the context of advancing the knowledge-based economy, public spending on science and technology (S&T) is regarded as a critical lever for fostering innovation in Vietnam. However, the link between increased S&T budget allocations and actual innovation outcomes remains ambiguous. This study proposes and empirically tests a theoretical model that examines the effects of four key characteristics of public expenditure – priority, stability, functional allocation, and actual disbursement size – on innovation outcomes. The model incorporates budget allocation efficiency as a mediating variable and institutional capacity as a moderating variable, with economic scale controlled. Based on Structural Equation Modeling (SEM) analysis of data from 396 experts, the findings reveal that three expenditure characteristics significantly influence innovation outcomes indirectly, with actual disbursement size demonstrating the most notable impact. Meanwhile, institutional capacity does not yet show a clearly moderating role. The results underscore the pivotal mediating role of budget allocation efficiency, implying that institutional reforms and performance-based governance are essential conditions for public investment in S&T to generate transformative innovation.
Keywords: R&D, Science and Techonology, Innovation, Public Speding, Vietnam

1. Introduction

In the contemporary knowledge economy, public spending on science and technology (S&T) has increasingly been recognized not merely as a fiscal instrument but as a strategic lever for national competitiveness and innovation. A substantial body of research demonstrates that public investment in research and development (R&D) acts as a catalyst for private sector R&D, enhances productivity, and supports long-term technological leadership (David, Hall, & Toole, 2000). Yet, a persistent question remains: does increasing government expenditure automatically translate into tangible innovation outcomes, and through what mechanisms does this transformation occur?

Vietnam offers a compelling case for this inquiry. For more than a decade, government spending on R&D has remained below 0.7% of GDP, significantly lower than neighboring Thailand (1.3%) and far behind Korea, where R&D investment exceeds 4% of GDP (OECD, 2023). Despite Resolution 57-NQ/TW (2025), which set an ambitious target of 2% of GDP for S&T expenditure, the actual share in 2023 reached only 0.82% of the state budget (Vietnam News, 2025). This persistent gap reflects not only financial constraints but also deeper structural challenges related to allocation efficiency and institutional capacity.

Cross-national evidence highlights that higher public R&D spending does not guarantee stronger innovation performance. Veugelers and Wang (2019) reveal stark differences in innovation outcomes across European economies despite comparable investment levels: Northern Europe's success is rooted in transparent allocation systems and performance-based budgeting, while Southern Europe struggles under weaker institutional environments. Similarly, the Global Innovation Index (WIPO, 2023) consistently shows that top-performing innovation nations combine high levels of R&D

investment with institutional robustness, competitive allocation schemes, and transparent governance.

In Vietnam, the paradox of "more spending but limited innovation outcomes" has become increasingly evident. Despite incremental increases in budget allocation, indicators such as international publications, patents, and total factor productivity (TFP) remain modest (OECD, 2023; WIPO, 2023). Moreover, Vietnam has fewer than 10 researchers per 10,000 people, far behind Korea and even Thailand. These realities underscore the urgent need to examine how public spending is transformed into actual innovation outputs, beyond the simplistic measure of budget size.

The international literature emphasizes two critical determinants of this transformation: *(i) allocation efficiency, defined as the extent to which public resources are distributed to priority areas, disbursed on time, and linked to measurable outputs; and (ii) institutional capacity, referring to the ability of state institutions to design, implement, and monitor S&T policies effectively* (Guellec & van Pottelsberghe, 2003). When these two conditions are met, public R&D can generate significant "leverage effects," crowding in private investment and amplifying innovation impacts. Conversely, weak institutions or inefficient allocation dilute the effectiveness of public budgets.

In Vietnam, however, empirical evidence on these mechanisms remains scarce. Existing studies largely describe aggregate spending trends or innovation outputs at the macro level without unpacking the transmission mechanisms between policy and outcomes. This creates a critical research gap: the need for a theoretical and empirical model that incorporates the mediating role of allocation efficiency and the moderating role of institutional capacity in the relationship between public spending and innovation.

This gap is particularly significant in the context of Vietnam's international comparisons. While ASEAN peers such as Singapore, Malaysia, and Thailand have advanced through institutional reforms and competitive allocation frameworks, Vietnam's position in the Global Innovation Index has stagnated around rank 44 in 2024 – despite being among the region's fastest-growing economies (WIPO, 2023). This paradox demonstrates that innovation does not automatically follow GDP growth; rather, it hinges on institutional quality and efficient public financial management.

Therefore, this study carries dual significance. Theoretically, it contributes empirical evidence to the global debate on the effectiveness of public R&D spending in driving innovation, especially in emerging economies. Practically, it offers timely policy insights for Vietnam's ongoing fiscal and institutional reforms, advocating a paradigm shift from "public spending" to "strategic public investment" in S&T. Only by ensuring sufficient scale, efficient allocation, and institutional robustness can public resources effectively translate into innovation outcomes that strengthen Vietnam's global competitiveness.

2. Literature review

2.1. Public R&D Investment Theory

The foundational premise of public R&D investment theory rests upon the insights of Nelson (1959) and Arrow (1962), who argued that scientific and technological knowledge is a public good, characterized by non-rivalry and non-excludability. As markets systematically underprovide public goods, governments are expected to play the role of "strategic investor," financing basic science, research infrastructure,

and the development of national innovation capacity.

Evidence over decades supports this role. David, Hall, and Toole (2000) demonstrated that public R&D often complements private investment, creating "crowding-in" effects by reducing risk and providing essential infrastructure. Guellec and van Pottelsberghe (2003) found that public R&D positively impacts labor productivity and knowledge diffusion, particularly when resources are strategically allocated.

Yet, recent literature offers a more nuanced view. In emerging economies, public R&D spending does not always yield proportional innovation outcomes (Aghion, Antonin, & Bunel, 2021). Kim and Park (2022) provide evidence of "crowding out" when public funds are poorly targeted, diminishing private firms' incentives to invest. Vietnam exemplifies this paradox: although public R&D expenditure has steadily increased – from about 0.15% of GDP in 2011 to roughly 0.43% in 2021 – innovation outputs such as patents, international publications, and total factor productivity remain modest compared with regional peers, with enterprise-level studies showing that growth has been driven largely by capital accumulation rather than productivity gains (OECD, 2025; Ha et al., 2024; Economies, 2021). This underscores the argument that the quality of spending – its design, allocation mechanisms, and governance – matters as much as, if not more than, its quantity.

Within ASEAN, success stories such as Singapore and Malaysia highlight how strategic public investment, coupled with strong institutional frameworks, has spurred private R&D and innovation ecosystems (ASEAN Secretariat, 2022). By contrast, Indonesia and the Philippines illustrate how fragmented allocation and weak oversight undermine the effectiveness of increased budgets (Intarakumnerd & Chaminade, 2011). For Vietnam, this theory implies that public R&D must be conceived as a long-term accumulative investment, not merely as annual fiscal expenditure.

2.2. New Public Management (NPM) Theory

NPM theory emerged in the 1980s, emphasizing efficiency, accountability, and outcome-oriented governance (Hood, 1991). In the realm of S&T, NPM reframes the state's role from a passive "funder" to an active "market enabler," linking public spending directly to research performance and innovation outcomes (Dunleavy & Hood, 1994).

In contexts where resources are scarce, NPM has been widely promoted as a mechanism to enhance budget utilization. OECD (2023) notes that performance-based funding, output-based financing, and competitive tenders have significantly improved transparency and efficiency in several advanced and emerging economies. Korea's experience demonstrates how applying NPM principles to public R&D allocation strengthened its innovation capacity while balancing basic and applied research (Kim, 2022).

Vietnam, where budgeting for science and technology often remains fragmented and discretionary, could substantially benefit from applying New Public Management principles – linking resource allocation to outcomes, enhancing transparency, and introducing performance-based mechanisms (Pollitt & Bouckaert, 2011; OECD, 2023; World Bank, 2017). Competitive mechanisms can mitigate administrative bias, channeling resources toward productive research entities.

Nevertheless, NPM has been subject to critical scrutiny. Marginson (2011) argues that performance-based funding risks undermining basic research, which is essential but yields uncertain and long-term outcomes. Chou (2021) cautions that in East Asia, premature adoption of NPM has led to excessive commercialization pressures, marginalizing fundamental research. Vietnam, therefore, must strike a balance: using

NPM-inspired accountability and competition while safeguarding strategic investment in basic science.

2.3. Institutional Capacity Theory

North's (1990) institutional economics perspective emphasizes that effective policy implementation depends on the quality of institutions, not merely on the scale of resources. Institutional capacity encompasses legal frameworks, decision-making processes, organizational strength, coordination mechanisms, and monitoring systems. In R&D, strong institutions ensure that public resources are allocated transparently and efficiently, enabling real innovation outcomes.

ASEAN evidence demonstrates the significance of institutional quality. Singapore and Malaysia have leveraged robust institutional frameworks to build dynamic national innovation systems, characterized by transparent allocation, accountability, and collaborative linkages across state, industry, and academia (ASEAN Secretariat, 2022). In contrast, Indonesia and the Philippines struggle with weak oversight and fragmented governance, which undermine the effectiveness of increased public spending (Intarakumnerd & Chaminade, 2011).

Recent studies confirm Vietnam's institutional challenges: delays in disbursement, weak labor policies, and limited local governance capacity reduce the effectiveness of public R&D spending. Evidence shows that even with rising investments, innovation outcomes remain constrained unless transparency, accountability, and governance reforms are strengthened (Ha et al., 2024). This suggests that institutional reform is a prerequisite for Vietnam's innovation-driven development strategy. Without transparent processes, clear accountability, and strong governance, increased public R&D budgets will not translate into sustainable innovation.

The critical gap in existing literature lies in the lack of integrated models that simultaneously capture the role of allocation efficiency and institutional capacity as mediators and moderators of the public R&D–innovation relationship. This study addresses that gap, contributing to both theory and policy practice.

2.4. Research Hypothesis

Based on the foundational theoretical frameworks of public spending and R&D (Arrow, 1962; Nelson, 1959), New Public Management (NPM) (Hood, 1991), and institutional theory (Scott, 2008; Peters, 2001), this study proposes three main hypotheses that reflect the causal relationships among the characteristics of public spending, allocation efficiency, institutional capacity, and the outcomes of science, technology, and innovation (STI) in Vietnam.

(i) H1+: Public spending on science and technology (S&T), when characterized by prioritization, stability, functional allocation, and reasonable scale, has a positive impact on STI outcomes.

(ii) H2+: Allocation efficiency serves as a mediating variable in the relationship between public spending and STI outcomes.

(iii) H3+: Institutional capacity moderates the relationship between public spending and allocation efficiency, such that stronger institutional capacity enhances the positive effect of public spending on allocation efficiency.

3. Conceptual Framework

This study proposes a conceptual model that explores the relationship between public expenditure on science and technology (S&T) and innovation outcomes in Vietnam, incorporating both mediating and moderating mechanisms to capture the complexity of fiscal policy implementation. The model postulates that allocation efficiency acts as a mediating variable linking public spending to innovation outcomes, while institutional capacity serves as a moderating variable that conditions the strength

of this relationship. In addition, economic scale is included as a control variable to account for macroeconomic influences.

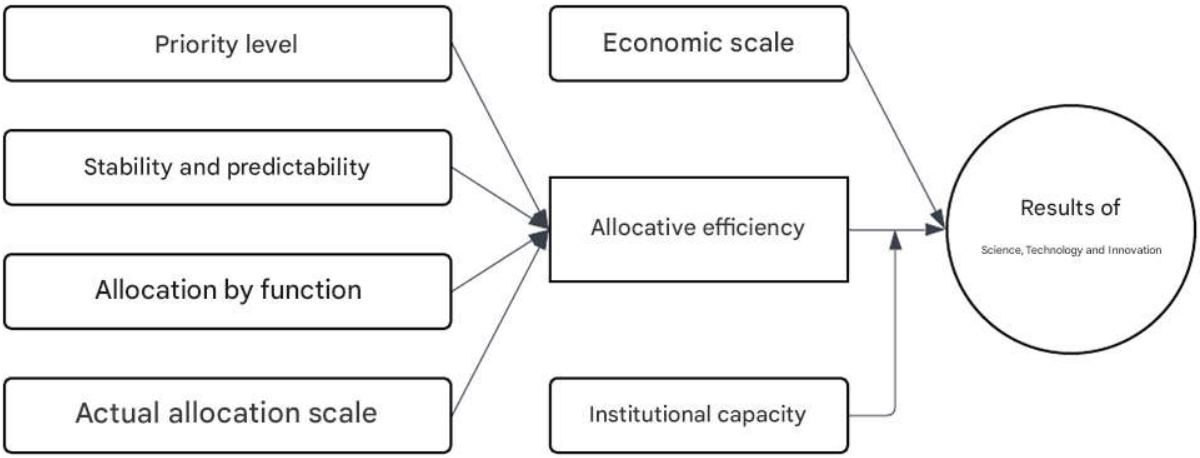

Figure 1. Research Model
(Source: Author's)

Public expenditure characteristics are operationalized through four latent constructs: (1) Prioritization (IV_PL), measured by the share of S&T spending in total public expenditure, reflecting policy commitment (Arrow, 1962; Nelson, 1959); (2) Stability and predictability (IV_SP), capturing fiscal reliability and medium-term budget consistency (OECD, 2015); (3) Functional allocation (IV_FA), representing alignment of R&D budgets with national priorities (Guellec & van Pottelsberghe, 2003); and (4) Actual disbursement scale (IV_AS), quantifying the relative size of R&D investment against GDP or total budgetary resources.

The dependent variable, Innovation Outcomes (DV_Result), captures systemic returns of public R&D spending through expert perceptions on a five-point Likert scale. Observable indicators include: (1) perceived quality and quantity of research outputs, (2) application and diffusion of research results, (3) contributions to both public and private sector innovation, (4) linkages to commercialization and knowledge spillovers, and (5) overall assessment of the funding system's effectiveness (Lichtenberg, 1988; David, Hall, & Toole, 2000).

The mediating construct, Allocation Efficiency (Mid_AE), reflects whether public resources are optimally distributed to generate expected returns. Items include alignment of budget with needs, timeliness of disbursement, linkage between spending and results, cost-effectiveness, and overall satisfaction with budget use. This operationalization draws on New Public Management theory, which emphasizes transparency, accountability, and output-oriented governance (Hood, 1991; Pollitt & Bouckaert, 2011).

The moderating construct, Institutional Capacity (RV_IC), refers to the effectiveness of state institutions in implementing and supervising S&T fiscal policies. Dimensions include organizational structure, clarity of delegation, human resource competence, and monitoring mechanisms (Scott, 2008; Peters, 2001). According to institutional theory, strong governance enhances the transformation of public resources into tangible innovation outcomes.

Finally, Economic Scale (CV_ES), measured by GDP and government expenditure size, is introduced as a control variable,

consistent with endogenous growth theory (Romer, 1990), which posits that larger economies are better positioned to invest effectively in R&D.

The study employed a purposive sampling strategy targeting stakeholders directly involved in the policy cycle of S&T expenditure. A total of 417 respondents were surveyed, including central-level budget officers (Ministry of Finance), S&T policy managers (Ministry of Science and Technology), representatives of research institutes and universities, experts from policy think tanks (CIEM, NEU, VASS), and principal investigators of ministerial/national projects. After data screening, 396 valid responses were retained, achieving a response rate exceeding 95%. The demographic profile of respondents reflects balanced representation across administrative, academic, and research sectors, with most participants having over 10 years of experience in S&T management.

To ensure measurement reliability, Cronbach's Alpha values were calculated for all constructs, ranging from 0.898 to 0.959 (Table 1), exceeding the recommended threshold of 0.7 (Nunnally & Bernstein, 1994), thereby confirming strong internal consistency.

Table 1. Scale Reliability Test Result

Factor	*Num**	*Variable – Total Correlation*	*Cronbach's Alpha if Variable Deleted*	*Cronbach's Alpha*
IV_PL	7	0.703 – 0.754	0.895 – 0.901	0.911
IV_SP	7	0.682 – 0.730	0.879 – 0.885	0.898
IV_FA	8	0.739 – 0.790	0.921 – 0.925	0.932
IV_AS	8	0.660 – 0.722	0.888 – 0.894	0.903
Mid_AE	6	0.830 – 0.907	0.947 – 0.955	0.959
DV_Result	10	0.716 – 0.869	0.952 – 0.958	0.958
RV_IC	7	0.705 – 0.766	0.900 – 0.907	0.916

**Number of observed variables*

(Source: Author's – IBM SPSS Statistics 26.0)

Data analysis followed a multi-step procedure: (1) Confirmatory Factor Analysis (CFA) was conducted to assess construct validity, convergent validity, and discriminant validity; (2) Structural Equation Modeling (SEM) was applied to estimate direct and indirect causal paths, testing the mediating role of allocation efficiency and overall model fit using indices such as CFI, TLI, RMSEA, and χ^2/df; and (3) Interaction regression analysis was employed in SPSS to examine the moderating effect of institutional capacity. Additionally, expert consultations were undertaken to validate content relevance and ensure contextual appropriateness of measurement items.

This integrated framework thus provides a robust empirical basis for testing the interplay of fiscal policy design, institutional governance, and innovation outcomes in Vietnam, while aligning with international literature on public R&D investment effectiveness in emerging economies.

4. Research result

4.1. Confirmatory Factor Analysis (CFA)

The CFA results conducted on four latent constructs representing the core aspects of public expenditure – namely, Spending Priority (IV_FA), Allocative Stability (IV_AS), Functional Allocation (IV_PL), and Spending Scale (IV_SP) – strongly support the validity and

goodness-of-fit of the proposed measurement model (Table 2).

The model yielded an exceptional fit to the empirical data, with a Chi-square/df ratio = 1.010, and indices such as GFI (0.938), CFI and TLI all approximating 0.999 – far exceeding the commonly accepted threshold of 0.95 (Hair et al., 2014). The RMSEA value of 0.005, accompanied by a PCLOSE = 1.000, indicates a near-zero error of approximation and suggests no statistical grounds for rejecting the model fit (Hu & Bentler, 1999; Byrne, 2016).

Table 2. Model fit analysis (CFA) results

Indicator	*Value*
CMIN	403.142
DF	399
P	0.000
CMIN/DF	1.010
GFI	0.938
TLI	0.999
CFI	0.999
RMSEA	0.005
PCLOSE	1.000

(Source: Author's – IBM Amos 24.0)

In terms of internal consistency reliability, all constructs exhibited high Composite Reliability (CR > 0.89) and Average Variance Extracted (AVE > 0.54), confirming a strong degree of convergent validity and measurement consistency, in Table 3 (Fornell & Larcker, 1981; Hair et al., 2014). Moreover, discriminant validity was affirmed as all Maximum Shared Variance (MSV) values were lower than the corresponding AVE, and all HTMT (Heterotrait-Monotrait ratio) values ranged narrowly from 0.016 to 0.074 – far below the critical cut-off of 0.85, suggesting low conceptual overlap among latent variables (Henseler, Ringle & Sarstedt, 2015).

Table 3. Convergence and Discrimination Results

	Validity Analysis								*HTMT Anslysis*			
	CR	***AVE***	***MSV***	***MaxR(H)***	***IV_FA***	***IV_AS***	***IV_PL***	***IV_SP***	***IV_FA***	***IV_AS***	***IV_PL***	***IV_SP***
IV_FA	0.932	0.633	0.002	0.933	0.795							
IV_AS	0.904	0.540	0.005	0.904	-0.038	0.735			0.041			
IV_PL	0.911	0.595	0.005	0.912	0.015	0.070	0.771		0.016	0.074		
IV_SP	0.898	0.557	0.004	0.899	-0.046	-0.057	0.066	0.747	0.045	0.058	0.061	

(Source: Author's – IBM Amos 24.0)

All factor loadings were high, ranging from 0.86 to nearly 1.00, indicating that the observed indicators are well-specified and effectively capture their respective theoretical constructs (Hair et al., 2014). These findings reinforce the theoretical validity rooted in public expenditure economics and New Public Management (NPM) theory, underscoring a coherent structure underlying the measurement model.

Regarding inter-construct relationships, the standardized path coefficients from IV_FA to other constructs ranged from 0.31 to 0.54, suggesting a moderately strong influence of budgetary priority on both the scale and functional orientation of spending. In contrast, some cross-construct relationships, such as from IV_AS to IV_PL, displayed weak or slightly negative associations. These may reflect the

complexities in Vietnam's R&D budgeting system, where policy consistency alone does not guarantee efficient allocation in the absence of strong administrative incentives or reform-oriented governance.

Overall, the CFA results confirm a highly robust measurement model, satisfying stringent criteria for reliability, convergent validity, and discriminant validity. This provides a solid empirical foundation for proceeding with the Structural Equation Modeling (SEM) phase, where causal relationships among public spending characteristics, allocation efficiency, and innovation outcomes will be rigorously tested in accordance with the proposed theoretical framework.

4.2. Linear Structural Model Analysis (SEM)

Table 4. Model fit analysis (SEM) results

Indicator	*Value*
CMIN	1188.992
DF	970
P	0.000
CMIN/DF	1.226
TLI	0.983
CFI	0.984
RMSEA	0.024
PCLOSE	1.000

(Source: Author's – IBM Amos 24.0)

The structural equation modeling (SEM) analysis, comprising four latent independent variables – Spending Priority (IV_FA), Stability and Predictability (IV_AS), Functional Allocation (IV_PL), and Actual Budget Scale (IV_SP) – along with one mediating variable (Allocative Efficiency – Mid_AE) and one dependent variable (Science, Technology and Innovation Outcomes – DV_Result), revealed a remarkably high degree of model fit between the theoretical framework and empirical survey data (see Table 4). The fit indices – CFI = 0.984, TLI = 0.983, RMSEA = 0.024, and PCLOSE = 1.000 – fall within the ideal thresholds proposed by Hu and Bentler (1999), thereby confirming the model's stability and replicability.

Table 5. Result of Causal Impact Analysis and Mediating Role

Factor	***Estimate***		***Std. Coeff***		***C.R.***		***p-value***	
	Mid_AE	*DV_Result*	*Mid_AE*	*DV_Result*	*Mid_AE*	*DV_Result*	*Mid_AE*	*DV_Result*
IV_SP	0.183	0.181	0.379	0.279	7.517	5.223	0.000	0.000
IV_AS	0.113	0.138	0.258	0.234	5.343	4.685	0.000	0.000
IV_PL	0.135	0.077	0.236	0.100	4.951	2.074	0.000	0.038
IV_FA	0.101	0.135	0.208	0.206	4.466	4.315	0.000	0.000
Mid_AE		0.290		0.216		3.878		0.000

(Source: Author's – IBM Amos 24.0)

The path analysis results show that all independent variables exert statistically significant effects on R&D budget allocative efficiency (Table 5). Among these, Actual Budget Scale (IV_SP) emerged as the strongest predictor (β = 0.379), followed by Stability (IV_AS: β = 0.258), Functional Allocation (IV_PL: β = 0.236), and Spending Priority (IV_FA: β = 0.208). These findings imply that not only the mechanisms but also the magnitude and consistency of public budget allocation play a central role in enhancing the effectiveness of state investment in science and technology.

In terms of impacts on STI outcomes (DV_Result), the analysis revealed that both allocative efficiency (Mid_AE) and the four independent constructs have direct effects on the dependent variable (Table 6). Specifically, Mid_AE exhibits a notable mediating effect (β = 0.216), underlining its role as a transmission mechanism between public expenditure and outcomes. Simultaneously, IV_SP (β = 0.279), IV_AS (β = 0.234), and IV_FA (β = 0.206) present statistically significant direct effects, while IV_PL (β = 0.100; p = 0.038) exerts a weaker influence, approaching the threshold of significance.

Table 6. Summary of Direct and Indirect Effects

Factor	*Direct to DV_Result*	*Indirect via Mid_AE*	*Total Impact**
IV_FA	0.206	0.208 × 0.216 = 0.045	0.251
IV_AS	0.234	0.258 × 0.216 = 0.056	0.290
IV_PL	0.100	0.236 × 0.216 = 0.051	0.151
IV_SP	0.279	0.379 × 0.216 = 0.082	0.361

**Total Impact = Direct Impact + Indirect Impact*

(Source: Author's – IBM Amos 24.0)

The aggregation of direct and indirect effects from each independent variable to DV_Result indicates that Actual Budget Scale (IV_SP) is the most influential factor overall (total effect = 0.361), with nearly 25% of this impact mediated through allocative efficiency. This finding offers compelling empirical evidence that allocative efficiency serves as an essential transmission channel through which public investment policy can be effectively translated into quantifiable innovation outcomes, such as the number of international scientific publications, patents, or improvements in the Global Innovation Index (GII). In the context of tightening public budgets and rising innovation demands, the study emphasizes that enhancing allocative efficiency – rather than merely increasing total expenditure – is the critical lever for improving innovation system performance.

Table 7. Results of Indirect Effect Test

Path	*Lower Bound (BC)*	*Upper Bound (BC)*	*p-value*	*Conclusion*
IV_PV → Mid_AE → DV_Result	0.018	0.074	0.000	Significant
IV_AS → Mid_AE → DV_Result	0.017	0.055	0.000	Significant
IV_FA → Mid_AE → DV_Result	0.015	0.051	0.000	Significant

IV_SP → Mid_AE → DV_Result	0.031	0.083	0.000	Significant

(Source: Author's – IBM Amos 24.0)

Following the SEM-based causal analysis, the study employed a Bootstrap technique with 5,000 resamples, using the Bias-Corrected Percentile (BC) method at the 95% confidence level, to test the mediating role of R&D allocative efficiency (Mid_AE) in the relationships between budgetary input variables and innovation outcomes (DV_Result).

The bootstrap summary presented in Table 7 shows that all indirect paths exhibit confidence intervals that exclude zero, thereby confirming statistical significance:

(1) IV_PV → Mid_AE → DV_Result: 0.018 – 0.074

(2) IV_AS → Mid_AE → DV_Result: 0.017 – 0.055

(3) IV_FA → Mid_AE → DV_Result: 0.015 – 0.051

(4) IV_SP → Mid_AE → DV_Result: 0.031 – 0.083

These results unequivocally confirm the mediating role of allocative efficiency in transmitting the effects of public expenditure characteristics to scientific and technological innovation outcomes. Notably, the strongest indirect effect was found in the pathway from Actual Budget Scale (IV_SP) to DV_Result via Mid_AE, highlighting the imperative of goal-oriented budgeting rather than rigid envelope allocations.

The findings affirm that not only do public R&D input variables exert direct influence on innovation outcomes, but allocative efficiency (Mid_AE) also acts as an essential "administrative-financial conduit" that translates policy intentions into real-world effectiveness. This conclusion resonates with the theoretical propositions of New Public Management (Hood, 1991) and Public R&D Investment Theory (David et al., 2000; Lichtenberg, 1988), both of which emphasize that the effects of public spending are not solely contingent on scale, but fundamentally shaped by the efficiency of allocation and implementation processes.

In sum, the SEM results not only validate the theoretical and causal structure of the proposed research model but also offer robust empirical grounds for policy recommendations. Public investment in science and technology in Vietnam will only achieve tangible innovation outcomes when budgetary allocations are sufficiently large, consistently maintained, and governed under a performance-oriented framework – with allocative efficiency serving as a "regulatory valve" that activates and amplifies innovation dynamics.

4.3. Multiple Regression Analysis with Interaction (MMR)

The results of the multiple regression analysis indicate that the overall model is statistically significant, with an R^2 value of 0.314 and an adjusted R^2 of 0.298 (Table 8). This suggests that approximately 31.4% of the variance in Innovation Outcome (IO) is explained by the independent variables, the moderating variable, and their interaction terms (Cohen, 1988). The Durbin–Watson statistic is 2.119, falling within the acceptable range (1.5–2.5), which confirms the absence of autocorrelation among residuals and supports the assumption of error term independence in the regression model (Field, 2013).

Table 8. Summary of Regression Results

Model	*R*	*R^2*	*R^2 Adjusted*	*Durbin – Watson*	*Sig. (ANOVA)*
1	0.560[a]	0.314	0.298	2.119	0.000[b]

a. Predictors: (Constant), Zscore(IV_FA), Zscore(IV_AS), Zscore(IV_PL), Zscore(IV_SP), Zscore(RV_IC), IC_FA, IC_AS, IC_PL, IC_SP.
b. Dependent Variables: DV_Result

(Source: Author's – IBM SPSS Statistics 26.0)

Among the key predictors, all four components of public spending on science and technology – namely IV_FA, IV_AS, IV_PL, and IV_SP – exhibit positive and statistically significant effects on the dependent variable (DV_Result), with p-values less than 0.005 (Fisher, 1925). The corresponding standardized beta coefficients are 0.231, 0.287, 0.133, and 0.311, respectively. These findings validate that appropriately allocated and effective public investments across different facets of science and technology expenditure are closely associated with the advancement of innovation in Vietnam.

Table 6. Fatorial Regression Results

	Model	***Unstandardized B***	***Beta***	***Sig.***	***VIF***
1	(Constant)	0.000		0.991	
	Zscore(IV_FA)	0.227	0.231	0.000	1.019
	Zscore(IV_AS)	0.282	0.287	0.000	1.031
	Zscore(IV_PL)	0.130	0.133	0.002	1.048
	Zscore(IV_SP)	0.306	0.311	0.000	1.031
	Zscore(RV_IC)	0.236	0.240	0.000	1.032
	IC_FA	0.029	0.030	0.484	1.018
	IC_AS	-0.014	-0.012	0.771	1.028
	IC_PL	0.014	0.015	0.730	1.048
	IC_SP	-0.016	-0.017	0.694	1.026

(Source: Author's – IBM SPSS Statistics 26.0)

Regarding the moderating variable, Institutional Capacity (IC), its interaction effects (IC_FA, IC_AS, IC_PL, and IC_SP) yield very small standardized beta values (ranging from -0.017 to 0.030), none of which reach statistical significance ($p > 0.05$). This indicates that institutional capacity does not significantly moderate the relationship between public S&T spending and innovation outcomes. In other words, while public expenditure exerts a direct and positive influence on innovation, the magnitude of this effect is not contingent upon variations in institutional capacity.

All Variance Inflation Factor (VIF) values are below 1.05, confirming the absence of multicollinearity among the independent and interaction variables in the model (Neter, Wasserman & Kutner, 1989).

4.4. The Relationship between Economic Scale and Innovation Capacity

Gross Domestic Product (GDP) – a metric representing the scale of a national economy – is not merely a numerical indicator of financial strength. Rather, it symbolizes the material foundation upon which an innovation ecosystem can take root, grow, and diffuse. Data reveals that Vietnam has undergone a remarkable economic transformation, with GDP rising from USD 14.09 billion in 1985 to USD 476.39 billion in 2024 – an increase of more than 33 times over nearly four decades (Figure 5). Notably, since 2010 – the year Vietnam officially entered the group of middle-income countries – GDP growth has maintained a steady and consistently positive

trajectory, with key milestones including USD 147.2 billion in 2010, USD 310.1 billion in 2018, and USD 433.8 billion in 2023 (Table 7).

Within the National Innovation System (NIS), economic scale constitutes a critical input factor, as it expands the capacity for:

(1) Budgetary allocation to research and development (R&D),

(2) Investment in both digital and physical infrastructure,

(3) Upgrading higher education systems and training a highly skilled workforce,

(4) Creating markets for new technological products.

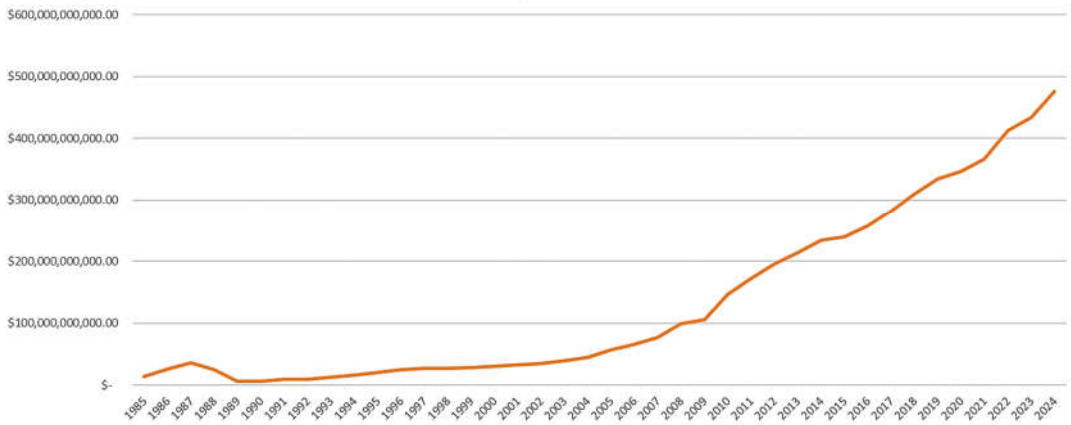

Figure 5. Vietnam GDP Statistics 1985 - 2024

(Source: Database GDP [Current US$] VietNam from WorldBank)

According to Freeman (1987) and Lundvall (1992), once an economy reaches a certain "maturity" in scale, it not only possesses sufficient resources to nurture science and technology infrastructure but also generates competitive pressure among enterprises, thereby stimulating an intrinsic demand for innovation as a means of survival and development in the marketplace.

Table 7. Comparing Vietnam's GDP and GII in the period 2010 - 2024

Year	*GDP (USD)*	*GII Ranking*
2010	$147,201,173,196.98	71
2011	$172,595,049,183.93	51
2012	$195,590,661,129.25	76
2013	$213,708,811,665.34	52
2014	$233,451,469,642.52	59
2015	$239,258,328,381.74	47
2016	$257,096,001,177.98	45
2017	$281,353,605,986.90	42
2018	$310,106,478,394.66	42
2019	$334,365,270,496.67	44
2020	$346,615,738,537.80	48
2021	$366,474,752,771.01	46
2022	$413,445,230,668.58	44

(Source: Database GDP [Current US$] VietNam from WorldBank)

The Global Innovation Index (GII) serves as a comprehensive and multidimensional instrument to assess a country's innovation capacity. It encompasses seven core pillars: institutions, human capital and research, infrastructure, market and business sophistication, knowledge and technology outputs, and creative outputs. This index – jointly produced by WIPO, INSEAD, and Cornell University – reflects both the input and output dimensions of national innovation systems.

Over the past decade, Vietnam has made steady progress on the GII, rising from 71st place in 2010 to 44th in 2024, entering the top 50 most innovative economies worldwide. Crucially, improvements in Vietnam's GII rankings have not always followed a linear path relative to GDP growth, indicating that innovation performance is not solely determined by economic resources but also hinges on institutional quality, resource allocation efficiency, and the degree of interaction among innovation actors (the triple helix of government–industry–academia).

For instance, in 2012, although Vietnam's GDP increased, its GII ranking declined to 76th place – highlighting that while economic growth is a necessary condition, effective governance and strategic resource allocation are sufficient conditions.

From the dataset provided, three core arguments can be drawn to elucidate the dialectical relationship between economic scale and innovation capacity:

(1) Infrastructure and technological investment increase with GDP growth: Economic expansion enhances the ability to allocate funds to R&D, improve technological infrastructure, and support enterprise innovation. According to WIPO (2023), countries with larger GDPs tend to have higher GII input scores, attributable to investments in higher education and research.

(2) Market expansion and competitive pressure spur innovation: A larger economy entails a broader market, which increases demand for innovative products and services. Enterprises are compelled to invest in technology, governance, and talent development to remain viable—creating a context of endogenous innovation pressure (Porter, 1990).

(3) The relationship is non-linear and mediated by institutional factors: The asymmetry between GDP growth and GII rankings suggests that transparency in institutions, efficient allocation strategies, and synergetic interactions among innovation stakeholders are crucial for fully leveraging the benefits of economic growth.

Scientific, technological, and innovation outcomes can thus be indirectly, macro-economically, and holistically measured through the GII. From the statistical evidence, it can be concluded that economic scale serves as the material foundation and launchpad for national innovation capacity. However, to fully realize this potential, coordinated innovation governance is imperative. One cannot assume a linear correlation wherein "larger GDP equates to higher GII." This relationship, therefore, embodies both logical inevitability and governance challenge – ultimately serving as the proving ground for national policy acumen and innovation-minded leadership.

5. Finding and discussion

The research findings confirm a pivotal reality: public spending on science and technology (S&T) – if well-designed and effectively administered – can serve as a powerful catalyst for fostering innovation. The positive impact of the four components of public expenditure (priority level, budget stability, functional allocation, and actual disbursement scale) on innovation outcomes (IO) is not only manifested through direct effects, but also diffuses via a mediating variable: budget allocation efficiency – an administrative factor reflecting implementation quality.

Notably, the study reveals that the component of "actual disbursement scale" exerts the strongest influence on innovation outcomes, both directly and indirectly (total $\beta = 0.361$), followed by budget stability and predictability. This finding is consistent with the classical assertions of David, Hall & Toole (2000) and Lichtenberg (1988), which argue that public investment only becomes effective when it is sufficiently large and optimally utilized. In other words, not every R&D expenditure yields tangible outcomes – the decisive factor lies in the allocation mechanism and the ability to translate fiscal inputs into practical results, as emphasized in the principles of New Public Management (Hood, 1991; Behn, 2003).

Moreover, allocation efficiency (Mid_AE) emerges as a critical mediating link. All indirect effects from the features of public expenditure to innovation outcomes via this variable are statistically significant ($p < 0.001$). This reinforces the OECD's (2015) standpoint that how resources are allocated is just as important as how much is allocated – especially in developing countries like Vietnam, where resources are often constrained and monitoring systems remain underdeveloped.

However, the research also highlights a paradox of concern: the moderating variable "institutional capacity" (RV_IC) does not exhibit a statistically significant moderating effect as hypothesized. Contrary to institutional theory (Scott, 2008; Peters, 2001), which regards institutional quality as a prerequisite for converting resources into outcomes, in Vietnam's case, the prevailing institutional framework appears insufficiently robust to perform a regulatory function. This may stem from the fact that Vietnam's institutions – despite undergoing reforms – remain heavily administrative-command in nature, lacking mechanisms for independent evaluation and accountability, thereby weakening their regulatory influence. In contrast, countries like South Korea, where institutions are more developed, demonstrate that institutional capacity significantly shapes R&D spending efficiency (OECD, 2023).

When compared with prior research, this study both reinforces and deepens several theoretical arguments. First, it aligns with Guellec and van Pottelsberghe's (2003) finding that public spending—if properly prioritized and functionally allocated – can generate a leverage effect, encouraging private sector investment and enhancing innovation productivity. However, the novel contribution of this study lies in its explicit articulation of budget allocation efficiency as an administrative intermediary – a factor that has not been systematically addressed in most Vietnamese or ASEAN-region research to date.

Furthermore, the study situates its analysis within the unique context of Vietnam, where GDP growth does not always correlate with improvements in Global Innovation Index (GII) rankings. This underscores that while economic scale is a necessary condition, the sufficient condition for fostering innovation lies in budget utilization efficiency and institutional governance capacity. This constitutes a "policy redirection insight," suggesting that increasing R&D funding must be accompanied by fiscal governance reform, enhanced transparency in allocation processes, and strengthened mechanisms for independent evaluation.

In summary, the research concludes that public spending on S&T in Vietnam only yields substantial innovation outcomes when three conditions are simultaneously met:

(i) adequate scale,

(ii) efficient allocation, and

(iii) operation within a transparent, accountable institutional environment.

Innovation effectiveness cannot be achieved solely through increased financial resources – it requires a competent, goal-oriented, and performance-measured policy–governance–implementation system. This is not merely a research message, but a policy warning of deep practical significance for Vietnam's next phase of development.

6. Suggested management implications

Based on the quantitative findings and theoretical reasoning presented, several critical managerial implications can be drawn to enhance the effectiveness of public spending on science and technology (S&T) and to accelerate innovation outcomes (IO) in Vietnam:

First, there is a pressing need to shift from a "spending mindset" to a "strategic public investment" approach in S&T.

The research results demonstrate that both the scale and stability of S&T budgets have a significantly positive effect on innovation outcomes. Accordingly, the State should reposition S&T budget allocations as long-term developmental investments rather than routine expenditures. Mechanisms should be established to ensure that public spending on S&T reaches the target threshold of 2% of GDP, as set forth in Resolution No. 57-NQ/TW (2025), while also integrating financial planning for S&T into national development strategies. Any reduction in the S&T budget should be cautiously considered as a form of "strategic divestment."

Second, it is essential to undertake profound reforms in the budget allocation mechanism, steering it toward results-based governance.

Allocation efficiency, as identified in the study, is a pivotal mediating variable reflecting the quality of fiscal policy implementation. This highlights the necessity of restructuring the S&T budgeting process from the ground up, including:

(i) preparing expenditure plans based on actual needs and the absorptive capacity of recipient units;

(ii) adopting an output-based funding mechanism;

(iii) establishing performance measurement systems and conducting regular public expenditure reviews.

Implementing a performance-based budgeting model will mitigate the prevalence of fragmented, discretionary allocation practices and ensure that every public dollar is used with maximum efficiency.

Third, a "unified coordination mechanism" among central, local, and implementing stakeholders should be institutionalized.

Innovation cannot thrive in a fragmented policy environment. In practice, linkages among central agencies, local authorities, and implementing entities remain weak and misaligned in terms of allocation priorities and performance monitoring. Therefore, it is recommended to establish National Coordination Councils for S&T Budgeting, comprising representatives from the Ministry of Finance, Ministry of Science and Technology, enterprises, universities, and local governments. These councils should be empowered to provide cross-cutting advisory and supervisory roles throughout the public expenditure cycle. This collaborative mechanism would ensure strategic coherence and avoid overlapping or redundant initiatives.

Fourth, there must be a strengthening of independent monitoring and evaluation institutions.

Although institutional capacity appears to influence overall effectiveness, the moderating role remains weak due to the absence of robust independent evaluation mechanisms. Therefore, Vietnam should establish independent budget oversight units for S&T – akin to Offices of Science and Technology Audit – to scrutinize project implementation, disbursement quality, and real-world impacts. The findings from these evaluations must be made publicly available and used as a basis for adjusting future allocations.

Fifth, innovation should be aligned with national sustainable development goals and digital economy strategies.

Innovation should not be pursued as an end in itself but should serve national priorities such as digital transformation, the advancement of high-tech industries, and climate resilience. Hence, public spending on S&T must be strategically directed toward national target programs with clearly defined priority weights. Refocusing the S&T budget according to clusters

of strategic objectives will create integrated pull effects, maximizing impact and policy coherence.

Lastly, it is imperative to promote transparency, competition, and accountability across the entire funding chain.

All expenditures for research and innovation should be monitored through a unified, digitalized database system that discloses allocation decisions, implementation progress, and output impacts. Budget recipients must be held accountable for tangible results rather than formalistic indicators. An open, competitive grant mechanism, evaluated by independent scientific councils, will generate constructive pressure, foster creativity, and dismantle entrenched patronage-based funding practices.

In conclusion, the managerial implications drawn from this study not only offer technical recommendations for improving public S&T spending policy, but also suggest a broader governance mindset—rooted in performance, transparency, and institutional effectiveness. In the context of Vietnam's ongoing transformation toward a knowledge-based and fully digital economy, these reforms represent the foundational pillars for shaping a genuinely impactful and sustainable national innovation ecosystem.

Limitations of the study

Although this study established a robust theoretical model and conducted systematic empirical validation, several limitations remain. First, the use of perceptual surveys with Likert scales for latent constructs (e.g., innovation outcomes, allocative efficiency, institutional capacity) entails subjective bias and does not fully incorporate objective indicators such as patents, scientific publications, or the Global Innovation Index (GII). Second, the survey sample mainly focused on ministerial officials, research institutions, and policy experts, thereby limiting the generalizability of findings to broader innovation actors such as enterprises, startups, and non-traditional entities. Third, the study only tested institutional capacity as a moderating factor, without examining other possible moderators like organizational culture, market structures, or international integration, which may also shape policy outcomes. Finally, the cross-sectional design constrains the ability to capture temporal dynamics or disentangle causal from contemporaneous relationships.

Future research should therefore: (1) integrate objective indicators (patents, publications, TFP, GII, technological spillovers) into the model; (2) expand the sample to include enterprises, startups, and diverse innovation actors; (3) test multi-level and multi-dimensional moderators, particularly organizational culture and internationalization; and (4) employ longitudinal or panel data designs to capture the dynamic and accumulative nature of public sector innovation.

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