

Institutional Efficiency and Research Productivity in Transitional Higher Education Systems: Panel Evidence from Uzbekistan

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Abstract

This study investigates the determinants of research productivity in Uzbekistan's public universities using a balanced panel of 15 institutions over 2010–2023. The analysis integrates three complementary dimensions: human capital, institutional efficiency, and macroeconomic conditions to explain why research output varies markedly across universities during a period of rapid reforms. A fixed-effects instrumental-variable model is employed to control for unobserved institutional characteristics and potential endogeneity in spending efficiency and economic indicators. The results show that academic staff capacity is the strongest predictor of research productivity, while GDP growth also contributes positively by creating more stable conditions for long-term academic development. Education spending efficiency has a meaningful effect, suggesting that governance and internal management shape how resources translate into research outcomes. These findings underscore the need to strengthen faculty development, improve institutional accountability, and align higher education policy with national economic priorities.

Keywords: Research productivity; human capital; institutional efficiency; higher education reform; panel data analysis; economic development; Uzbekistan.

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1. Introduction

Over the past decade, Uzbekistan has implemented broad reforms to modernize its higher education system and strengthen universities' role in national development. Institutions are increasingly expected to expand their contribution to research, innovation, and evidence-based policymaking. Recent research shows that the COVID-19 pandemic has been a powerful catalyst for the digital transformation of higher education, accelerating the spread of distance and blended learning and forcing universities to rethink their teaching models (Jackson & Konczos Szombathelyi, 2022; Kovács et al., 2025). At the same time, the rapid expansion of

generative artificial intelligence creates new pedagogical opportunities while also raising risks related to academic integrity, prompting universities to reconsider assessment practices and quality-assurance mechanisms (Wojciechowski & Korjonen-Kuusipuro, 2023; Sułkowski et al., 2024; Ahmad et al., 2024).

International studies emphasize that university research performance depends on the alignment of human capital, governance quality, and broader economic conditions (Aghion et al., 2010; Hanushek & Woessmann, 2020; Popescu, 2012). These insights are particularly relevant for countries undergoing systemic reforms, where institutional change and economic transformation evolve simultaneously.

Despite significant policy initiatives in Uzbekistan, the mechanisms shaping research productivity across universities remain insufficiently studied. Existing scholarship on developing and transitional economies typically focuses either on macroeconomic influences (Bloom et al., 2006; World Bank, 2019; Tinmaz & Fanea-Ivanovici) or on internal university factors such as staffing capacity, resource allocation, and governance efficiency (Marginson, 2018; Psacharopoulos & Patrinos, 2018). Yet these dimensions rarely operate independently. In reforming systems, institutional performance is often shaped by the interaction of internal capabilities and external economic conditions. The lack of research that jointly assesses these mechanisms limits understanding of why universities respond differently to similar policy shifts.

The Uzbek context provides an essential and understudied case for examining this interaction. Since 2017, higher education institutions have undergone rapid institutional restructuring alongside substantial macroeconomic changes. Expanding autonomy, updated funding practices, and heightened expectations for research productivity have coincided with improvements in economic stability and public investment. With these changes co-occurring, human capital, institutional efficiency, and economic factors begin to reinforce one another more than in stable systems.

However, global literature still lacks integrated empirical studies that bring these dimensions together. Research on university performance remains fragmented, with human capital, governance quality, and macroeconomic factors typically examined in isolation. This is especially evident in the case of transitional economies, where simultaneous institutional and economic reforms require an approach that captures combined mechanisms rather than separate effects.

This study offers a novel contribution by developing a unified framework that integrates human capital capacity, institutional spending efficiency, and macroeconomic stability within a single empirical model. Unlike existing work that evaluates these factors independently, our approach reflects their mutual reinforcement and acknowledges the multidimensional nature of research performance. Furthermore, evidence from Central Asia remains limited in global comparative literature. By providing long-term panel data from Uzbekistan's public universities for 2010–2023, this study broadens the geographic scope of international research. It highlights dynamics in a system undergoing one of the most intensive reform cycles in the post-Soviet region.

In doing so, the study fills a clear empirical gap, introduces a new integrated analytical perspective, and contributes to understanding how institutional and economic transformations jointly influence research productivity in transitional higher education systems.

2. Conceptual Framework

Understanding the determinants of university research productivity requires drawing on complementary strands of economic and educational theory. Human capital theory provides the first foundation, emphasizing that the qualifications, experience, and collective expertise of academic staff are central to knowledge production and institutional performance (Becker, 2009; Hanushek & Woessmann, 2020). Universities with larger and more capable faculties typically demonstrate higher research output, as they possess stronger collaboration networks, mentorship capacity, and disciplinary diversity.

International results show that the quality of human capital at the macroeconomic level is a key condition for maintaining countries' competitiveness and sustainable development, consistent with our approach to assessing universities' human capital potential (Balcerzak, 2016).

Institutional economics offers a second perspective, highlighting the role of governance structures, autonomy, and resource allocation. Aghion et al. (2010) show that universities embedded in supportive governance systems characterized by accountability, managerial flexibility, and strategic decision-making achieve higher research performance. In reforming environments, increases in funding do not automatically translate into improved outcomes unless institutions can deploy resources efficiently and coordinate internal processes effectively (Psacharopoulos & Patrinos, 2018; OECD, 2020).

Cross-country evidence based on data envelopment analysis shows that higher efficiency of public expenditure on education is systematically associated with better performance outcomes, demonstrating that how resources are managed matters as much as how much is spent (Gavurova et al., 2017). Recent evidence also highlights that managerial efficiency and governance quality significantly enhance university performance, including research activity, institutional capacity, and labour-market outcomes of graduates.

A third body of literature focuses on macroeconomic conditions. Economic stability and sustained growth enhance universities' ability to invest in research infrastructure, attract qualified staff, and engage in long-term academic planning (Bloom et al., 2006; World Bank, 2019). For transitional economies, fluctuations in national economic performance influence both the scale of public funding and the institutional climate in which universities operate.

Cross-country evidence from OECD systems shows that variations in publication volume, citation impact, and international collaboration are closely linked to national science policies, funding models, and research capacity strategies. Abramo and D'Angelo (2023) demonstrate substantial structural differences in research output across OECD universities, mainly driven by national-level research investment and governance.

Finally, labour market dynamics may indirectly shape research performance. When demand for skilled professionals rises, universities face greater competition for qualified personnel, potentially affecting hiring, retention, and workloads (Popescu, 2012). Although this channel varies across countries, it provides a valuable perspective when interpreting external pressures on academic productivity.

These theoretical approaches support a multidimensional understanding of university research performance: human capital provides the foundational capacity; institutional efficiency determines how resources are transformed into results; and macroeconomic trends shape the

broader environment. These mechanisms jointly inform the conceptual framework and guide the development of the hypotheses.

To clarify the study's analytical logic, Table 1 summarizes the key variables, their theoretical grounding, and the mechanisms by which they are expected to influence research productivity. This structure provides a concise overview of the model's core components.

Table 1. Conceptual Framework

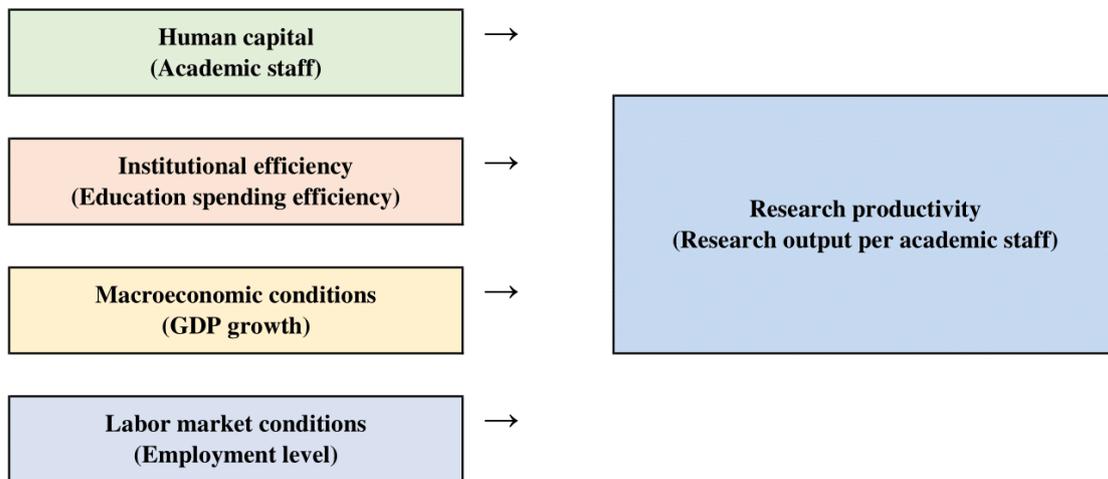
Level	Variable	Theoretical basis	Mechanism	Expected effect
Human capital	Academic staff	Human Capital Theory	Stronger faculty → higher research capacity	+
Institutional efficiency	Education spending efficiency	Institutional Economics	Efficient allocation improves outcomes	+
Macroeconomy	GDP growth	Development Economics	Economic stability supports research	+
Labor market	Employment level	Labor Market Theory	Higher external demand reduces retention	–
Dependent variable	Research productivity	Knowledge Production Theory	Outcome of accumulated inputs	–

Note: The authors' conceptualization is based on Resource-based theory and institutional economics. Source: Developed by authors (2025).

Overall, Table 1 shows that the study is built on interconnected mechanisms through which human capital, managerial effectiveness, and the broader macroeconomic environment shape research outcomes. This logic provides the foundation for developing the hypotheses and the model's overall structure.

Building on the conceptual framework and the mechanisms summarized in Table 1, the hypotheses are developed by linking each model component to expected patterns of university performance. Human capital theory suggests that the scale and qualifications of academic staff directly influence a university's ability to generate research, as larger and more capable faculties typically possess greater collective expertise and research capacity (Becker, 2009; Hanushek & Woessmann, 2020). Accordingly, institutions with more academic staff are expected to demonstrate stronger research output.

Building on the conceptual relationships summarized above, Figure 1 presents an overarching framework that integrates human capital, institutional efficiency, macroeconomic conditions, and labour-market factors into a unified model of research productivity in Uzbekistan's public universities.

Figure 1. Conceptual Framework of the Determinants of Research Productivity

Note: The conceptual framework links human capital, institutional efficiency, macroeconomic conditions, and labor market dynamics to university research productivity in Uzbekistan's public universities.

Source: Authors' elaboration based on Becker (2009), Aghion et al. (2010), Bloom et al. (2006), Psacharopoulos & Patrinos (2018), OECD (2020) and related literature.

Figure 1 summarizes the key mechanisms and clarifies how internal and external factors jointly shape universities' research performance. Building on this framework, the next step is to translate these conceptual relationships into specific, testable hypotheses. Based on the conceptual model, the study identifies four main channels through which internal university characteristics and broader economic conditions may shape research performance.

First, the size and qualifications of the academic workforce determine the basic capacity to produce research. Institutions with larger faculties typically benefit from stronger collaboration networks and greater disciplinary depth.

H1. Larger academic staff size is associated with higher research productivity.

Second, national economic conditions influence universities' financial stability. Periods of stronger GDP growth generally expand resource availability and support longer-term academic planning.

H2. Higher GDP growth has a positive effect on research productivity.

A third mechanism concerns internal organization. Universities that use their financial resources more efficiently tend to achieve better outcomes even without significant increases in funding.

H3. Higher education spending efficiency is positively linked to research productivity.

Finally, developments in the labour market may constrain universities' ability to attract and retain qualified researchers. When employment opportunities outside academia expand, competition for skilled staff intensifies.

H4. Higher employment levels may negatively affect research productivity.

3. Methodology

This study employs a balanced panel dataset covering 15 public universities in Uzbekistan over the period 2010–2023. The dataset combines institutional statistics from the Ministry of Higher Education with macroeconomic indicators from the State Statistics Committee. This structure allows the analysis to capture both cross-sectional differences between universities and changes occurring within each institution over time. The dependent variable, research productivity, is measured as research output per academic staff member and is expressed in logarithmic form to reduce the impact of institutional size differences and to interpret coefficients as elasticities.

In this study, research output refers to the total number of publications reported annually by each university, including articles, conference papers, and institutional journals. These counts reflect the full volume of research activity rather than only Scopus or Web of Science-indexed publications, which explains the relatively broad distribution of values across institutions.

The empirical strategy is grounded in the idea that universities possess unique structural characteristics, such as historical research traditions, governance practices, or specialization, that remain stable over time but may influence research performance. To control for these unobserved institutional features, the study applies a fixed-effects (FE) estimator. The FE model isolates within-university variation and is widely used in higher education and productivity research, where unobserved heterogeneity may bias coefficients if ignored (Wooldridge, 2010; Baltagi, 2021).

While the FE approach accounts for time-invariant differences, concerns remain regarding potential endogeneity among some explanatory variables. In particular, education efficiency and economic conditions may themselves be influenced by prior levels of university performance. To address this issue, the study employs an instrumental-variable fixed-effects (IV–FE) model. Lagged values of GDP growth and education efficiency are used as instruments, following established empirical practice for panel models with potentially endogenous regressors (Cameron & Trivedi, 2005). These lagged indicators are likely to correlate with current institutional conditions but are unlikely to be affected by immediate changes in research output. Instrument validity is assessed through the Hansen J-test for overidentifying restrictions, while instrument strength is evaluated using the Kleibergen–Paap statistic.

To ensure robust inference, all models use heteroscedasticity- and autocorrelation-consistent standard errors clustered at the university level. Several diagnostic procedures support the reliability of the estimates. Heteroscedasticity is tested with the Breusch–Pagan test, serial correlation with the Durbin–Watson statistic, and residual normality with the Jarque–Bera test. Multicollinearity is assessed using variance inflation factors (VIF). In addition, a Hausman test compares the fixed-effects and random-effects specifications, confirming the appropriateness of the FE approach.

Finally, the analysis includes robustness checks using alternative lag structures and reduced specifications to verify the stability of the core results. The combination of fixed-effects modelling, instrumental-variable estimation, and extensive diagnostic testing provides a comprehensive empirical framework for evaluating how human capital capacity, institutional efficiency, and macroeconomic conditions jointly influence research productivity in Uzbekistan’s universities.

4. Results

The empirical analysis begins with an overview of how key institutional and economic indicators evolved across universities over the 2010–2023 period. Descriptive statistics provide the first indication of substantial heterogeneity within the higher education system. Table 2 summarizes the distribution of the main variables and highlights the extent to which research-related conditions differ among institutions.

Before estimating the model, it is helpful to note several patterns. Research output varies widely across universities: while some institutions consistently score above 2,500 publications per faculty member, others remain below 100. This variation suggests uneven research capacity and differing stages of institutional development. Faculty size also ranges widely, from fewer than 100 academic staff to nearly 900, underscoring the need for size-normalized measures. Education efficiency exhibits similarly broad dispersion, indicating that universities vary significantly in how effectively they utilize available resources. In contrast, the employed population displays limited variation, as expected for a national-level variable.

Table 2. Descriptive statistics

Variable	Mean	Median	Std. Dev.	Min	Max	Observations
Research output	847.2	612.5	634.8	89.4	2,845.6	210
Academic staff	285.7	234.0	198.3	87.0	891.0	210
GDP growth (%)	5.8	6.2	2.4	-0.8	8.7	210
Education efficiency	73.4	71.8	18.9	28.5	124.7	210
Employed population (millions)	13.2	13.1	0.9	11.8	14.7	210

Source: Authors' calculations (2025)

The presented indicators confirm significant heterogeneity across universities, particularly in research output, faculty size, and expenditure efficiency. This variation ensures sufficient identification of effects in subsequent models.

To explore the pairwise associations between variables, a correlation matrix was constructed. Table 3 reports the strength and direction of these relationships. Academic staff shows the strongest positive correlation with research productivity, consistent with expectations from human capital theory. Education efficiency also correlates positively with research output, suggesting that institutions using their resources more effectively tend to perform better. GDP growth exhibits a moderate positive correlation, while the employed population shows a weak negative association.

Importantly, correlations among the independent variables are relatively low, all below 0.50. This reduces concerns about multicollinearity and supports the inclusion of these variables within the exact empirical specification.

Table 3. Correlation analysis

	Research output	Academic staff	GDP growth	Education efficiency	Employed population
Research output	1.000				
Academic staff	0.756***	1.000			
GDP growth	0.423***	0.267**	1.000		
Education efficiency	0.612***	0.445***	0.189*	1.000	
Employed population	-0.234*	-0.198*	-0.156	0.098	1.000

Source: Authors' calculations (2025)

Notes: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$

Correlations between key variables remain at acceptable levels and do not indicate multicollinearity issues. This confirms the appropriateness of the factor selection for the subsequent regression analysis.

The study's core results are presented in Table 4, which reports estimates from the fixed-effects instrumental-variable (IV–FE) model. The findings reveal a clear and consistent pattern of relationships.

First, academic staff capacity emerges as the strongest determinant of research productivity. The estimated coefficient of 0.634 ($p < 0.01$) indicates that a 10% increase in faculty size is associated with approximately a 6–7% rise in research output. This effect aligns with both theoretical expectations and earlier evidence from emerging higher education systems.

Second, GDP growth positively and significantly influences research output. The coefficient of 0.089 ($p < 0.05$) suggests that periods of stronger national economic performance create more favourable conditions for academic activity, possibly through improved funding stability, enhanced infrastructure, or broader institutional reforms.

Third, education spending efficiency shows a positive effect on research productivity ($\beta = 0.156$, $p < 0.01$). This finding indicates that universities that manage their resources more effectively, regardless of overall spending level, tend to achieve higher research performance. In settings where budgets are constrained or unevenly distributed, efficiency becomes a critical factor in shaping outcomes.

Finally, the coefficient for the employed population is negative but statistically insignificant, suggesting that broader labour-market dynamics do not exert a measurable direct effect on institutional research performance. This pattern is consistent with the limited integration between universities and industry in the current national context.

Overall model performance is strong. The R-squared of 0.692 and adjusted R-squared of 0.671 show that the model explains a substantial share of the within-university variation in research productivity.

Table 4. Panel regression summary of determinants of research productivity (IV–FE Model)

Variable	β -Coefficient	Std. Error	t-Statistic	p-Value	Significance
Academic staff	0.634	0.187	3.39	0.001	***
GDP growth	0.089	0.041	2.17	0.031	**
Education efficiency	0.156	0.053	2.94	0.004	***
Employed population	-0.023	0.028	-0.82	0.418	n.s.
Model statistics	$R^2 = 0.692$	Adj. $R^2 = 0.671$	$F = 34.21^{***}$		
Diagnostic tests	Hansen J = 2.84 ($p = 0.241$)	Kleibergen-Paap F = 18.7	N = 210	Universities = 15	Period = 2010–2023

Note: *** $p < 0.01$, ** $p < 0.05$, * $p < 0.10$. Robust standard errors clustered at the university level

The regression model results confirm the key role of academic staff size, expenditure efficiency, and macroeconomic stability. These results are consistent with international research and demonstrate the robustness of the effects when using the IV-FE specification. The negative but statistically insignificant employment effect indicates a weak connection between universities and the labour market.

To assess the reliability of the estimates, several diagnostic tests were conducted. Table 5 summarizes the results. The Breusch–Pagan test indicates heteroscedasticity, which is adequately addressed by clustered standard errors. The Durbin–Watson statistic suggests an absence of residual autocorrelation, while the Jarque–Bera test supports the assumption of near-normal residual distribution. VIF values remain well below conventional thresholds, confirming that multicollinearity is not a concern. Finally, the Hausman test strongly favours the fixed-effects specification, validating the choice of modelling strategy.

Together, these diagnostics demonstrate that the empirical findings are statistically robust and that the model provides a reliable basis for interpreting the determinants of research productivity in Uzbekistan’s universities.

Table 5. Model diagnostics and robustness tests

Diagnostic Test	Test statistic	p-value	Result
Breusch-Pagan test (Heteroscedasticity)	15.67**	0.015	Heteroscedasticity detected
Durbin-Watson test (Autocorrelation)	1.89	-	No autocorrelation
Jarque-Bera test (Normality)	3.45	0.178	Residuals normally distributed
Mean VIF	1.78	-	No multicollinearity
Hausman test	23.45***	0.001	Fixed effects preferred

Source: Authors' calculations (2025)

Notes: ** $p < 0.05$, *** $p < 0.01$. Robust standard errors were used to address concerns about heteroscedasticity.

Diagnostic checks confirm the reliability of the estimates: the residuals do not exhibit autocorrelation, the distribution is normal, and multicollinearity is absent. This strengthens confidence in the main results and confirms the appropriateness of the choice of fixed effects.

5. Discussion

The empirical findings of this study provide a clearer understanding of how human capital, institutional efficiency, and macroeconomic conditions jointly shape research productivity in Uzbekistan’s public universities. The strong positive effect of academic staff aligns with international evidence showing that the size and qualifications of university faculty consistently predict higher research output (Aghion et al., 2010; Hanushek & Woessmann, 2020).

Recent regional diagnostics emphasise that universities in Central Asia face persistent structural constraints, including limited research funding, fragmented governance systems, and uneven accumulation of human capital. According to the World Bank’s 2023 review, improving research capacity requires simultaneous progress in institutional efficiency, academic staffing, and national policy coordination.

In Eastern Europe, macroeconomic stability in the 2000s facilitated investments into research infrastructure and accelerated universities’ integration into European research networks (Kwiek, 2015). The Uzbek case follows a similar trajectory: improvements in national economic conditions appear to create a more predictable environment for long-term academic planning, enabling universities to expand programmes, retain qualified staff, and participate in grant-based research initiatives.

Similar conclusions have been drawn in transition economies in Eastern Europe, where universities that adopted modern management practices were more successful in leveraging funding to generate internationally visible research (Estermann & Nokkala, 2009). Against this regional background, the Uzbek results underscore the importance of consolidating governance reforms and strengthening internal accountability systems within universities.

The absence of a significant influence of labor market conditions on research output offers additional insight. In countries with strong university–industry linkages, such as Poland, Estonia, and Georgia, labor market changes often affect recruitment, retention, and applied research output. The findings for Uzbekistan follow this pattern. Universities remain only partially connected to the national labor market, and research activity is still predominantly driven by internal incentives rather than external demand. Strengthening university–industry collaboration may therefore be essential for translating economic development into research-based innovation (Samoilikova et al., 2023; Kuzior et al., 2024).

Taken together, these results highlight both shared regional patterns and country-specific features. Across Central Asia, universities face similar constraints, unequal concentration of qualified researchers, developing governance systems, and limited capacity to absorb research funding. At the same time, Uzbekistan’s rapid reforms create a unique institutional environment in which macroeconomic change and governance modernization co-occur. This combination amplifies the role of human capital and institutional efficiency, making them decisive factors for research development. Comparable evidence from other emerging economies confirms that institutional efficiency remains a key determinant of innovation and research performance, particularly during periods of systemic transition.

These findings contribute to broader international debates on higher education reform in transitional economies. Comparative studies of Eastern Europe show that research capacity grows fastest when reforms simultaneously enhance institutional autonomy, strengthen managerial capability, and stabilize national funding frameworks (Kwiek, 2015; Estermann & Nokkala, 2009). The evidence from Uzbekistan is consistent with this perspective. Improvements in research productivity appear to depend not only on expanding resources but on building the institutional foundations that determine how effectively those resources are used.

Finally, the results underscore a practical implication for countries pursuing similar reforms: human capital development, efficient resource allocation, and macroeconomic stability are mutually reinforcing. Without addressing all three dimensions, progress in research productivity is likely to remain uneven. For Uzbekistan, this means continued investment in academic staff, further refinement of governance reforms, and closer alignment between higher education policy and national economic strategies will be essential to sustain long-term improvements in university performance.

6. Conclusion

This study shows that three interconnected factors largely shape differences in research productivity across Uzbekistan’s public universities: the scale and strength of academic staff, the efficiency with which institutions manage their resources, and the broader macroeconomic environment. Universities with larger and more qualified faculties consistently perform better, while efficient internal budgeting and stable economic conditions further support long-term research development.

The study advances the literature by offering an integrated framework that brings together human capital, institutional efficiency, and macroeconomic stability within a single model. While previous research often examines these dimensions separately, our results demonstrate

that their combined influence provides a more accurate explanation of research performance in transitional higher education systems.

Using a balanced panel of 15 universities and an IV–FE estimation strategy, the analysis provides robust evidence for the relative importance of staff capacity, spending efficiency, and economic conditions. The findings extend empirical work on developing and post-transition economies, where long-time series institutional data are rarely available.

For policymakers, the results highlight three priorities: strengthening academic staff through recruitment and professional development, improving internal management and accountability, and aligning higher education reforms with periods of macroeconomic stability. Addressing these areas simultaneously is essential to ensure more even and sustained growth in research productivity. Recent evidence also indicates that institutional support for digital competence and research infrastructure can substantially reinforce long-term academic productivity.

Despite its strengths, the study has limitations. It focuses solely on public universities and uses aggregate measures of research output that do not capture disciplinary differences or publication quality. Although the IV–FE approach helps reduce endogeneity, short-term institutional shocks or unobserved factors may still influence the results.

Future research could explore publication quality, cross-country comparisons, and the impact of recent governance reforms such as performance-based funding. Such work would deepen understanding of how transitional higher education systems can build research capacity amid broader economic and institutional change.

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