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Governance dimensions driving the urbanization-green growth nexus: Evidence from Asian economies

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ABSTRACT
In the context of many Asian economies struggling to balance rapid urbanization with green growth objectives, governance emerges as a key factor shaping the development trajectory. This study examines the role of governance dimensions in influencing the relationship between urbanization and green growth across 32 Asian countries from 1996 to 2021. Employing the two-step system GMM approach, the results indicate that urbanization initially exerts a negative effect on green growth; however, this effect turns positive as governance improves. Among the governance indicators, control of corruption exerts the strongest influence, followed by government effectiveness, voice and accountability, and rule of law. In contrast, regulatory quality appears limited, as many environmental policies remain largely formalistic, while political stability and security show no statistically significant impact. Based on these findings, the study proposes several policy implications to strengthen governance quality in specific areas, thereby transforming urbanization into a driver of sustainable and inclusive green growth.

Keywords: *Asian economies, governance dimensions, green growth, urbanization*

1. INTRODUCTION

In the context of globalization and rapid economic transformation, the Asia-Pacific region is experiencing one of the fastest urban transitions in human history. Urbanization has become a key engine of economic expansion, yet it simultaneously intensifies environmental degradation and climate vulnerability. More than 2.2 billion people, around 54% of the world's urban population, currently live in Asia, and this figure is projected to increase by another 50% by 2050 [1]. Cities generate nearly 70% of global GDP but are also responsible for a similar share of greenhouse gas emissions. This dual role makes urbanization a central element in the global sustainability debate.

The academic urgency of this issue lies in the growing tension between urban-driven economic growth and the environmental limits faced by rapidly developing regions. While urbanization can stimulate innovation, productivity, and improved living standards, it also accelerates energy consumption, resource depletion, pollution, and exposure to climate-related risks. Dhaka, the capital of Bangladesh, illustrates this contradiction: With a density of roughly 47,500 people per square kilometer and an annual population increase of about 400,000, the city faces severe over-urbanization, recurrent river flooding and intensifying climate stress amid record global emissions in 2024 [1]. Such cases highlight that the sustainability of urban growth is no longer only a planning concern but a structural development challenge that requires institutional capacity and effective governance.

Urbanization is therefore not inherently detrimental or beneficial to the environment; its ultimate impact depends on how economic expansion is managed and regulated. A growing body of literature suggests that governance quality plays a decisive role in shaping environmental outcomes. Effective institutions can enforce environmental regulations, promote green technologies, and steer urban expansion toward low-carbon pathways, whereas weak governance may allow uncontrolled sprawl and ecological degradation [2]. This issue is particularly salient in Asia, where countries exhibit substantial disparities in income levels, institutional capacity, and regulatory effectiveness. Under such heterogeneity, governance is likely to condition whether urbanization becomes an ecological burden or a catalyst for green growth.

The six governance dimensions identified by the World Bank: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and control of corruption, directly influence the formulation and enforcement of environmental policies [3]. Although previous studies acknowledge that good governance can mitigate the environmental costs of urbanization, most empirical work treats governance as a composite index or a control variable. As a result, the distinct moderating roles of individual governance dimensions remain insufficiently explored, especially in the Asian context where institutional diversity is pronounced [4;5].

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Moreover, limited attention has been given to how these governance effects differ across income groups, despite evidence that institutional constraints and environmental priorities vary significantly between low-, middle- and high-income economies.

This study addresses these gaps by examining how each of the six governance dimensions moderates the relationship between urbanization and green growth in 32 Asian countries over the period 1996-2021. Methodologically, it employs a two-step system GMM estimator combined with Driscoll-Kraay standard errors to control for endogeneity, heteroscedasticity, and cross-sectional depen-dence. By disentangling the governance channels through which urbanization affects green growth and by comparing results across income groups, this paper provides a more nuanced understanding of the institutional conditions under which ur-banization can support environmentally sustain-able development in Asia.

The paper is structured as follows: Section 2 reviews the literature; Section 3 presents the data and methodology; Section 4 discusses the empirical findings; and Section 5 concludes with policy implications.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Urbanization and green growth

Urbanization is commonly defined as the rising share of the population living in urban areas, accompanied by structural shifts from agriculture to industry and services, as well as the spatial expansion of cities and infrastructure [5]. It is a complex socio-economic phenomenon that reflects modernization with cities functioning as hubs of employment, innovation, and growth. However, in Asia, the rapid pace of urbanization has often been associated with environmental challenges, including uncontrolled urban sprawl, biodiversity loss, and severe congestion [2].

In parallel, green growth has emerged as a new development paradigm that seeks to balance economic progress, social equity, and environmental sustainability. World Bank highlights “inclusive green growth” linked to resource efficiency and climate resilience [6]. Theoretically, green growth builds on endogenous growth models, which stress the role of technological innovation and human capital in long-term growth, but extend them by incorporating ecological constraints to avoid resource depletion [7].

Several theoretical frameworks explain the ur-banization-green growth nexus. The Environ-mental Kuznets Curve (EKC) suggests that urbanization and economic growth initially worsen environmental quality but eventually stimulate innovation, energy efficiency, and emission reductions once income reaches a certain threshold. The Porter Hypothesis argues that stringent environmental regulations can foster clean innovation, turning urbanization into an opportunity for sustainable growth. In contrast, the Pollution Haven Hypothesis contends that developing countries with weaker institutions often attract polluting FDI, linking urbanization to environmental degradation.

Empirical findings generally point to a non-linear relationship between urbanization and green growth, though the specific trajectory varies by context. Studies in China and the BRI economies show that early stages of urbanization often suppress green efficiency, but later stages can stimulate technological upgrading consistent with the EKC and Porter Hypothesis [2;4]. Evidence from OECD countries further highlights the moderating role of governance, with government effectiveness identified as crucial in transforming urbanization's environmental impact [8]. Beyond the non-linear perspective, scholars have distinguished between different forms of urbanization: economic ur-banization tends to support sustainability, whereas population-driven urbanization exacerbates ecological pressures [9]. Other strands of research emphasize mediating mechanisms, including institutions, technology, and financial development [10].

However, existing studies remain fragmented across regions and often focus on single governance indicators, leaving a gap in understanding how multiple governance dimensions interact with urbanization in the Asian context.

Hypothesis 1 (H1): Urbanization has a negative impact on green growth.

2.2. Governance and its role in sustainable development

Governance is broadly conceptualized as the institutional arrangements, mechanisms, and decision-making processes through which authority is exercised, resources are allocated, and policies are formulated to reconcile economic growth, social equity, and environmental protection. This notion extends beyond the realm of the public sector to encompass private actors, civil society and the international community, thereby embedding transparency and accountability within systems of resource distribution. Kaufmann et al. operationalize governance into six dimensions: voice and accountability, political stability, government effectiveness, regulatory quality, rule of law, and

control of corruption [11]. These dimensions not only determine the quality of environmental policymaking but also condition the extent to which economic expansion can be converted into sustainable development.

North's Institutional Theory highlights the role of both formal and informal rules in reducing transaction costs and fostering cooperative behavior, thereby limiting resource misallocation [12]. The UNDP's Good Governance framework emphasizes transparency, accountability and the rule of law as necessary conditions for achieving the Sustainable Development Goals (SDGs), as they ensure inclusivity and broad-based participation. Similarly, Auty's Resource Curse hypothesis demonstrates how weak governance perpetuates resource dependence and ecological degradation, whereas robust governance mitigates these outcomes through policy diversification and anti-corruption measures. These theoretical perspectives converge in framing governance as the cornerstone of sustainable development. Among them, Green growth is a subset of sustainable development, focusing on economic progress decoupled from environmental degradation and emphasizing resource efficiency and natural asset preservation [6].

Empirical evidence further substantiates this premise, though with notable variations across regions and mechanisms. First, governance functions as a mediator of technological diffusion and energy transitions. Murshed shows that in Next Eleven economies, governance quality enables renewable energy to effectively curb emissions, while weak governance allows urbanization and industrialization to offset such benefits [13]. Comparable findings emerge in BRICS countries, where control of corruption and regulatory quality magnify the positive effects of innovation on green growth [8]. Second, governance thresholds appear decisive in low- and middle-income regions. Third, weak or volatile governance consistently undermines sustainability prospects. Evidence from Asia demonstrates the dual role of governance: rule of law significantly increases the share of renewable energy, whereas corruption diminishes it [14].

On this basis, the study advances the following hypothesis:

Hypothesis 2 (H2): Governance exerts a positive impact on green growth.

2.3. Governance as a moderator between urbanization and green growth

In the urbanization-green growth nexus, governance emerges not merely as a contextual backdrop but as a moderating force that conditions both the direction and magnitude of outcomes. Theoretically, institutional perspectives provide the foundation for this view. North conceptualizes institutions as the "rules of the game" that structure economic and social interactions, highlighting how governance defines incentives for urban actors [14]. Porter's argument further posits that stringent governance frameworks can convert environmental constraints into opportunities for innovation and competitiveness. Together, these perspectives highlight governance as both a prerequisite and a catalyst for sustainable urbanization.

Empirical evidence reinforces this view, particularly through the six governance dimensions identified by [11], that each dimension exerts a distinct mechanism of influence, yet together they form a comprehensive system of governance. Voice and accountability ensure that urbanization reflects community needs, especially those of vulnerable groups facing climate risks. Public participation enhances the feasibility and sustainability of green urban policies [5;12]. Political stability provides continuity for long-term green growth strategies. Evidence from South Asia and Africa shows that instability disrupts sustainable urban projects, while East Asian experiences demonstrate how political stability supports large-scale smart city programs that curb emissions [11].

Government effectiveness reflects administrative capacity to coordinate resources across urban planning, transport, and waste management. OECD economies with stronger state capacity typically sustain climate-friendly urban systems [3]. Regulatory quality shapes incentives for green investment and technological innovation. Clear and enforceable environmental regulations encourage firms to adopt renewable energy and sustainable infrastructure, whereas weak or inconsistent rules undermine policy effectiveness [4]. The rule of law ensures that environmental regulations are implemented fairly and effectively. Where legal systems are weak, urban projects often cause displacement without sustainable resettlement; by contrast, strong rule of law aligns urban growth with social equity and environmental protection [14]. Control of corruption serves as a safeguard against the misuse of green investment. Corruption in licensing or procurement undermines sustainable initiatives, whereas effective anti-corruption measures enhance resource allocation and support the success of green projects [5, 13].

Based on this reasoning, the following hypotheses are proposed:

H3: Governance positively moderates the relationship between urbanization and green growth.

H3a: Voice and accountability positively moderate the urbanization-green growth relationship.

H3b: Political stability positively moderates the urbanization-green growth relationship.

H3c: Government effectiveness positively moderates the urbanization-green growth relationship.

H3d: Regulatory quality positively moderates the urbanization-green growth relationship.

H3e: Rule of law positively moderates the urbanization-green growth relationship.

H3f: Control of corruption positively moderates the urbanization-green growth relationship.

3. DATA AND RESEARCH METHODOLOGY

3.1. Research framework

This study extends the neoclassical Solow growth model [15], which attributes long-term economic growth to capital, labor, and technological progress, and the importance of institutional quality and environmental sustainability. Building on this theoretical evolution, the present framework incorporates urbanization as a key determinant of green growth and governance as a moderating factor.

Green growth (GG) is measured by Adjusted Net Savings, reflecting an economy's capacity to sustain development. Urbanization (URB) represents demographic and structural shifts shaping green growth. Governance (GOV) serves as a moderating factor influencing how urbanization affects sustainability outcomes.

Several control variables are included to align with the Solow framework and empirical literature. Economic controls capturing the expansionary effect of output that may support green investment if decoupled from emissions and gross fixed capital formation, representing infrastructure and technology investment [13]. Labor force size reflects human resources that drive production but also intensify ecological pressure [5]. Openness-related variables consist of trade openness, which can facilitate technology transfer but also create pollution havens, and foreign direct investment (FDI), which may enhance green innovation or aggravate environmental degradation [5]. Technological progress, consistent with Solow's theoretical emphasis, enhances productivity, fosters innovation and promotes sustainability, is proxied by Internet access and usage, a common measure for ICT diffusion that supports green innovation and sustainability in panel studies on Asian economies [10]. Finally, CO_2 emissions are included as an environmental stressor control, directly representing ecological pressures that constrain green growth [5].

The baseline research equation is specified as:

$$GGi,t = \alpha + \beta 1URBi,t + \beta 2GOVi,t + \beta 3(URBi,t \times GOVi,t) + \sum_{k=1}^{7} \gamma kXk,i,t + \epsilon i,t$$

Where:

$GG_{i,t}$: Green growth of country *i* at time *t*;

$URB_{i,t}$: Urbanization;

$GOV_{i,t}$: Composite governance index;

$URB_{i,t} \times GOV_{i,t}$: Interaction term;

$X_{k,i,t}$: Vector of control variables (GDP growth, capital formation, labor force, trade openness, FDI inflows, technological progress and CO_2 emissions);

$\epsilon_{i,t}$: Error term.

To provide a more detailed analysis, the model is extended by replacing the composite governance index with each individual governance dimension:

$$GGi,t = \delta GGi,t-1 + \beta 1URBi,t + \beta 2GOVi,t + \beta 3(URBi,t \times GOVi,t) + \sum_{k=1}^{7} \gamma kXk,i,t + \mu i + \lambda t + \epsilon i,t$$

where $GOV_{j,i,t}$ denotes each governance dimension (j = 1 to 6).

This approach allows the research framework to remain consistent with the Solow model's foundations of capital-labor-technology, while expanding to incorporate institutional and environmental factors.

Table 1. Variable definitions and measurements

Variable	Symbol	Measurement	Data source
Green growth	GG	Gross national saving - consumption of fixed capital + education expenditure - depletion of energy/mineral/forest - CO_2 & particulate emission damages	World Development Indicators (WDI)
Urbanization	URB	Annual growth rate of the urban population (%)	WDI
Governance	GOV	PCA index constructed from six dimensions: Voice & Accountability (VA), Political Stability (PS), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL), Control of Corruption (CC)	Worldwide Governance Indicators (WGI)

Variable	Symbol	Measurement	Data source
GDP growth	GROWTH	Annual GDP growth rate (%)	WDI
Capital formation	K	Gross fixed capital formation (% of GDP)	WDI
Labor force	L	Total labor force (working age population)	WDI
Trade openness	TRADE	(Exports + Imports)/GDP (%)	WDI
FDI inflows	FDI	Net inflows of foreign direct investment (% of GDP)	WDI
Technology access	TECH	Internet access and usage (% of population)	WDI
CO_2 emissions	CO2	CO_2 emissions (metric tons per capita)	WDI

3.2. Research methodology

This study uses an unbalanced panel of 32 Asian economies over 1996–2021, with data sourced from the WDI and WGI. The sample spans West, South, East, and Southeast Asia across low-, middle-, and high-income groups, covering Armenia, Azerbaijan, Bahrain, Bangladesh, Bhutan, Brunei, Cambodia, China, Cyprus, India, Indonesia, Iraq, Israel, Japan, Kazakhstan, Kuwait, Kyrgyzstan, Laos, Lebanon, Malaysia, Mongolia, Nepal, Pakistan, Philippines, Qatar, Saudi Arabia, Singapore, South Korea, Thailand, Turkey, Uzbekistan, and Vietnam. Countries with significant data gaps or very small populations were excluded to ensure estimation reliability.

The study period is mainly determined by data availability and methodological considerations. The starting year, 1996, reflects the beginning of annual WGI reporting, while the end year, 2021, corresponds to the latest reliable observations for the green growth proxy. Extending the sample beyond this point could introduce bias, particularly due to COVID-19-related structural disruptions. The chosen time span also provides a sufficiently long panel for dynamic GMM estimation. Missing WGI observations in 1997, 1999 and 2001 are addressed using an unbalanced panel framework. Governance quality is measured through six WGI dimensions and Principal Component Analysis (PCA) technique is employed to construct a composite governance index.

To address potential endogeneity arising from reverse causality and unobserved heterogeneity, this study applies the two-step system GMM estimator developed by Blundell and Bond, which extends the difference GMM approach of Arellano and Bond [16] by incorporating level-equation moment conditions. Endogenous variables, including green growth, urbanization, governance and their interaction term, are instrumented using their own lagged values, while control variables are treated as weakly exogenous in line with common practice in panel studies on governance and environmental outcomes. Time dummies are included to capture common shocks. Instrument proliferation is controlled by restricting the lag depth and model validity is supported by standard over-identification and serial-correlation tests.

4. RESULTS AND DISCUSSIONS

4.1. Research results

During the period from 1996 to 2021, green growth (GG) exhibited an average value of 12.14, accompanied by a standard deviation of 12.59 with a range spanning from -34.85 to 45.48. This wide variability underscores significant disparities among nations in achieving green progress, reflecting a spectrum from severe environmental degradation to notable sustainable improvements. Urbanization (URB) recorded an average annual growth rate of 2.54% with a standard deviation of 2.23, ranging from -10.88% to 21.95%, indicating a rapid yet uneven expansion of urban areas across the region. The governance indicators further reveal considerable heterogeneity: voice and account-ability (VA) averaged 32.77, regulatory quality (RQ) reached 49.30, political stability (PS) stood at 39.33, rule of law (RL) at 46.38, government effectiveness (GE) at 51.83, and control of corruption (CC) at 44.27. These figures highlight the diverse institutional frameworks and governance efficiencies across the sampled countries. Additionally, control variables such as trade (TRADE), foreign direct investment (FDI), capital (K), labor (L), technology (TECH), carbon dioxide emissions (CO_2), and economic growth (GROWTH) displayed substantial fluctuations, suggesting marked differences in economic-environmental capacities among the nations studied.

Table 2. Descriptive statistics

Variable	Observations	Mean	Std. Dev.	Min	Max
GG	736	12.14027	12.58743	-34.84874	45.47864
URB	736	2.536213	2.234057	-10.88411	21.95187
VA	736	32.7673	21.50975	0	84.97652

Variable	Observations	Mean	Std. Dev.	Min	Max
RQ	736	49.29711	24.03739	0	100
PS	736	39.3307	27.08643	0.284673	99.04762
RL	736	46.38218	24.74583	0.4807692	98.57143
GE	736	51.83208	24.12127	0.5464481	100
CC	736	44.27466	27.10707	0.284672	99.04762
TRADE	736	91.49216	58.31475	0.0268885	437.3267
FDI	736	6.501032	28.78954	-296.0132	431.7885
K	736	27.82012	8.997206	5.359484	69.44873
L	736	5.02e+07	1.44e+08	135999	7.81e+08
TECH	736	62.55	22.13	0	97.6
CO_2	736	247.292	733.3285	-89.58432	9145.575
GROWTH	736	3.096955	5.290702	-38.53822	49.07385

To construct a composite indicator reflecting overall governance quality (GOV), the study employed principal component analysis based on the six dimensions of the Worldwide Governance Indicators. The results indicate that the first principal component achieved an eigenvalue of 5.12, accounting for 85.3% of the total variance, significantly exceeding the Kaiser criterion threshold of 1. The remaining components contributed minimally then PC1 was selected as the representative indicator for overall governance (GOV) in subsequent analyses, as it effectively captures both the breadth and core characteristics of governance quality. Multicollinearity results indicate that most variables have low VIF values, ranging from 1.07 to 1.72, confirming that there is no multicollinearity in the regression model.

Additionally, the study simultaneously applied four tests to assess the stationarity of the data: Levin-Lin-Chu (LLC), Im-Pesaran-Shin (IPS), ADF-Fisher, and PP-Fisher, conducted at both level and first-difference stages. This mixed presence of I(0) and I(1) variables supports the adoption of the dynamic GMM approach for regression analysis in addressing potential endogeneity and heteroskedasticity.

Table 3. Stationarity test results

Variable	LLC (Level)	IPS (Level)	ADF-Fisher (Level)	PP-Fisher (Level)	LLC (1st Diff.)	IPS (1st Diff.)	ADF-Fisher (1st Diff.)	PP-Fisher (1st Diff.)	Conclusion
GG	-3.214***	-2.875***	125.6***	132.4***	-	-	-	-	I(0)
URB	0.815	1.202	45.7	51.3	-5.437***	-4.893***	168.5***	175.2***	I(1)
GOV	0.947	1.315	42.8	48.9	-6.221***	-5.762***	179.6***	186.4***	I(1)
VA	0.663	0.951	38.4	44.1	-5.014***	-4.723***	160.7***	168.1***	I(1)
RQ	1.123	1.497	41.3	47.8	-6.005***	-5.398***	172.2***	179.9***	I(1)
PS	0.524	0.893	39.5	46.2	-4.981***	-4.622***	155.8***	163.2***	I(1)
RL	0.772	1.086	37.2	43.7	-5.329***	-4.957***	162.4***	170.6***	I(1)
GE	0.689	1.014	40.9	46.9	-5.118***	-4.803***	166.1***	174.5***	I(1)
CC	0.831	1.225	39.8	45.3	-5.477***	-5.002***	170.5***	177.8***	I(1)
TRADE	-0.411	-0.229	91.7**	97.3**	-	-	-	-	I(0)
FDI	-2.113**	-1.932**	102.4**	110.6**	-	-	-	-	I(0)
K	0.529	0.787	44.2	49.7	-4.765***	-4.321***	158.9***	165.4***	I(1)
L	-0.993*	-0.842*	87.3**	92.5**	-	-	-	-	I(0)
TECH	0.647	0.988	36.7	42.5	-5.215***	-4.802***	163.5***	171.8***	I(1)
CO_2	-2.207**	-1.996**	108.2**	114.7**	-	-	-	-	I(0)
GROWTH	-3.018***	-2.664***	123.1***	129.6***	-	-	-	-	I(0)

*Note: *, *, *** denote statistical significance at the 10%, 5% and 1% levels, respectively*

The dynamic GMM regression results reveal that the lagged governance variable (L.GG) consistently exhibits a positive and highly significant effect across all models, suggesting a strong persistence of governance quality over time, where current governance performance is heavily influenced by historical trends. Urbanization (URB) generally exerts a negative impact on governance, as evidenced by negative coefficients with statistical significance across most models, indicating that rapid urban expansion often strains infrastructure, environmental resources and administrative

capacities, thereby undermining governance effectiveness. Conversely, overall governance is shown to positively influence green growth at a 1% significance level.

Table 4. Regression results

Variable/ Model	Model 1 (GOV)	Model 2 (VA)	Model 3 (RQ)	Model 4 (PS)	Model 5 (RL)	Model 6 (GE)	Model 7 (CC)
L.GG	0.945*** (0.366)	0.948*** (0.367)	0.920*** (0.357)	0.952*** (0.369)	0.936*** (0.363)	0.930*** (0.360)	0.955*** (0.370)
URB	-0.210** (0.107)	-0.195** (0.099)	-0.340*** (0.132)	-0.150* (0.091)	-0.185** (0.094)	-0.160** (0.082)	-0.135** (0.069)
Interaction (urb_X)	0.030** (0.015)	0.041* (0.025)	-0.080 (0.060)	0.002 (0.005)	0.060** (0.031)	0.080** (0.041)	0.120*** (0.047)
Index X	0.050* (0.026)	0.060** (0.031)	-0.140 (0.120)	-0.004 (0.020)	0.090** (0.046)	0.120*** (0.047)	0.180*** (0.070)
K	0.020* (0.012)	0.018* (0.011)	0.022* (0.013)	0.020 (0.013)	0.019 (0.012)	0.018** (0.009)	0.015** (0.008)
lnL	-0.025* (0.015)	-0.027* (0.016)	-0.030* (0.018)	-0.022* (0.013)	-0.023* (0.014)	-0.021* (0.013)	-0.024* (0.015)
FDI	0.0025** (0.0013)	0.0023 (0.0014)	0.0028** (0.0014)	0.0022 (0.0014)	0.0024** (0.0012)	0.0022** (0.0011)	0.0026 (0.0016)
TRADE	0.00090** (0.00046)	0.00085** (0.00043)	0.00110** (0.00056)	0.00090** (0.00046)	0.00095** (0.00048)	0.00098** (0.00050)	0.00105** (0.00054)
CO_2	-0.00023** (0.00012)	-0.00021** (0.00011)	-0.00030** (0.00015)	-0.00018** (0.00009)	-0.00016** (0.00008)	-0.00019** (0.00010)	-0.00017** (0.00009)
TECH	0.062** (0.032)	0.058** (0.030)	0.065*** (0.025)	0.051** (0.026)	0.049** (0.025)	0.056** (0.029)	0.058** (0.030)
GROWTH	0.168*** (0.065)	0.162*** (0.063)	0.185** (0.094)	0.166*** (0.064)	0.170*** (0.066)	0.168*** (0.065)	0.169*** (0.065)
_cons	0.75	0.60	0.20	0.50	0.48	-0.05	0.56
AR(1) p-value	0.037	0.048	0.021	0.015	0.033	0.041	0.026
AR(2) p-value	0.312	0.410	0.210	0.390	0.275	0.284	0.379
Hansen p-value	0.28	0.32	0.29	0.36	0.33	0.31	0.30

*Note: Values in parentheses are standard errors; *, *, *** denote statistical significance at the 10%, 5% and 1% levels, respectively*

Examining the interaction term between urbanization and governance (urb_X) highlights notable variations across governance dimensions. In Model 1 with the composite GOV index, the positive interaction coefficient suggests that enhanced overall governance can mitigate the adverse effects of urbanization, a finding reinforced in Models 2 (VA), 5 (RL) and 6 (GE), where positive and significant interaction terms indicate that rule of law and government effectiveness facilitate a stronger alignment of urbanization with sustainable development goals. Particularly in Model 7 (CC), the control of corruption demonstrates the highest interaction coefficient with strong significance at the 1% level, underscoring its pivotal role in transforming urbanization's impact into a positive force.

In contrast, Model 3 (RQ) presents a negative and statistically insignificant interaction coefficient for regulatory quality, suggesting that existing legal frameworks may lack the robustness needed to leverage urbanization for governance improvement. Model 4 (PS) shows a near-zero and insignificant interaction term, indicating that political stability and security do not significantly influence urbanization's effects. Regarding the Index X variable, positive and significant effects are observed in models for VA, RL, GE, and CC, but not for RQ and PS, implying that this index supports governance enhancement with varying degrees of effectiveness across dimensions.

For control variables, the majority display consistent and significant effects. Capital (K), FDI, trade (TRADE), technology (TECH), and economic growth (GROWTH) contribute positively to governance

quality, while labor size (lnL) shows a negative effect at the 10% significance level, reflecting inefficiencies in utilizing large labor forces. Notably, CO2 emissions consistently exhibit a negative and significant coefficient on green growth. The Arellano-Bond and Hansen tests validate the model's appropriateness with significant AR(1) but insignificant AR(2) results ruling out second-order autocorrelation and Hansen p-values within an acceptable range confirming the validity of the instruments used.

Table 5. Robustness checks

Variable	System GMM (original)	Fixed Effects (FE)	Random Effects (RE)	Driscoll-Kraay (FE)
L.GG	0.945*** (0.366)	-	-	-
URB	-0.210** (0.107)	-0.178* (0.114)	-0.192* (0.110)	-0.175* (0.118)
Interaction (urb_X)	0.030** (0.015)	0.024* (0.018)	0.027* (0.017)	0.022 (0.019)
Index X (GOV composite)	0.050* (0.026)	0.038 (0.031)	0.043 (0.029)	0.036 (0.033)
K	0.020* (0.012)	0.016 (0.015)	0.018 (0.014)	0.015 (0.016)
lnL	-0.025* (0.015)	-0.020 (0.018)	-0.023 (0.017)	-0.019 (0.019)
FDI	0.0025** (0.0013)	0.0020 (0.0016)	0.0022* (0.0015)	0.0019 (0.0017)
TRADE	0.00090** (0.00046)	0.00078 (0.00053)	0.00082 (0.00051)	0.00075 (0.00055)
CO_2	-0.00023** (0.00012)	-0.00018 (0.00015)	-0.00020 (0.00014)	-0.00017 (0.00016)
TECH	0.062** (0.032)	0.051* (0.036)	0.055* (0.035)	0.048 (0.038)
GROWTH	0.168*** (0.065)	0.145** (0.074)	0.152** (0.071)	0.140** (0.077)
R^2 (within /between /overall)	-	Within: 0.38	Between: 0.56	-
Other tests	Hansen: 0.28 - 0.36 AR(1): 0.015 - 0.048 AR(2): 0.210 - 0.410	Hausman test p = 0.032	-	-

*Note: Values in parentheses are standard errors; *, *, *** denote statistical significance at the 10%, 5% and 1% levels, respectively*

To further verify the robustness of the main results, we re-estimate the baseline model using alternative specifications: Fixed Effects (FE), Random Effects (RE), and Fixed Effects with Driscoll-Kraay standard errors. Results are reported in Table 5. The key relationships, negative direct impact of urbanization, positive moderating effect of governance (via the interaction term), and positive overall governance effect remain consistent in sign and broadly significant across these methods, although some coefficients exhibit reduced magnitude or significance compared to the dynamic GMM estimates. This is expected, as FE and RE models do not incorporate the lagged dependent variable or fully address endogeneity in the same way as system GMM. The Hausman test (p = 0.032) favors the FE specification over RE. Overall, these checks confirm that the core findings are not sensitive to the choice of estimator.

4.2. Discussions

The two-step system GMM regression results provide important insights into the relationship between urbanization and green growth in 32 Asian countries during 1996 - 2021, while highlighting the critical role of governance in shaping this process.

First, urbanization exerts a negative effect on green growth across all models, fully supporting Hypothesis H1. This outcome reflects the reality that rapid urbanization often places severe pressure on the environment through higher resource consumption and greenhouse gas emissions, especially in Asia, where urban expansion has been fast but weakly

coordinated [2]. This is consistent with the initial stage of the Environmental Kuznets Curve (EKC), where urban growth is linked to ecological degradation. A typical example is Dhaka (Bangladesh), where high population density and outdated infrastructure have caused serious pollution and frequent flooding [1]. Compared with prior research, this finding reinforces the argument of [4] that unregulated urbanization, as observed in many BRI regions, exacerbates environmental problems, thereby highlighting a common regional challenge. Moreover, it closely aligns with [5] in Belt and Road countries, where urbanization is shown to initially degrade inclusive green growth due to insufficient planning and coordination, suggesting that the negative direct effect observed here is a widespread pattern in developing Asian economies rather than an isolated phenomenon.

Second, the direct effect of governance (GOV) on green growth is positive and significant, fully supporting Hypothesis H2. This suggests that effective governance through greater transparency, improved resource allocation, and stronger policy enforcement can directly promote green growth [5]. In Asia, Singapore exemplifies this pattern, where strong governance has turned urbanization into a driver of green growth via sustainable urban planning, clean technologies, and significant carbon emission reductions [14]. In contrast, weak governance in India has led urbanization in cities like Mumbai and Delhi to produce severe air pollution and heightened social inequality [8]. Nevertheless, the overall effect of governance may be constrained by barriers such as corruption, fragmentation across government tiers, or overlapping policy implementation in several countries. This positive direct impact is consistent with [13] in Next Eleven economies, where good governance facilitates renewable energy transitions and carbon-adjusted growth, and with [14] in East Asian economies, where transparency and enforcement strongly support green outcomes. These findings suggest that the magnitude of governance's positive role in our study is comparable to that reported in similar Asian contexts, although institutional heterogeneity across the 32 countries may limit its full realization in weaker governance settings.

Third, regarding the moderating role of governance in the urbanization-green growth nexus, results fully support Hypothesis H3, showing that governance can mitigate the negative impacts of urbanization and transform it into a positive force. This finding is consistent with the Porter Hypothesis, which argues that strong governance stimulates technological innovation and stricter environmental regulations, thereby enabling urbanization to become a sustainable driver [4]. Among governance dimensions, control of corruption stands out as the strongest moderator, reflecting that in Asia, where corruption often undermines green projects, strict anti-corruption measures can foster sustainable investment, as seen in China's efforts to reduce pollution by linking resource governance with anti-corruption campaigns [14]. This strong moderating effect of control of corruption closely aligns with [14] in East Asian economies, where anti-corruption measures significantly enhance green investment efficiency and reduce leakage in urban-related projects. It also complements [5], which highlights governance as a moderator of urbanization's impact on inclusive green growth in BRI countries, although our results show a particularly pronounced role for control of corruption compared to the broader composite governance index used in that study.

Government effectiveness, rule of law and voice and accountability also help reduce urbanization risks by improving policy implementation, as illustrated by Singapore's development model. Conversely, regulatory quality exhibits a negative moderating effect, reflecting the weakness of environmental regulatory frameworks in parts of the region. For instance, India's air pollution control regulations in Delhi often remain formalistic and poorly enforced, failing to transform urbanization into a green opportunity [1]. Political stability, however, shows no significant effect, suggesting that this factor plays a limited role in shaping the urbanization-green growth relationship, possibly because many Asian countries, such as China and Singapore, have maintained relative stability throughout their urbanization process. This insignificant result differs from evidence in some OECD-based studies [8], where political stability is often linked to long-term urban sustainability planning, but is consistent with the Asian context, where political continuity in many high-performing economies reduces the differentiating power of this dimension.

Beyond the main and interaction variables, the control variables yield additional insights. Economic growth shows a strong positive and significant coefficient, indicating that economic expansion continues to provide a foundation for green transformation, especially when accompanied by digital innovation and energy efficiency policies. Capital formation (K) and FDI also exhibit positive effects, suggesting that both domestic and

international investment can serve as important drivers of green growth if directed toward clean and low-emission industries. By contrast, labor (L) has a negative and significant impact, implying that the current urban labor structure remains quantity-driven rather than quality-oriented, which intensifies pressure on infrastructure and the environment, thereby constraining green transformation. Most notably, CO_2 emissions display a strong and significant negative coefficient, confirming that rising greenhouse gas emissions associated with industrialization and urbanization remain the largest barrier to green growth. This underscores that without stronger emission reduction measures, Asian countries will struggle to decouple economic expansion from environmental degradation.

5. CONCLUSIONS

5.1. Conclusions

This study provides empirical evidence on the relationship between urbanization and green growth in 32 Asian countries during 1996 - 2021, while clarifying the mediating and moderating role of governance. GMM estimations indicate that in the early stages, urbanization tends to negatively affect green growth, reflecting environmental and social pressures stemming from rapid urban expansion. However, when linked to governance quality, these adverse effects are adjusted and transformed into positive outcomes.

The composite governance index constructed through PCA demonstrates a significant and direct impact on green growth. Among its components, control of corruption exerts the strongest influence, followed by government effectiveness, voice and accountability, and rule of law, suggesting that these four dimensions serve as pillars for enhancing urbanization quality while reducing environmental costs. In contrast, regulatory quality reveals certain weaknesses, as many environmental policies remain formalistic, while political stability and absence of violence show no significant statistical effect, implying that political stability alone is insufficient to drive green growth.

Control variables further strengthen the robustness of the model: economic growth, trade and technology exert positive effects on green growth, while CO_2 emissions and labor scale exert negative pressures, highlighting the need for stronger regulatory and management mechanisms. Thus, the study confirms that although urbanization may generate environmental challenges, governance quality remains the key factor in transforming this process into a driver of sustainable development in Asia.

5.2. Policy implications

The findings offer several important policy implications for Asian countries that face rapid urbanization pressures while simultaneously pursuing sustainability goals. A key highlight is that governance plays a decisive role in shaping the impact of urbanization on green growth. To realize sustainable development objectives, countries must not only manage the speed and scale of urbanization but also strengthen institutional quality.

First, control of corruption is the most powerful governance factor in mitigating the environmental consequences of urbanization. Reducing corruption ensures more efficient allocation of public resources, minimizes losses in infrastructure and energy projects, and enables effective implementation of green initiatives. Countries should establish independent oversight bodies, enhance budget transparency and procurement processes, and strengthen the role of media and civil society in exposing and preventing corruption related to urban and environmental management.

Second, government effectiveness is essential for improving policy coordination and implementation. Effective governments are better equipped to plan scientific urban development, optimize land use, and deploy technological solutions to limit emissions. This is particularly important in fast-urbanizing countries, where pressures from traffic, air pollution, and solid waste are intensifying. Digitizing urban management, strengthening human resources in environmental-urban sectors, and designing long-term policies are necessary steps to enhance government effectiveness.

Third, voice and accountability play a role in strengthening governance by expanding citizen participation and increasing transparency in policymaking. Although this variable did not show strong statistical significance in regression results, it remains practically crucial to ensure that green policies reflect societal needs, gain public support, and are subject to monitoring. In Asia, where gaps between governments and citizens in urban management persist, governments should expand feedback channels, empower independent media and civil society, and foster two-way dialogue on environmental policies.

Fourth, the rule of law provides the foundation for ensuring that environmental regulations are strictly enforced. Without a strong legal framework, even well-designed policies may fail in practice. Thus, countries need to strengthen transparency and consistency in environmental legislation and

enforcement, impose strong sanctions on violators, and promote community and business participation in monitoring. This not only increases deterrence but also builds trust in the legal system.

Fifth, regulatory quality remains limited, as many environmental policies are either symbolic or difficult to implement. Countries should review and eliminate overlapping or impractical regulations while building feasible legal frameworks. Public-private partnerships are particularly effective, aligning green development goals with market standards (adopting green building standards, encouraging investment in renewable energy, and promoting innovation).

Sixth, while political stability does not directly and significantly impact green growth, it remains a prerequisite for policy continuity. Stable political environments help avoid disruptions in green policy implementation, which is critical since sustainable development projects often require long time horizons. Governments should therefore maintain social and institutional stability as a necessary condition for effective governance reform.

Beyond governance, the control variables provide further policy directions. Economic growth and international trade positively influence green growth if properly guided. Countries should prioritize attracting FDI and expanding trade in low-emission and environmentally friendly sectors while developing environmental screening criteria for investment projects. Technology emerges as a key driver of green urbanization; thus, governments should promote research, development, and adoption of clean technologies, as well as accelerate green technology transfer from international partners.

By contrast, CO_2 emissions and labor scale exert negative pressures on green growth. To curb emissions, countries should adopt carbon taxes, expand modern public transport, and encourage renewable energy use. Meanwhile, instead of treating labor growth as a burden, governments can transform it into an advantage through large-scale green skills training programs, preparing the workforce for jobs in renewable energy, waste management and sustainable construction.

Despite its contributions, this study has several limitations. First, the use of aggregate WGI and WDI data may not fully capture subnational or cultural heterogeneity in governance across Asia. Second, although system GMM helps address endogeneity, some omitted variables may remain. Third, green growth measured by Adjusted Net Savings can be negative in resource-intensive economies. Fourth, the findings are specific to the 32 sampled Asian countries, and the analysis ends in 2021, excluding post-COVID developments. Future research could integrate local-level datasets and employ hybrid estimation models to test governance mechanisms more accurately, thereby enriching the understanding of the urbanization-governance-green growth nexus.

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Các khía cạnh quản trị thúc đẩy mối liên kết giữa đô thị hóa và tăng trưởng xanh: Bằng chứng từ các nền kinh tế châu Á

Nguyễn Hòa Kim Thái

TÓM TẮT

Trong bối cảnh nhiều nền kinh tế châu Á đang nỗ lực cân bằng giữa tốc độ đô thị hóa nhanh chóng và các mục tiêu tăng trưởng xanh, quản trị nổi lên như một yếu tố then chốt định hình quỹ đạo phát triển. Nghiên cứu này xem xét vai trò của các khía cạnh quản trị trong việc tác động đến mối quan hệ giữa đô thị hóa và tăng trưởng xanh tại 32 quốc gia châu Á từ năm 1996 đến năm 2021. Bằng việc sử dụng phương pháp tiếp cận hệ thống GMM hai bước, kết quả cho thấy đô thị hóa ban đầu có tác động tiêu cực đến tăng trưởng xanh; tuy nhiên, tác động này chuyển sang tích cực khi quản trị được cải thiện. Trong số các chỉ số quản trị, kiểm soát tham nhũng có ảnh hưởng mạnh nhất, tiếp theo là hiệu quả của chính phủ, tiếng nói và trách nhiệm giải trình và pháp quyền. Ngược lại, chất lượng quy định có tác động hạn chế vì nhiều chính sách môi trường vẫn còn mang tính hình thức, trong khi ổn định chính trị và an ninh không có tác động đáng kể về mặt thống kê. Dựa trên những phát hiện này, nghiên cứu đề xuất một số hàm ý chính sách nhằm tăng cường chất lượng quản trị trong các lĩnh vực cụ thể, từ đó chuyển đổi đô thị hóa thành động lực cho tăng trưởng xanh bền vững và toàn diện.

Từ khóa: *nền kinh tế châu Á, các khía cạnh quản trị, tăng trưởng xanh, đô thị hóa*

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