“How urban ecosystems and energy investment changed across global regions: An international business perspective”

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HOW URBAN ECOSYSTEMS AND ENERGY INVESTMENT CHANGED ACROSS GLOBAL REGIONS: AN INTERNATIONAL BUSINESS PERSPECTIVE

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Abstract

Urbanization and energy investment are increasingly interconnected, yet previous studies provide conflicting evidence regarding their relationship across different regional contexts. The relationship is particularly relevant to international business because regional differences in urban development and energy investment may shape the conditions for infrastructure-related investment. This study examines the relationship between changes in urban ecosystem indicators and energy investment growth across eight global regions from an international business perspective. The analysis is based on urban indicators derived from the Global Human Settlement Layer and energy investment data from the International Energy Agency. Urban indicators are aggregated for the ten largest cities in each region, comprising 80 cities, while energy investment is measured at the regional level. Percentage changes between 2015 and 2025 are compared using a 2×2 classification based on cross-regional median values across 20 urban–energy matrix combinations. The results reveal substantial heterogeneity. China most frequently exhibits Above-Median Urban Change–Above-Median Investment Growth configurations in 16 combinations, while India most frequently exhibits Below-Median Urban Change–Above-Median Investment Growth configurations in 12 combinations. Africa and the United States most frequently exhibit Below-Median Urban Change–Below-Median Investment Growth, whereas Latin America most frequently exhibits Above-Median Urban Change–Below-Median Investment Growth. The European Union, Southeast Asia, and the Middle East show borderline patterns because of tied configurations. These findings indicate that changes in urban ecosystems and energy investment do not follow a uniform regional pattern. The results support a context-dependency in which institutional and regional contexts are relevant to understanding urban–investment relationships.

Keywords agglomeration, cities, energy, investment, infrastructure, urbanization

JEL Classification F23, R11, Q42

INTRODUCTION

Global investment in the energy sector has expanded rapidly in response to growing energy demand, urbanization, and the transition toward low-carbon development. Recent estimates indicate that worldwide energy-transition investment is expected to exceed USD 2 trillion annually, driven primarily by renewable energy, electrified transportation, and electricity infrastructure. (BloombergNEF, 2026). Despite this growth, the geographical distribution of energy investment remains highly uneven. Most investment continues to concentrate in major economies such as China, the United States, and the European Union. At the same time, many developing regions face persistent shortages of capital for energy infrastructure and modernization (IRENA & CPI, 2025).

At the same time, urbanization is reshaping the spatial organization of economic activity worldwide. Cities increasingly function as hubs of production, consumption, innovation, and infrastructure development within the global economy (Acuto & Leffel, 2021; Sassen, 2005). Rapid urban expansion creates new demand for electricity generation, transmission networks, and energy services, thereby influencing the attractiveness of locations for energy-related investment. However, the effects of urban development vary across regions. While some urbanizing economies have become major destinations for energy investment, others continue to experience substantial infrastructure deficits despite sustained urban growth (Adelakun et al., 2025).

A methodological challenge in examining the relationship between urban ecosystems and energy investment arises from the different spatial scales at which these phenomena are measured. Internationally comparable energy investment statistics are generally available only at the regional level, whereas urban ecosystem characteristics are inherently city-based. Previous research suggests that major cities capture the dominant spatial, infrastructural, and economic characteristics of wider urban systems because urban development follows hierarchical and scaling processes (Bagnoli, 2026; Bettencourt, 2013; Ribeiro & Netto, 2025). Studies of energy systems have likewise employed leading metropolitan areas as proxies for broader territorial systems when economic activity and energy demand are highly concentrated (Parkpoom & Harrison, 2008; Zhang et al., 2012). This provides a conceptual basis for treating major-city urban characteristics as a regional urban-system proxy, while recognizing that such indicators do not represent the full spatial extent of the region. The analytical question is therefore whether differences in the characteristics of major urban nodes are associated with different regional energy-investment trajectories.

This uneven pattern raises an important question for international business research. If urbanization generally increases economic activity and energy demand, why do regions with similar urban growth trajectories exhibit markedly different levels of energy investment? The persistence of these differences suggests that the relationship between urban development and energy investment cannot be explained solely by population growth or market size. Instead, regional development trajectories, institutional environments, and spatial structures may shape how urban systems interact with global investment flows.

The scientific problem this study addresses is the inability of existing explanations of energy investment to account for the substantial cross-regional variation observed among economies with comparable levels of urbanization. While urban growth is generally associated with rising energy demand and expanding infrastructure needs, empirical evidence indicates that similar urbanization trajectories often yield markedly different investment outcomes. This inconsistency suggests that the mechanisms linking urban ecosystem development and energy investment remain poorly understood, creating uncertainty about how urban transformation translates into investment attractiveness across regional contexts.

1. LITERATURE REVIEW

International business theory explains cross-border investment primarily as a location choice problem. According to Dunning's Eclectic (OLI) Paradigm, investors invest where ownership advantages can be effectively combined with location-specific advantages and internalization benefits (Cruz et al., 2022). Location advantages increasingly extend beyond traditional market size and natural resources to include urban infrastructure, sustainability capacity, and city-level ecosystems that influence investors' investment decisions (Goerzen et al., 2024). Bass and Grøgaard (2021) argue that investors influence and are affected by changes in the long-term energy transition (LTE). The energy transition encourages investors to choose urban locations. In this context, urban ecosystems become relevant.

In this study, the urban ecosystem is conceptualized as the physical and spatial configuration of urban settlements. Settlement Scaling Theory argues that urban systems exhibit regular relationships between spatial concentration, built infrastructure, interaction intensity, and energy requirements (Bettencourt, 2013; Lobo et al., 2020). From the urban metabolism perspective, cities function

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as material and energy systems in which accumulated built stocks, infrastructure density, and energy flows jointly characterize urban performance (Cui et al., 2019; Delgado-Ramos, 2015). This view is supported by urban scaling theory, which argues that the fundamental social, infrastructural, and spatial processes governing cities are remarkably scale-invariant, allowing major cities to capture the dominant characteristics of broader urban systems (Bettencourt, 2013; Ribeiro & Netto, 2025). Likewise, urban hierarchy theory suggests that higher-order cities function as regional innovation hubs, concentrating infrastructure, economic activity, and renewable energy development while simultaneously organizing networks that connect surrounding smaller cities and rural areas (Bagnoli, 2026). Previous energy studies have similarly employed major metropolitan areas as proxies for larger territorial systems when economic activity and energy demand are spatially concentrated. For example, Parkpoom and Harrison (2008) justified the use of the Bangkok metropolitan area because it represented approximately 70% of Thailand's electricity demand, while Zhang et al. (2012) treated provincial capital cities as proxies for regional energy production and consumption in China. Moreover, recent evidence indicates that urban agglomerations account for the overwhelming majority of national energy consumption and carbon emissions, reinforcing the role of major cities as the principal metabolic engines of regional development (Ning et al., 2026).

Cities increasingly function as strategic nodes connecting global production systems, infrastructure networks, and institutional environments, thereby influencing the location decisions of investors (Acuto & Leffel, 2021; Sassen, 2005). According to Goerzen et al. (2024), location-specific advantages such as digitalization and sustainability complement and interact with city characteristics, thus attracting investments. Furthermore, dense urban systems reduce infrastructure costs, which increases knowledge spillovers (Bohnsack et al., 2021). Increased knowledge spillovers then improve coordination, making locations attractive to energy investment (Turkina & Sultana, 2023).

Some researchers argue that urban ecosystems have a positive impact on energy investment. Urbanization increases market density, energy demand, and infrastructure efficiency, thus creating an attractiveness for investors. Studies show that the urban population is positively correlated with energy consumption, which in turn drives energy investment to meet this demand (Kang et al., 2021). Urban agglomeration can also improve infrastructure efficiency and lower energy distribution costs, thereby increasing investment attractiveness (Khan & Xin, 2026; Şenyel & Guldmann, 2016). Moreover, Sit (2001) states that dense urban systems also provide stronger market accessibility, labor pooling, and network effects, which are important determinants of investment location decisions. These agglomeration advantages increase the attractiveness of cities for energy-related investment activities.

Although urban ecosystems provide location-specific advantages, investors respond differently because investment decisions are filtered through institutional quality, regulatory certainty, political risk, and local capabilities. The international business literature increasingly recognizes that investment decisions are shaped not only by market characteristics and resource availability but also by the institutional environments in which firms operate. Institutions, including legal systems, regulatory frameworks, governance quality, and administrative structures, constitute location-specific factors that influence the attractiveness and profitability of investment (Mudambi & Navarra, 2002). Consequently, investors rarely respond to economic opportunities uniformly across locations. From an institutions-based perspective, the attractiveness of a location depends on the interaction between host-country conditions and firm-specific capabilities. Institutional quality has consistently been identified as a critical determinant of location choice because it affects transaction costs, investment risks, and coordination efficiency (Kim & Aguilera, 2016). At the same time, institutional diversity across countries creates substantial variation in how firms evaluate investment opportunities and formulate internationalization strategies (Hitt, 2016; Saikia et al., 2025).

Similarly, network and economic geography perspectives highlight that energy investment is not solely determined by urban characteristics, but also by factors such as resource availability, geopolitics, and global connectivity (Martinus &

Tonts, 2015). Moreover, not all forms of urban growth generate favorable investment conditions. Urban sprawl may increase infrastructure costs, reduce distribution efficiency, and create additional investment risks, particularly for energy projects that require extensive network connectivity (Hinestroza-Olascuaga et al., 2023). This suggests that the urban ecosystem is not the sole determinant, but part of a broader system.

Beyond responding to existing demand, investment can drive urban restructuring and infrastructure development. Hamilton and Carter (2005) argue that energy investment acts as an exogenous force that stimulates the expansion of commercial and industrial activities, thereby reshaping urban spatial structures and increasing demand for supporting infrastructure, including energy systems. Recent studies further suggest that urban expansion may reinforce energy investment through policy coordination and green development strategies. Urbanization integrated with green finance and industrial policy can create mutually reinforcing cycles between infrastructure development and renewable energy investment (Hepburn et al., 2021; Kouam & Catche, 2025).

Although previous studies have established that urban development, institutional quality, and energy investment are interrelated, three important gaps remain. First, existing evidence remains empirically fragmented and inconsistent. Some studies conclude that urban density and agglomeration enhance infrastructure efficiency, reduce distribution costs, and stimulate energy investment through stronger market accessibility and economies of scale. Zvoleff et al. (2009) and Şenyel and Guldmann (2016) showed that population density can reduce the cost of energy infrastructure deployment and generate economies of scale in distribution networks, thereby increasing the efficiency and attractiveness of energy-related investments. Dense urban environments are increasingly viewed as advantageous because they reduce infrastructure costs, improve energy efficiency, and generate stronger agglomeration economies (Ahlfeldt & Pietrostefani, 2017). In contrast, other studies demonstrate that rapid urbanization may reinforce fossil-fuel dependence, increase infrastructure inefficiencies, or fail to attract investment where governance and institutional quality are weak. Studies on developing economies further indicate that weak governance, regulatory uncertainty, and institutional voids can significantly reduce the attractiveness of energy investment despite growing market opportunities (Adegboye et al., 2020; Ajayi, 2006). Rapid urban growth can also increase fossil fuel dependence and carbon intensity, particularly in industrializing economies (Chen et al., 2025; Chowdhury et al., 2024). These conflicting findings indicate that the relationship between urban ecosystems and energy investment has not yet been empirically resolved.

Second, the existing literature lacks an integrated international business explanation of why similar urban conditions generate different investment outcomes. Urban studies predominantly emphasize agglomeration economies, infrastructure, and spatial development, whereas international business research focuses primarily on institutional quality, transaction costs, and location-specific advantages influencing enterprises (Mudambi & Navarra, 2002; Kim & Aguilera, 2016). Formal and informal institutions influence transaction costs, access to resources, and coordination mechanisms, thereby affecting the attractiveness of locations (Meyer et al., 2011). Consequently, these two streams of literature have largely evolved independently, providing limited theoretical understanding of how urban ecosystem characteristics and institutional environments jointly shape the regional attractiveness of energy investment.

Third, previous studies generally examine individual determinants of energy investment in isolation and pay limited attention to the long-term interaction between urban transformation and investment trajectories across heterogeneous regional contexts. Existing evidence shows that energy investment patterns are frequently influenced not only by current urban conditions but also by historically accumulated technological and institutional structures (Freitas & Jehling, 2023). Long-term investments in energy infrastructure create path-dependent trajectories that shape future investment decisions and technological choices (Fouquet, 2016; Helmrich et al., 2023). Nevertheless, most studies analyze urbanization, institutional quality, or energy investment separately, without considering how these factors

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jointly evolve across regions with different technological capacity, institutional quality, and levels of economic development (Bu et al., 2019; Li et al., 2019). This leaves limited understanding of the broader spatial patterns linking urban ecosystem transformation and regional energy investment.

Taken together, the reviewed literature indicates that the relationship between urban ecosystems and energy investment remains insufficiently explained within an integrated international business framework. Addressing these gaps, this study examines the relationship between changes in urban ecosystem indicators and energy investment growth across eight global regions from an international business perspective.

2. METHOD

This study adopts a quantitative, comparative, and macro-regional research design to examine the relationship between urban ecosystems and energy investment. The analysis integrates spatial-urban indicators with cross-regional investment data to capture heterogeneous patterns across global regions. The study focuses on eight major regions: Africa, China, India, the United States, the European Union, the Middle East, Southeast Asia, and Latin America. Regional classification follows a functional grouping approach. Caribbean countries are included in Latin America, Arab states in North Africa are classified under Africa (not the Middle East), and the United Kingdom is excluded from the European Union. The analysis is based on two observation points (2015 and 2025), enabling the calculation of growth dynamics while recognizing limitations in capturing short-term fluctuations.

The analytical procedure consisted of five steps. First, urban and energy investment data for 2015 and 2025 were collected from the GHSL and IEA databases. After that, the ten largest cities in each region were selected based on their 2025 population sizes. In the third step, urban ecosystem indicators (BUV/Capita, BUV/Area, NRE Share, and MCI) were calculated for each city. Next, growth rates for all urban and energy investment variables were computed as the percentage change from 2015 to 2025. Finally, regions were mapped into a two-dimensional (2×2) matrix combining urban ecosystem indicators and energy investment variables to identify patterns in the urban–energy relationship.

Specifically, this study utilizes energy investment data from the IEA. The IEA dataset reports aggregate energy investment by sector and does not distinguish between domestic and foreign sources of capital. Accordingly, this study analyzes overall energy investment rather than foreign direct investment (FDI).

All variables are transformed into percentage growth rates of a city or region *i*, calculated as:

$$Growth_i = \frac{X_{2025} - X_{2015}}{X_{2015}} \cdot 100, \qquad (1)$$

where X_{2025} is the value of the variable in 2025, while X_{2015} is the value of the variable in 2015.

This transformation allows for cross-regional comparability by normalizing differences in scale.

Meanwhile, urban data are derived from the Global Human Settlement Layer (GHSL), a globally harmonized geospatial dataset developed to provide consistent measurements of human settlements across countries and time. The GHSL, particularly through the Global Human Settlement Urban Center Database (GHS-UCDB), has been recognized as a new standard for global urban data, enabling cross-country comparisons based on consistent definitions of cities and settlement structures (Melchiorri et al., 2024; Melchiorri, 2022).

The dataset includes 11,686 cities worldwide. To ensure representativeness while maintaining analytical tractability, the study selects the ten largest cities (by 2025 population) in each region. These cities serve as proxies for regional urban ecosystems, following prior research that uses leading urban centers to capture macro-regional dynamics (Parkpoom & Harrison, 2008; Zhang et al., 2012). The ten-city aggregation is used to construct a standardized major-city urban-system proxy representing the concentrated urban component of each region as suggested by urban hierarchy and urban scaling theories (Bagnoli, 2026; Bettencourt, 2013). The full list of selected cities is provided in Appendix A.

The dataset generated and analyzed during the current study is available in the Zenodo repository at Kaukab (2026). The repository contains the processed urban ecosystem indicators derived from GHSL data and energy investment indicators compiled from IEA sources, together with metadata and variable descriptions necessary for replication.

The following variables are extracted:

1. Total built-up volume (BUV_{2015}, BUV_{2025}).

2. Non-residential built-up volume ($NREBUV_{2015}$, $NREBUV_{2025}$).

3. Total population ($Population_{2015}$, $Population_{2025}$).

4. Urban land area ($Area_{2015}$, $Area_{2025}$).

Urban land area for both 2015 and 2025 was obtained from the multi-temporal urban boundary dataset provided by the Global Human Settlement Layer (GHSL), which reconstructs historical urban boundaries consistently across time. Regional population data used for normalization are obtained from Global Population Review for the years 2015 and 2025. In measuring urban ecosystems, this study adopts built-up volume (BUV) as a primary indicator. A three-dimensional (3D) approach, such as BUV, enables a more accurate representation of urban density, spatial heterogeneity, and functional land use patterns (Ranagalage & Murayama, 2018).

To capture the multidimensional nature of urban ecosystems, four key indicators are constructed:

5. Built-up Volume per Capita ($BUVCap_i$)

$$\frac{BUVC}{ap_i} = \frac{BUV_i}{Population_i}. \quad (2)$$

This variable reflects spatial density and infrastructure intensity relative to population.

6. Built-up Volume per Area ($BUVArea_i$)

$$\frac{BUV}{Area_i} = \frac{BUV_i}{Area_i}. \quad (3)$$

This indicator measures urban compactness and spatial efficiency.

7. Non-Residential Share (NRE_i)

$$NRE_i = \frac{NREBUV_i}{BUV_i}. \quad (4)$$

This variable captures the proportion of economic and commercial space within the urban structure.

8. Major Cities Concentration Index (MCI)

$$MCI = \frac{\sum_{i=1}^{10} Population_i}{Regional\ Population}. \quad (5)$$

MCI reflects the degree of population concentration in ten major cities within each region, which is particularly relevant in international business as urban concentration influences agglomeration economies, market access, and investment attractiveness. Unlike the three within-city indicators, MCI explicitly incorporates the regional denominator and therefore measures the degree to which population is concentrated in the selected major urban nodes relative to the wider region. MCI consequently provides a direct bridge between the major-city and regional spatial scales.

A central methodological issue in this study is the difference between the spatial resolution of the urban and energy-investment data. The urban indicators are derived from the ten largest cities in each region, whereas the IEA reports energy investment at the broader regional level. The two datasets are therefore not treated as measurements of the same geographic object. Instead, the ten-city aggregation is used to construct a standardized major-city urban-system proxy representing the concentrated urban component of each region, while IEA investment data represent the corresponding regional investment environment. The unit of comparison in the subsequent analysis is therefore the region, rather than the individual city. This approach allows the study to examine whether differences in the urban characteristics of major urban nodes are systematically associated with differences in regional energy-investment trajectories. Accordingly, the results should be interpreted as relationships between a region-

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al urban-core proxy and regional energy investment, rather than as a direct city-level effect on investment.

To synthesize the complex relationships between urban ecosystems and energy investment, this study employs a two-dimensional (2×2) typological matrix. Typological analysis allows researchers to organize empirical observations into structured categories, thereby facilitating comparison, explanation, and generalization (Collier et al., 2012). This approach reduces multidimensional empirical patterns into meaningful, theoretically interpretable categories, which is particularly valuable in international business research characterized by cross-regional heterogeneity. Regions with indicator values above the cross-regional median were classified as high, while those below the median were classified as low. The objective of the typology is not to establish statistical significance but to distinguish relatively stronger and weaker regional positions in a comparative framework. The main analytical output is a quadrant-based typology that maps regions by urban ecosystem (X-axis) and energy investment (Y-axis). This typology provides a parsimonious yet theoretically grounded interpretation of global heterogeneity in the relation of urban ecosystems and energy investment.

3. RESULTS

The 80 cities included represent 811 million people worldwide. Based on urban land area, Guangzhou has the largest spatial extent (6,454 km²), whereas Sana'a has the smallest (218 km²). Guangzhou also has the largest population at 42.9 million, while Rotterdam (The Hague) has the smallest at 2.2 million. In terms of population density, Phoenix is the least densely populated city at 2,000 people/km², while Mumbai is the most densely populated at 27,700 people/km².

In terms of NRE share, the region with the highest in 2015 was the European Union at 24.85%, while Africa had the lowest at 5.32% (Appendix B). The EU consistently had the highest proportion of non-residential space, at 24.97% in 2025. Meanwhile, Africa had the lowest NRE share, at 5.32% in 2015 and 5.40% in 2025.

In terms of changes from 2015 to 2025, the most dramatic decrease is in BUV/capita in Africa, which reached 22.83% from 275 to 212 m³/capita. During the same period, the population of the sampled African cities increased from 79,669,160 to 108,178,432 (35.78%), while total built-up volume increased from 21,929,209,168 to 22,978,578,150 (4.79%). The largest increase among the urban ecosystem indicators was observed in the European Union, where the MCI increased from 8.45% to 8.66% (2.58%), excluding the United Kingdom from the 2015 data. During the same period, the population of the sampled cities increased by 4.20%, while the regional population increased only by 1.58%, contributing to the increase in the MCI value.

In terms of energy (Table 1), the most dramatic transformation was seen in the 56.80% decline in energy investment in fossil fuels in Africa. This was supported by a 90.91% increase in energy investment in renewables. However, Africa's nearly 100% increase was not the highest in the data. The largest increase occurred in the Middle East, where energy investment in renewables rose 350%, while investment in fossil fuels decreased by only 1.37%.

Table 1. Percentage change in energy investment by region and energy segment (2015–2025)

Source: IEA (2025).

Region	Fossil fuels	Renewables	Grids & storage	Energy efficiency	Total energy investment
The Middle East	–1.37%	350.00%	–33.33%	150.00%	4.52%
Latin America	–21.85%	–10.34%	–18.75%	187.50%	–6.36%
The United States	–37.75%	85.96%	121.31%	75.00%	14.15%
Africa	–56.80%	90.91%	16.67%	180.00%	–31.37%
Southeast Asia	–24.64%	111.11%	–20.00%	133.33%	0.00%
India	19.51%	184.62%	–19.35%	146.15%	51.52%
China	18.43%	197.27%	36.71%	40.87%	65.11%
The European Union	–25.58%	108.93%	162.86%	114.67%	95.79%

Analysis of the 20 urban–energy matrix combinations reveals recurring but heterogeneous regional configurations across the indicator pairs. China is predominantly classified in the Above-Median Urban Change–Above-Median Investment Growth quadrant, with this configuration occurring in 16 of the 20 matrix combinations. India is predominantly positioned in the Below-Median Urban Change–Above-Median Investment Growth quadrant, occurring in 12 of the 20 combinations. Africa and the United States most frequently appear in the Below-Median Urban Change–Below-Median Investment Growth quadrant, with this configuration occurring in nine of the 20 combinations for each region. Latin America most frequently appears in the Above-Median Urban Change–Below-Median Investment Growth quadrant, also occurring in nine of the 20 combinations. In contrast, the European Union, Southeast Asia, and the Middle East exhibit tied configurations across the 20 matrices. The European Union has equal counts of Above-Median Urban Change–Below-Median Investment Growth and Below-Median Urban Change–Below-Median Investment Growth configurations (six each). Southeast Asia has equal counts of Below-Median Urban Change–Below-Median Investment Growth and Above-Median Urban Change–Below-Median Investment Growth configurations (eight each). Finally, the Middle East has equal counts of Above-Median Urban Change–Above-Median Investment Growth and Below-Median Urban Change–Above-Median Investment Growth configurations (six each). These results indicate that some regions exhibit a predominant configuration, whereas others are better characterized as mixed or borderline cases.

Because the regional classifications are highly similar across the 20 matrix combinations, presenting every matrix would result in considerable repetition (Appendix C). The subsequent results present three matrix pairs (BUV/Capita versus renewable energy investment, NRE versus total energy investment, and MCI versus grid and storage investment) to illustrate the recurring regional classifications observed across the complete set of 20 matrix combinations.

Figure 1 shows the BUV/capita matrix with renewable energy investment growth. Africa is classified in the Below-Median Change in BUV/capita–Below-Median Renewable Energy Investment Growth quadrant, while China is classified in the Above-Median Change in BUV/capita–Above-Median Renewable Energy Investment Growth quadrant. Southeast Asia, India, and the Middle East are classified in the Below-Median Change

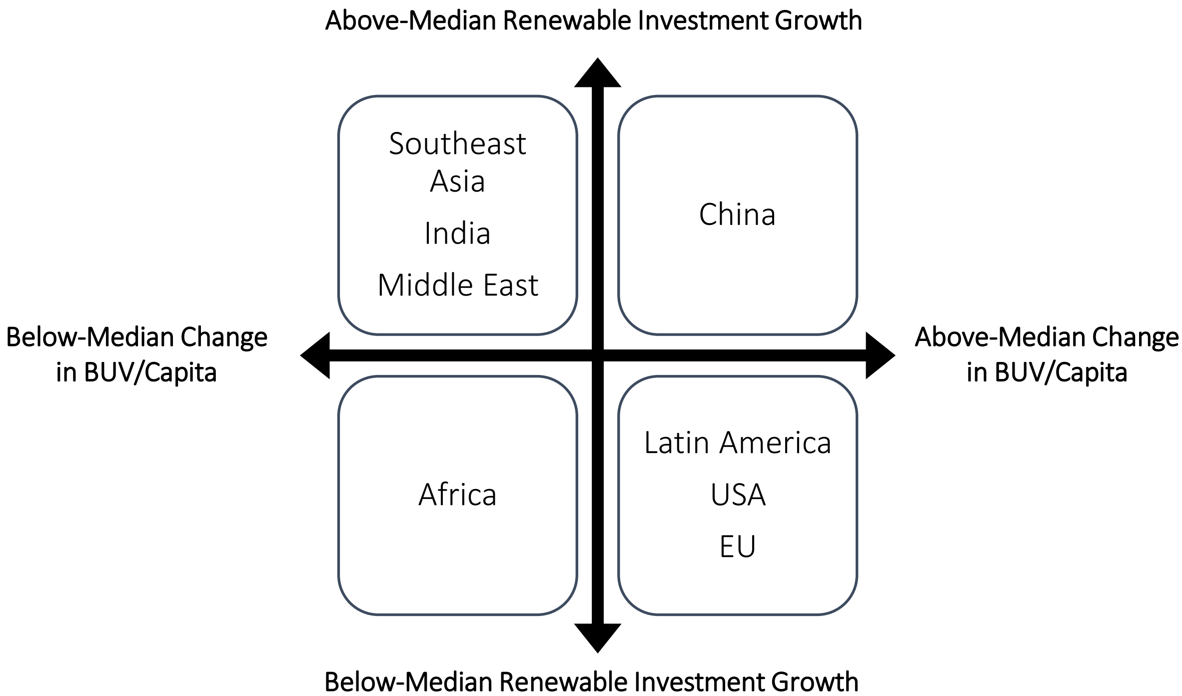

Figure 1. BUV/Capita vs energy investment in renewables matrix

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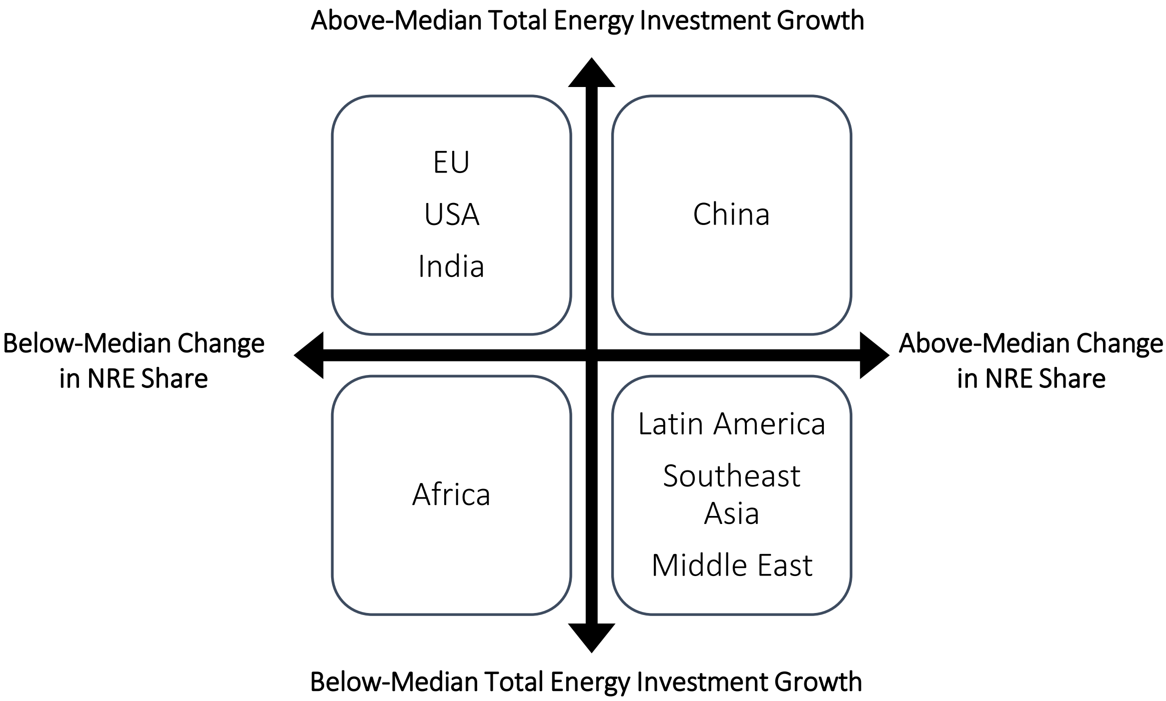

Figure 2. NRE share vs energy investment in energy matrix

in BUV/capita–Above-Median Renewable Energy Investment Growth quadrant. Meanwhile, Latin America, the United States, and the European Union are classified in the Above-Median Change in BUV/capita–Below-Median Renewable Energy Investment Growth quadrant.

Figure 2 compares the non-residential expansion (NRE) share with energy investment in energy. In the below-median change in NRE share with above-median change in total energy investment growth category, there are the European Union, the United States, and India. On the other

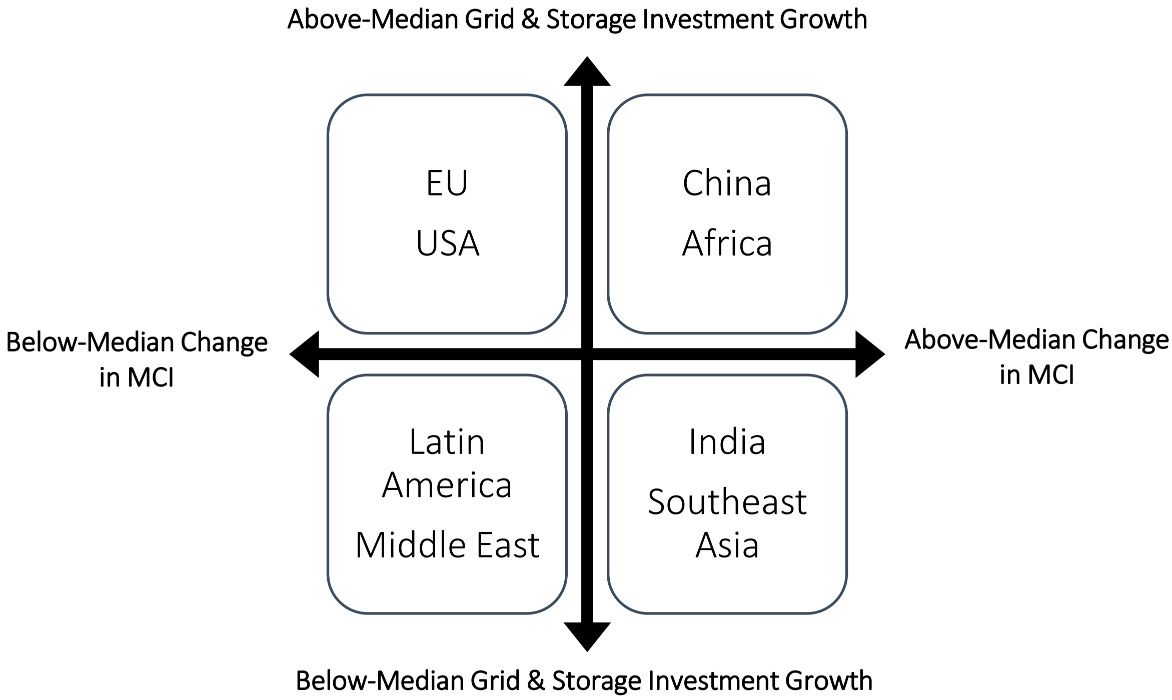

Figure 3. MCI vs energy investment matrix in grid and storage

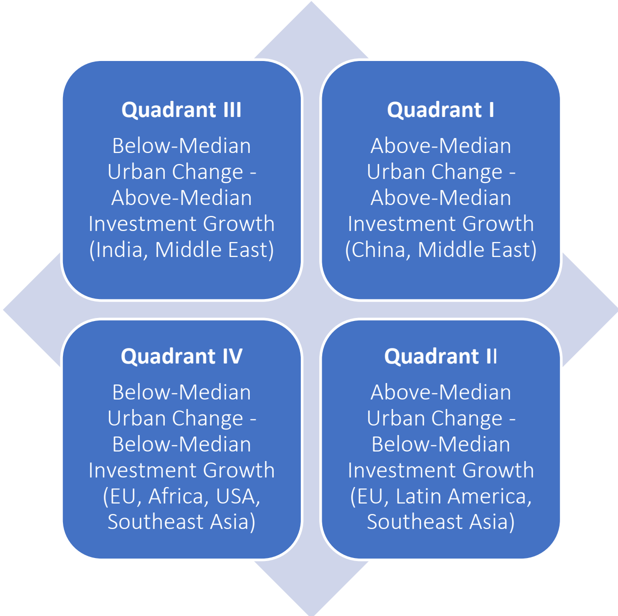

Figure 4. Regional typology of urban ecosystems and energy investment

hand, the above-median change in NRE share in Southeast Asia, Latin America, and the Middle East is associated with low total energy investment. China exclusively occupies the above-above category. Africa is low in both axes.

The third typology, shown in Figure 3, compares the Major-Cities Concentration Index (MCI) with grid and storage investment, revealing the relationship between urban population concentration and investment in electricity infrastructure. The below–below quadrant includes the Middle East and Latin America, while the below–above quadrant includes the United States and the European Union. Conversely, Southeast Asia and India are classified in the above–below quadrant. The above–above quadrant includes Africa and China.

Figure 4 shows the final mapping of this overall synthesis. Table 2 describes the characteristics of each quadrant. The quadrant labels were interpretive descriptors summarizing the dominant empirical characteristics observed within each regional cluster rather than formal theoretical categories.

Figure 4 summarizes the overall regional configurations based on the most frequently occurring classification across the 20 urban–energy matrix combinations. The classification is based on the modal (most frequent) configuration. China is classified as Above-Median Urban Change–Above-Median Investment Growth because this configuration occurs in 16 of the 20 matrix combinations. India is classified as Below-Median Urban Change–Above-Median Investment Growth, occurring in 12 of the 20 combinations. Africa and the United States have a modal Below-Median Urban Change–Below-Median Investment Growth configuration, with nine occurrences each, while Latin America has a modal Above-Median Urban Change–Below-Median Investment Growth configuration, also with nine occurrences. The European Union, Southeast Asia, and the Middle East are classified as mixed or borderline cases because each exhibits a tie between two configurations. The European Union has an equal number of Above-Median Urban Change–Below-Median Investment Growth and Below-Median Urban Change–Below-Median Investment Growth classifications (six each). Southeast Asia has an equal number of Below-Median Urban Change–Below-Median Investment Growth and Above-Median Urban Change–Below-Median Investment Growth classifications (eight each). Finally, the Middle East has an equal number of Above-Median Urban Change–Above-Median Investment Growth and Below-Median Urban Change–Above-Median Investment Growth classifications (six each). Figure 4 therefore summarizes predominant and mixed regional patterns rather than assigning every region to a single definitive quadrant.

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4. DISCUSSION

This study reveals substantial regional heterogeneity in the co-occurrence of changes in urban ecosystem indicators and energy investment growth across eight global regions. The urban dimension is represented by changes in built-up volume per capita (BUV/capita), non-residential expansion (NRE), and the Major-Cities Concentration Index (MCI), while the investment dimension is represented by percentage growth in different energy investment segments. The resulting classifications therefore describe relative rates of change. Accordingly, an Above-Median Urban Change classification indicates that the percentage change in the relevant urban indicator is above the cross-regional median, while an Above-Median Investment Growth classification indicates that investment growth is above the corresponding median.

The regional patterns can be interpreted through four principal configurations, although not all regions can be assigned unambiguously to a single category. China represents the clearest Above-Median Urban Change–Above-Median Investment Growth configuration, whereas India represents a predominant Below-Median Urban Change–Above-Median Investment Growth configuration. Africa and the United States exhibit modal Below-Median Urban Change–Below-Median Investment Growth configurations, while Latin America exhibits a modal Above-Median Urban Change–Below-Median Investment Growth configuration. The European Union, Southeast Asia, and the Middle East are better interpreted as mixed or borderline cases because two configurations occur with equal frequency across the 20 matrices. Accordingly, the typology should be understood as a descriptive classification of relative changes and investment-growth patterns.

One of the most salient findings is the differentiated association between changes in urban ecosystem indicators and renewable-energy investment growth. The results reveal substantial cross-regional heterogeneity in the direction and relative magnitude of change. China is classified in the Above-Median Change in BUV/capita–Above-Median Renewable Energy Investment Growth quadrant, whereas India, Southeast Asia, and the Middle East are classified in the Below-Median Change in BUV/capita–Above-Median Renewable Energy Investment Growth quadrant. Africa occupies the Below-Median–Below-Median quadrant, while Latin America, the United States, and the European Union occupy the Above-Median Change in BUV/capita–Below-Median Renewable Energy Investment Growth quadrant.

This finding is broadly consistent with Kang et al. (2021), who argued that urbanization increases energy demand and can create favorable conditions for energy investment. Similarly, Şenyel and

Table 2. Characteristics of members of the urban-energy relation quadrant

Regional configuration	Region	Empirical pattern
Above-Median Urban Change – Above-Median Investment Growth	China	Predominant configuration; 16/20 matrices
Below-Median Urban Change – Above-Median Investment Growth	India	Predominant configuration; 12/20 matrices
Below-Median Urban Change – Below-Median Investment Growth	Africa, United States	Modal configuration; 9/20 matrices each
Above-Median Urban Change – Below-Median Investment Growth	Latin America	Modal configuration; 9/20 matrices
Mixed: Above-Median Urban Change – Below-Median Investment Growth / Below-Median Urban Change – Below-Median Investment Growth	European Union	Tie; 6/20 and 6/20
Mixed: Below-Median Urban Change – Below-Median Investment Growth / Above-Median Urban Change – Below-Median Investment Growth	Southeast Asia	Tie; 8/20 and 8/20
Mixed: Above-Median Urban Change – Above-Median Investment Growth / Below-Median Urban Change – Above-Median Investment Growth	Middle East	Tie; 6/20 and 6/20

Note: Regional configurations are based on the modal (most frequent) classification across 20 urban–energy matrix combinations. Tied configurations are classified as mixed or borderline cases. "Above-Median" and "Below-Median" refer to the percentage change or investment growth relative to the cross-regional median, rather than to absolute levels of urban indicators or investment.

Guldmann (2016) demonstrated that dense urban environments can reduce infrastructure costs and improve energy distribution efficiency. Sit (2001) further suggested that dense urban systems generate stronger market accessibility, labor pooling, and network effects, which may influence the location of energy investment. These perspectives provide plausible mechanisms through which changes in urban systems may be associated with changes in energy investment.

The regional comparison also provides an important qualification to these arguments. Above-Median Urban Change does not systematically correspond to Above-Median Renewable Energy Investment Growth. Latin America, the United States, and the European Union provide examples in which the selected urban indicator changes are above the cross-regional median while renewable-energy investment growth is below the median. Conversely, India, Southeast Asia, and the Middle East exhibit Below-Median Change in BUV/capita alongside Above-Median Renewable Energy Investment Growth. These contrasting configurations indicate that relative urban change and renewable-energy investment growth can diverge substantially across regional contexts.

This heterogeneity is consistent with Bu et al. (2019) and Li et al. (2019), who emphasized the importance of institutional quality, technological capability, and economic conditions in shaping energy investment. The contrasting configurations therefore suggest that changes in urban ecosystem indicators may constitute one contextual dimension associated with energy investment growth. The evidence is consequently more appropriately interpreted as demonstrating regional variation in the association between urban change and renewable-energy investment growth.

The Latin American case further illustrates this distinction. Latin America exhibits an Above-Median Urban Change–Below-Median Investment Growth configuration in the overall typology, indicating that relatively higher percentage changes in the selected urban indicators can coexist with comparatively lower energy investment growth. This pattern is consistent with the possibility that urban transformation and energy investment do not necessarily proceed at the same relative pace across regions. As suggested by Hinestroza-Olascuaga et al. (2023), the relationship between urban transformation and investment can depend on institutional, economic, and infrastructural conditions. The present findings extend this perspective by showing that the relative rates of urban change and investment growth can diverge across regional contexts.

The analysis of non-residential expansion (NRE) and total energy investment further highlights the association between changes in non-residential urban activity and changes in energy investment. China is the only region positioned in the above-above quadrant for this specific relationship. The classification indicates that China's percentage change in NRE share and its percentage growth in total energy investment were both above the respective cross-regional medians.

This pattern is consistent with Hamilton and Carter's (2005) argument that energy investment can contribute to urban restructuring and infrastructure development. Expansion in commercial and industrial activities can increase energy requirements, while changes in energy infrastructure can simultaneously accompany broader economic transformation. Nevertheless, this descriptive design cannot determine whether changes in NRE preceded investment growth, followed it, or occurred simultaneously due to other factors.

The results also extend the arguments of Hepburn et al. (2021) and Kouam and Catche (2025), who emphasized that urbanization can be closely linked with green finance and industrial policy. While these studies primarily focused on the role of policy coordination in supporting sustainable investment, the present findings reveal that relative changes in urban indicators and investment growth do not follow a uniform regional pattern. China represents the clearest Above-Median Change–Above-Median Investment Growth configuration for NRE and total energy investment, whereas Africa represents a Below-Median Change–Below-Median Investment Growth configuration. Other regions display combinations that differ from these two patterns.

The contrast between China and Africa should represent a difference in the relative change ob-

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served between 2015 and 2025. This regional contrast can be interpreted in light of Bu et al. (2019) and Li et al. (2019), who emphasized that the effects of energy-related investment depend on institutional quality and development conditions. It is also consistent with the broader arguments of Ajayi (2006) and Adegboye et al. (2020), who highlighted the role of governance, regulatory conditions, and institutional capacity in shaping investment outcomes.

The observed regional differences may also be interpreted through the lens of path dependency in energy transitions. Existing infrastructure, industrial specialization, and regulatory arrangements may influence the pace and direction of subsequent investment. However, since the present quadrant analysis does not directly measure historical lock-in, institutional persistence, or causal path dependency, the path-dependency interpretation should therefore be treated as a possible explanatory perspective.

Overall, the NRE results suggest that relative changes in non-residential urban activity and energy investment growth can be aligned in some regions and divergent in others. Economic expansion, urban transformation, and energy investment therefore appear to constitute interconnected but not mechanically synchronized processes.

The relationship between changes in urban concentration and investment growth in energy grids and storage further highlights the importance of spatial structure. The MCI analysis identifies different regional combinations of change in population concentration and investment growth. China and Africa are classified in the Above-Median Change–Above-Median Investment Growth quadrant for this relationship, while the United States and European Union exhibit Below-Median Change–Above-Median Investment Growth configurations. India and Southeast Asia exhibit Above-Median Change–Below-Median Investment Growth configurations, whereas Latin America and the Middle East occupy the Below-Median Change–Below-Median Investment Growth quadrant.

These patterns are consistent with the arguments of Zvoleff et al. (2009) and Şenyel and Guldmann (2016), who emphasized the potential of population density and urban concentration to reduce infrastructure costs and generate economies of scale in energy distribution. The present findings complement this literature by showing that higher relative changes in urban concentration do not uniformly coincide with higher growth in grid and storage investment. The China and Africa configuration is consistent with such co-occurrence, but the India and Southeast Asian configurations demonstrate that Above-Median Change in MCI can also coexist with Below-Median Investment Growth.

Conversely, the United States and European Union exhibit Below-Median Change in MCI alongside Above-Median Growth in grid and storage investment. This configuration demonstrates that relatively higher investment growth can occur even when change in the selected urban concentration indicator is below the cross-regional median. Latin America and the Middle East provide the opposite configuration: Below-Median Change in MCI is accompanied by Below-Median Investment Growth. This pattern indicates a relatively weaker co-occurrence of change in urban concentration and grid and storage investment growth during the study period. Both dimensions experienced changes that were below their respective cross-regional medians.

These contrasting configurations qualify a simple interpretation based on economies of scale. Urban concentration may influence the economic and spatial conditions under which infrastructure investment occurs, but the observed investment-growth pattern is also likely to depend on infrastructure maturity, institutional arrangements, energy policy, technological change, and other regional conditions. The present results therefore support a context-dependent association.

From an international business perspective, this divergence is relevant because markets experiencing relatively rapid urban concentration change should not automatically be interpreted as markets with correspondingly rapid growth in grid and storage investment. Conversely, regions with relatively limited changes in the selected concentration indicator may nevertheless experience comparatively high investment growth. Enterprises should therefore evaluate urban change and investment growth as separate but potentially interconnected dimensions of market conditions.

The descriptive typology developed in this study offers a nuanced strategic framework for enterprises operating in the energy sector, emphasizing the need to align investment approaches with the spatial and structural characteristics of urban systems.

The descriptive typology developed in this study provides a comparative framework for enterprises operating in the energy sector. Its principal value is to distinguish regions according to the relative co-occurrence of urban ecosystem change and energy investment growth.

China represents the clearest Above-Median Urban Change–Above-Median Investment Growth configuration, occurring in 16 of the 20 matrix combinations. The result indicates that changes in the selected urban ecosystem indicators frequently coincide with above-median energy investment growth across the matrix combinations examined. This may provide a basis for considering integrated infrastructure strategies, including renewable-energy deployment, grid modernization, and urban energy-system development. However, the classification does not imply that all urban indicators or all investment segments exhibit above-median growth.

The Middle East represents a different case. It is equally divided between Above-Median Urban Change–Above-Median Investment Growth and Below-Median Urban Change–Above-Median Investment Growth configurations across the 20 matrices. The results indicate that Above-Median Investment Growth is relatively frequent in the region, while the direction of urban change varies across indicator pairs. For enterprises, this suggests the importance of segment-specific and indicator-specific market assessment.

In contrast, India exhibits a Below-Median Urban Change–Above-Median Investment Growth configuration, occurring in 12 of the 20 urban–energy matrix combinations. This configuration indicates that relatively lower percentage changes in the selected urban ecosystem indicators can coexist with comparatively higher energy investment growth. Importantly, this does not mean that India has inherently low urban development or that its energy investment level is inherently high. Rather, the result indicates a relative difference in rates of change during the study period. From an international business perspective, this highlights the importance of assessing investment-growth dynamics independently from changes in urban ecosystem indicators. For enterprises, the Indian case therefore suggests that relatively rapid investment growth may occur even when changes in selected urban indicators remain below the cross-regional median. Market assessment should consequently consider investment trajectories directly rather than assuming that stronger urban change necessarily precedes or accompanies stronger investment growth.

Latin America exhibits a modal Above-Median Urban Change–Below-Median Investment Growth configuration, occurring in nine of the 20 urban–energy matrix combinations. This pattern indicates that relatively higher changes in selected urban ecosystem indicators can coexist with comparatively lower energy investment growth. The finding identifies a relative divergence between urban indicator change and investment growth. From an international business perspective, this divergence highlights the importance of evaluating energy investment conditions independently from urban transformation indicators.

The European Union represents a mixed or borderline case, with equal frequencies of the Above-Median Urban Change–Below-Median Investment Growth and Below-Median Urban Change–Below-Median Investment Growth configurations (six of 20 combinations each), indicating that its overall pattern cannot be reduced to a single dominant configuration.

Africa and the United States exhibit modal Below-Median Urban Change–Below-Median Investment Growth configurations, whereas Southeast Asia represents a mixed case, with equal numbers of Below-Median Urban Change–Below-Median Investment Growth and Above-Median Urban Change–Below-Median Investment Growth classifications (eight each). These patterns suggest that investment strategies should be differentiated according to the relative configuration of

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urban change and investment growth, rather than according to assumptions about absolute urban development. In regions where both dimensions are frequently below the median, enterprises may need to pay greater attention to market readiness, infrastructure gaps, financing conditions, and institutional environments. In mixed configurations, more selective or segment-specific strategies may be appropriate. Partnerships with public institutions, development finance institutions, and other strategic actors may help enterprises manage uncertainty, although the precise strategy would depend on country- and sector-specific conditions.

The findings of this study also make an important contribution to the development of theory in international business by clarifying the relationship between urban ecosystem change and energy investment growth from a contextual perspective. First, this study contributes to the literature on urbanization and energy investment by showing that the relationship is heterogeneous in terms of relative change. Previous studies have shown contradictory results, with some finding a positive relationship through increased energy demand and efficiency (Kang et al., 2021), while others highlight potential negative effects such as dependence on fossil fuels or decreased investment in renewable energy (Elliott et al., 2013; Singh, 2022). The findings of this study suggest that these apparently contrasting perspectives can be reconciled when regional heterogeneity is taken into account. China most frequently exhibits Above-Median Urban Change–Above-Median Investment Growth, whereas India exhibits Below-Median Urban Change–Above-Median Investment Growth. Latin America provides the opposite combination of Above-Median Urban Change–Below-Median Investment Growth. Africa and the United States most frequently exhibit Below-Median Urban Change–Below-Median Investment Growth, while the remaining regions show mixed patterns. These findings therefore suggest that the relationship between urban transformation and energy investment growth cannot be adequately represented by a single universal configuration. Rather, different combinations of relative urban change and investment growth coexist across regions. This contextual heterogeneity provides one possible explanation for why previous studies may report different relationships between urbanization and energy investment.

Second, this study contributes to the perspectives of economic geography and global networks by showing that patterns of energy investment growth vary across regions in association with different patterns of urban ecosystem change across regions. Previous literature has emphasized the importance of global connectivity, geopolitics, and industrial networks in shaping energy investment (Martinus & Tonts, 2015). This study complements these perspectives by showing that changes in the spatial characteristics of major urban systems are associated with different investment-growth configurations across regional contexts.

Importantly, the analysis does not suggest that regions with Above-Median Urban Change possess stronger urban characteristics in absolute terms, nor that regions with Above-Median Investment Growth necessarily have higher absolute levels of investment. Instead, the classification captures relative percentage changes during the study period. Above-Median Urban Change may coincide with Above-Median Investment Growth, as observed most frequently in China, or with Below-Median Investment Growth, as observed in Latin America. Conversely, Below-Median Urban Change may coincide with Above-Median Investment Growth, as observed in India, or with Below-Median Investment Growth, as observed most frequently in Africa and the United States. These contrasting configurations demonstrate that the relationship between urban change and energy investment growth is context-dependent and not mechanically synchronized across regions.

Third, the descriptive patterns indicate that changes in urban ecosystem indicators and energy investment growth may occur concurrently, although the present two-period design does not permit direct assessment of causal or reciprocal dynamics. On the one hand, changes in urban development may be associated with changing energy demand and investment requirements. On the other hand, energy investment, particularly in grids, storage, and renewable energy, may accompany broader changes in urban infrastructure and economic activity. The configuration observed in China, where Above-Median Urban Change–Above-Median Investment Growth occurs in 16 of the 20 urban–energy matrix combinations, provides the clearest empirical example of this co-occurrence. However, this pat-

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tern should be interpreted as a descriptive association between relative changes, not as evidence of a self-reinforcing causal cycle. The study does not establish whether urban change generates investment growth, whether investment growth contributes to urban change, or whether both are driven by common underlying factors. The findings therefore suggest that urban ecosystem change and energy investment growth can exhibit different forms of cross-regional co-occurrence, while the direction, magnitude, mechanisms, and temporal dynamics of these relationships remain subjects for future longitudinal and causal research.

An important limitation concerns the spatial correspondence between the urban and investment measures. The urban indicators are constructed from the ten largest cities in each region, whereas energy investment is measured for the wider regional economy. The analysis therefore does not establish that the selected cities themselves receive or generate the corresponding regional investment. Instead, the results identify whether changes in indicators derived from major urban nodes are associated with broader regional investment-growth trajectories. The fixed ten-city approach also does not capture variation among secondary cities, peri-urban areas, and rural territories. Although the standardized selection procedure improves comparability across regions, future research should test the robustness of the findings using alternative city samples, population-weighted urban aggregates, metropolitan boundaries, or finer subnational investment data.

CONCLUSION

This study examines the relationship between changes in urban ecosystem indicators and energy investment growth across eight global regions from an international business perspective. China exhibits the clearest Above-Median Urban Change–Above-Median Investment Growth configuration, occurring in 16 of the 20 matrix combinations, while India predominantly exhibits a Below-Median Urban Change–Above-Median Investment Growth configuration in 12 of 20 combinations. Africa and the United States most frequently exhibit Below-Median Urban Change–Below-Median Investment Growth configurations, whereas Latin America most frequently exhibits an Above-Median Urban Change–Below-Median Investment Growth configuration; the European Union, Southeast Asia, and the Middle East represent mixed or borderline cases because of tied configurations. Overall, these findings indicate that changes in urban ecosystem indicators and energy investment growth vary substantially across regions and do not follow a uniform pattern. The results therefore support a context-dependent interpretation in which institutional and regional contexts should be considered when examining urban–energy investment relationships.

AUTHOR CONTRIBUTIONS

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APPENDIX A

Table A1. Representative cities for each region

City	Region	No.	Size	Population 2025
Cairo	Africa	1	1680	25,230,325
Kinshasa	Africa	2	487	12,945,683
Lagos	Africa	3	1199	12,846,045
Luanda	Africa	4	936	11,672,134
Dar es–Salaam	Africa	5	907	8,918,525
Johannesburg	Africa	6	1756	8,592,843
Addis Ababa	Africa	7	465	7,280,463
Khartoum	Africa	8	958	7,114,789
Alexandria	Africa	9	439	6,931,369
Nairobi	Africa	10	598	6,646,257
Ten largest cities in Africa	**Africa**		**9425**	**108,178,432**
Guangzhou	China	1	6454	42,987,704
Shanghai	China	2	3128	30,678,616
Beijing	China	3	2179	18,150,576
Suzhou	China	4	1802	11,540,430
Shantou	China	5	1961	10,579,303
Chongqing	China	6	653	8,449,690
Wuhan	China	7	772	8,079,484
Nanjing	China	8	1012	8,061,029
Tianjin	China	9	671	7,330,648
Hangzhou	China	10	1517	6,387,064
Ten largest cities in China	**China**		**20149**	**152,244,543**
Paris	The European Union	1	1421	9,328,385
Madrid	The European Union	2	680	5,680,137
Barcelona	The European Union	3	438	3,908,362
Berlin	The European Union	4	681	3,549,997
Athens	The European Union	5	412	3,166,757
Milan	The European Union	6	785	3,135,553
Naples	The European Union	7	618	2,885,079
Essen	The European Union	8	880	2,718,996
Rome	The European Union	9	467	2,476,089
Rotterdam [The Hague]	The European Union	10	677	2,173,754
Ten largest cities in The European Union	**The European Union**		**7059**	**39,023,110**
New Delhi	India	1	2139	31,422,508
Kolkata	India	2	2482	23,314,585
Mumbai	India	3	738	20,453,270
Bengaluru	India	4	1008	15,178,533
Chennai	India	5	1052	11,466,400
Hajipur	India	6	3166	9,755,303
Hyderabad	India	7	889	9,455,230
Ahmedabad	India	8	365	7,898,650
Kozhikode	India	9	1341	7,612,130
Surat	India	10	296	7,100,723
Ten largest cities in India	**India**		**13476**	**143,657,332**
São Paulo	Latin America	1	2111	19,485,158
Mexico City	Latin America	2	2134	17,639,164
Buenos Aires	Latin America	3	2186	14,179,912
Lima	Latin America	4	984	10,828,104
Bogota	Latin America	5	534	10,419,361
Rio de Janeiro	Latin America	6	1285	9,853,693
Santiago	Latin America	7	801	6,633,767
Santo Domingo	Latin America	8	483	4,593,164

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Table A1 (cont.). Representative cities for each region

City	Region	No.	Size	Population 2025
Belo Horizonte	Latin America	9	609	4,376,747
Guadalajara	Latin America	10	598	4,138,350
Ten largest cities in Latin America	**Latin America**		**11725**	**102,147,418**
Istanbul	The Middle East	1	1269	14,210,222
Tehran	The Middle East	2	825	9,363,124
Riyadh	The Middle East	3	1108	7,970,319
Baghdad	The Middle East	4	688	6,891,722
Amman	The Middle East	5	520	6,425,246
Mashhad	The Middle East	6	474	5,377,005
Jeddah	The Middle East	7	696	4,842,257
Dubai	The Middle East	8	854	4,565,478
Damascus	The Middle East	9	270	3,771,638
Sana'a	The Middle East	10	218	3,759,520
Ten largest cities in The Middle East	**The Middle East**		**6922**	**67,176,530**
Jakarta	Southeast Asia	1	4614	40,545,126
Manila	Southeast Asia	2	2555	25,921,189
Bangkok	Southeast Asia	3	2697	19,048,032
Ho Chi Minh City	Southeast Asia	4	1487	14,557,830
Bandung	Southeast Asia	5	988	8,691,181
Kuala Lumpur	Southeast Asia	6	1340	8,413,206
Surabaya	Southeast Asia	7	1304	6,856,993
Yangon	Southeast Asia	8	545	6,190,958
Singapore	Southeast Asia	9	438	5,117,759
Hanoi	Southeast Asia	10	925	4,965,520
Ten largest cities in Southeast Asia	**Southeast Asia**		**16893**	**140,307,794**
New York City	The United States	1	3031	14,197,659
Los Angeles	The United States	2	4498	13,474,333
Miami	The United States	3	2784	5,733,042
Chicago	The United States	4	2046	5,318,735
San Francisco	The United States	5	1614	4,718,349
Houston	The United States	6	1859	4,301,461
Washington	The United States	7	1301	3,471,725
Phoenix	The United States	8	1304	2,608,874
Dallas	The United States	9	1237	2,577,308
Denver	The United States	10	1194	2,425,086
Ten largest cities in The United States	**The United States**		**20868**	**58,826,571**

APPENDIX B

Table B1. Urban ecosystem indicators by region (2015 and 2025)

Africa	2015	2025	Difference
BUV	21,929,209,168	22,978,578,150	4.79%
Pop	79,669,160	108,178,432	35.78%
BUV/Capita	275	212	–22.83%
Area	8,251	9,425	14.23%
BUV/Area	2,657,687	2,438,045	–8.26%
NRE	1,167,374,935	1,240,961,440	6.30%
NRE Share	5.32%	5.40%	1.45%
Pop Region	1,170,000,000	1,540,000,000	31.62%
MCI	6.81%	7.02%	3.16%

Table B1 (cont.). Urban ecosystem indicators by region (2015 and 2025)

China	2015	2025	Difference
BUV	56,859,616,024	59,711,934,630	5.02%
Pop	131,883,163	152,244,543	15.44%
BUV/Capita	431	392	–9.03%
Area	18,844	20,149	6.92%
BUV/Area	3,017,372	2,963,518	–1.78%
NRE	7,157,454,890	8,371,995,717	16.97%
NRE Share	12.59%	14.02%	11.38%
Pop Region	1,380,000,000	1,410,000,000	2.17%
MCI	9.56%	10.80%	12.98%
European Union	**2015**	**2025**	**Difference**
BUV	16,963,268,196	17,189,544,551	1.33%
Pop	37,450,582	39,023,110	4.20%
BUV/Capita	453	440	–2.75%
Area	6,907	7,059	2.20%
BUV/Area	2,455,919	2,435,124.60	–0.85%
NRE	4,215,666,236	4,291,515,821	1.80%
NRE Share	24.85%	24.97%	0.46%
Pop Region	443,400,000	450,400,000	1.58%
MCI	8.45%	8.66%	2.58%
India	**2015**	**2025**	**Difference**
BUV	18,680,724,423	19,311,978,662	3.38%
Pop	121,996,669	143,657,332	17.76%
BUV/Capita	153	134	–12.21%
Area	11,488	13,476	17.30%
BUV/Area	1,626,088	1,433,065	–11.87%
NRE	1,587,018,126	1,680,690,253	5.90%
NRE Share	8.50%	8.70%	2.44%
Pop Region	1,310,000,000	1,460,000,000	11.45%
MCI	9.31%	9.84%	5.66%
Latin America	**2015**	**2025**	**Difference**
BUV	34,379,084,567	35,243,098,218	2.51%
Pop	98,051,159	102,147,418	4.18%
BUV/Capita	351	345	–1.60%
Area	11,477	11,725	2.16%
BUV/Area	2,995,509	3,005,807	0.34%
NRE	2,135,411,768	2,272,494,982	6.42%
NRE Share	6.21%	6.45%	3.81%
Pop Region	625,000,000	667,900,000	6.86%
MCI	15.69%	15.29%	–2.51%
Middle East	**2015**	**2025**	**Difference**
BUV	17,720,528,014	19,016,875,197	7.32%
Pop	56,601,516	67,176,530	18.68%
BUV/Capita	313	283	–9.58%
Area	6,304	6,922	9.81%
BUV/Area	2,811,198	2,747,309	–2.27%
NRE	1,982,465,747	2,211,238,547	11.54%
NRE Share	11.19%	11.63%	3.94%
Pop Region	375,000,000	475,000,000	26.67%
MCI	15.09%	14.14%	–6.30%
Southeast Asia	**2015**	**2025**	**Difference**
BUV	30,401,094,965	31,156,888,243	2.49%
Pop	121,067,080	140,307,794	15.89%
BUV/Capita	251	222	–11.57%
Area	16,017	16,893	5.47%

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Table B1 (cont.). Urban ecosystem indicators by region (2015 and 2025)

BUV/Area	1,897,996	1,844,366.79	–2.83%
NRE	4,036,547,139	4,292,369,467	6.34%
NRE Share	13.28%	13.78%	3.76%
Pop Region	628,500,000	693,400,000	10.33%
MCI	19.26%	20.23%	5.05%
United States of America	**2015**	**2025**	**Difference**
BUV	46,372,236,027	47,153,936,627	1.69%
Pop	55,449,897	58,826,571	6.09%
BUV/Capita	836	802	–4.15%
Area	19,534	20,868	6.83%
BUV/Area	2,373,916	2,259,628.94	–4.81%
NRE	9,657,771,448	9,946,957,808	2.99%
NRE Share	20.83%	21.09%	1.29%
Pop Region	321,000,000	347,500,000	8.26%
MCI	17.27%	16.93%	–2.00%

APPENDIX C

Table C1. Complete matrix

	BUVcap vs Fosil	**BUVcap vs Renewables**	**BUVcaps vs Grids**	**BUVcaps vs Efficiency**	**BUVcaps vs Total**
Below-below	Africa, SEA	Africa	ME, SEA, India	SEA	Africa, SEA, ME
Below-above	ME, India	SEA, India, ME	Africa	India, ME, Africa	India
Above-below	USA, EU	Latam, USA, EU	Latam	China, USA, EU	Latam
Above-above	Latam, China	China	China, USA, EU	Latam	China, USA, EU
	BUVar vs Fosil	**BUVar vs Renewables**	**BUVar vs Grids**	**BUVar vs Efficiency**	**BUVar vs Total**
Below-below	Africa, USA, SEA	Africa, USA	India, SEA	USA, SEA	Afica, SEA
Below-above	India	India, SEA	Africa, USA	India, Africa	India, USA
Above-below	EU	EU, Latam	ME, Latam	EU, China	ME, Latam
Above-above	ME, Latam, China	ME, China	EU, China	ME, Latam	EU, China
	NRE vs Fosil	**NRE vs Renewables**	**NRE vs Grids**	**NRE vs Efficiency**	**NRE vs Total**
Below-below	EU, USA, Africa	EU, USA, Africa	India	EU, USA	Africa
Below-above	India	India	EU, USA, Africa	Africa, India	EU, USA, India
Above-below	SEA	Latam	SEA, Latam, ME	SEA, China	SEA, Latam, ME
Above-above	Latam, ME, China	SEA, ME, China	China	Latam, ME	China
	MCI vs Fossil	**MCI vs Renewables**	**MCI vs Grids**	**MCI vs Efficiency**	**MCI vs Total**
Below-below	USA, EU	Latam, USA,EU	ME, Latam	USA, EU	ME, Latam
Below-above	ME, Latam	ME	USA, EU	ME, Latam	USA, EU
Above-below	Africa, SEA	Africa	SEA, India	SEA, China	Africa, SEA