REVIEW ARTICLE
https://doi.org/10.31063/AlterEconomics/2026.23-2.12
UDC 332.1
JEL O18, P20, R11

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Does Urbanization Still Drive Economic Growth in the Era of Smart Cities and Climate Challenges?[1]

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For citation: Asiamah, R. (2026). Does Urbanization Still Drive Economic Growth in the Era of Smart Cities and Climate Challenges? *AlterEconomics, 23*(2), 477–494.
https://doi.org/10.31063/AlterEconomics/2026.23-2.12

Abstract. Urbanization has long been viewed as a driver of economic growth through agglomeration economies. However, emerging challenges such as digital transformation and climate change call into question the universality of this relationship. A major gap in the literature is the limited integration of digital and environmental factors in explaining nonlinear urbanization–growth effects, as previous reviews (e.g., Gilles Duranton and Diego Puga, 2023) focus mainly on traditional mechanisms. This review therefore examines the evolution of the urbanization–growth nexus, identifies critical thresholds, evaluates the roles of digitalization and climate factors, and proposes a new conceptual framework. Following the PRISMA 2020 guidelines, searches were conducted in Web of Science, Scopus, EconLit, RePEc/IDEAS, and Google Scholar using Boolean search strings. From 3,892 records, 186 peer-reviewed studies published between 1960 and 2024 were selected. These studies linked urbanization indicators (e.g., population density and city size) to growth outcomes (e.g., GDP and productivity), while accounting for digital or environmental moderators. The findings reveal three distinct phases. Between 1960 and 2000, urbanization showed strong positive effects on growth. From 2000 to 2015, growth effects remained broadly linear during the period of rapid urbanization in China, India, and parts of Southeast Asia. After 2015, however, the relationship became increasingly conditional, with average agglomeration elasticities declining from 0.05 to 0.03. Digital infrastructure was found to increase urbanization benefits by 8–15 %, whereas environmental degradation reduced them by 4–12 %. Building on these findings, the review proposes a novel multiplicative framework in which net agglomeration benefits depend on physical density, amplified by digital (D) and environmental (E) multipliers. This framework helps explain why mid-sized smart and sustainable cities often outperform megacities in generating economic gains. Overall, the review confirms that urbanization can continue to support economic growth, but primarily in cities that are both digitally advanced and environmentally sustainable. Key limitations include geographic biases in the existing literature. Future research should therefore focus on identifying the causal effects of 5G and net-zero initiatives through experimental methods and harmonized measurement indices.

Keywords: urbanization, economic growth, agglomeration economies, smart cities, climate change, digital infrastructure

Acknowledgments: No external funding was received. Gratitude is extended to peers at HSE University for valuable feedback.

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ОБЗОРНАЯ СТАТЬЯ

Продолжает ли урбанизация стимулировать экономический рост в эпоху умных городов и климатических вызовов?

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Для цитирования: Асиама, Р. (2026). Продолжает ли урбанизация стимулировать экономический рост в эпоху умных городов и климатических вызовов? *AlterEconomics, 23*(2), 477–494. https://doi.org/10.31063/AlterEconomics/2026.23-2.12

Аннотация. В прошлом урбанизация стимулировала экономический рост за счет эффекта агломерации. Однако такие новые вызовы, как цифровая трансформация и экологические изменения (изменение климата), ставят под сомнение универсальность этой стимулирующей связи. Ключевой пробел в исследованиях заключается в том, что роль этих новых вызовов еще не получила достаточной количественной оценки. Цель данной статьи — проследить эволюцию взаимосвязи между урбанизацией и экономическим ростом с учетом количественных оценок взаимодействия цифровых технологий и экологических изменений, определить их пороговые значения, а также предложить новую концептуальную основу. В соответствии с рекомендациями PRISMA 2020 авторы провели поиск в Web of Science, Scopus, EconLit, RePEc/IDEAS и Google Scholar и проанализировали 3892 записи по данной проблематике. В результате были отобраны 186 рецензируемых исследований (1960–2024 годы), связывающих показатели урбанизации (например, плотность населения, размер города) с результатами экономического роста (например, ВВП, производительность), с учетом факторов цифровой трансформации и окружающей среды. Результаты показывают три фазы: сильные положительные эффекты (1960–2000 годы), почти линейный рост в период урбанизации в Индии, Китае и Юго-Восточной Азии (2000–2015 годы) и условное слабое воздействие после 2015 года, при этом средняя эластичность агломерации снизилась с 0,05 до 0,03. Цифровая инфраструктура увеличивает выгоды на 8–15 %, в то время как деградация окружающей среды снижает их на 4–12 %. Новая мультипликативная модель показывает, что чистая выгода от агломерации зависит от физической плотности, усиленной цифровыми (D) и экологическими (E) множителями. Это объясняет, почему эффекты агломерации более выражены в средних по размеру зеленых «умных» городах, чем в мегаполисах. Выводы подтверждают потенциал роста урбанизации за счет эффектов агломерации, но только для цифровых «умных» городов. Ограничения проведенного исследования относятся к возможным географическим искажениям. Поэтому будущие исследования должны оценить причинно-следственные связи инициатив 5G/нулевого уровня выбросов с помощью дополнительных экспериментов и согласованных индексов.

Ключевые слова: урбанизация, экономический рост, эффект агломерации, «умные» города, изменение климата, цифровая инфраструктура

Благодарность: Внешнее финансирование отсутствует. Выражаю благодарность коллегам из НИУ ВШЭ за ценные замечания.

1. Introduction

For more than 60 years, one of the most persistent and contentious issues in development economics and urban studies has been the connection between urbanization and economic growth. Scholars noted as early as the 1950s that low-income nations continued to be primarily rural, whereas almost all high-income nations were heavily urbanized (Hoselitz, 1955). The widely held idea that cities act as “engines of growth” comes from a well-known pattern: urban areas tend to generate higher productivity and support long-term economic development through agglomeration economies, knowledge spillovers, larger labor markets, and economies of scale (Glaeser & Henderson, 2017). Between 1990 and 2015, often described as the age of urbanization-led growth, the world experienced the largest urban transition in human history. The global

urban population grew from 2.3 billion to 4.0 billion, while hundreds of millions of people in East Asia, particularly in China, moved from rural agriculture into urban manufacturing and service sectors. This transformation was accompanied by unprecedented growth in GDP per capita (Gollin et al., 2016; Jedwab & Vollrath, 2019). A large body of cross-country and city-level research, using increasingly sophisticated data and identification strategies, finds that urbanization and city size are strongly associated with higher productivity and incomes, and in many cases may have a causal effect on them (Henderson, 2003; Au & Henderson, 2006; Combes et al., 2012; Ahlfeldt & Pietrostefani, 2019).

However, since the mid-2010s, a growing body of evidence has begun to challenge the idea that this relationship is linear or universal. Researchers have identified inverted U-shaped patterns, optimal levels of urbanization, cases of "urbanization without growth," and even situations in which congestion and coordination failures associated with urban growth can reduce economic performance (Brülhart & Sbergami, 2009; Castells-Quintana, 2017; Frick & Rodríguez-Pose, 2018). Megaslums and negative agglomeration externalities have resulted from fast urban population increase in parts of South Asia and sub-Saharan Africa that has outpaced formal job creation and infrastructure investment (Glaeser, 2014; Lall et al., 2017). Simultaneously, high-income nations have seen slower productivity increases in their biggest cities and, in certain instances, net out-migration sped up by the COVID-19 epidemic and the increase in distant labor (De La Roca & Puga, 2017; Delventhal et al., 2022).

Most significantly, two revolutionary megatrends of the twenty-first century are radically altering the character of cities and their capacity for growth. First, according to Allam (2019) and Lund et al. (2021), the digital revolution and the rise of smart cities, platform urbanism, and remote/hybrid work undermine traditional distance-dependent agglomeration dynamics while generating new kinds of virtual and polycentric concentration. Second, environmental restrictions imposed by the growing climate crisis and the need for green, resilient, and net-zero urban development can either impede growth or, if properly handled, offer new sources of innovation and efficiency (Acuto et al., 2018).

These developments raise an important question that has not yet been thoroughly explored in the literature: Is the growth dividend of cities becoming conditional, nonlinear, and heavily mediated by digital transformation and environmental constraints, or does urbanization still drive economic growth in the same way as it did during the twentieth century?

Although several insightful narrative reviews (Duranton, 2014; Glaeser & Henderson, 2017; Duranton & Puga, 2023) and a number of focused meta-analyses (Ahlfeldt & Pietrostefani, 2019) have examined aspects of the urbanization–growth relationship, no study has systematically traced the full evolution of this literature. Existing research ranges from the foundational contributions of the 1960s to recent work on smart-city economics and climate-resilient urban development. This review seeks to address this gap. Its specific objectives are as follows:

1. Trace the theoretical and empirical evolution of the urbanization–growth relationship across six decades;
2. Synthesize evidence on turning points, thresholds, and contextual moderators;
3. Assess how digital technologies and climate-change constraints are altering traditional agglomeration mechanisms;
4. Propose an updated conceptual framework for understanding the growth effects of urbanization in the 21st century;
5. Derive policy implications and priority areas for future research.

This review provides a comprehensive and up-to-date assessment of whether, how, and under what conditions cities continue to function as engines of economic growth in an era shaped by smart-city development and escalating climate challenges. Using a rigorous PRISMA-guided systematic methodology, the review synthesizes evidence from 186 studies, including 73 published between 2020 and 2024. The next chapter will discuss the methodology, followed by a historical perspective, after which the review will move to its core analysis.

2. Methodology

Pre-registered on the Open Science Framework (OSF Registries, DOI 10.17605/OSF.IO/7KX3M), this systematic review was carried out in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement (Page et al., 2021).

2.1. Eligibility Criteria and Information Sources and Search Strategy

The literature searches were performed between the 10th and 15th of December 2025 across several major academic databases. These included the Web of Science Core Collection (covering SCI-EXPANDED, SSCI, A&HCI, and ESCI), Scopus, EconLit, and the RePEc/IDEAS repository. To ensure comprehensive coverage of the grey and emerging literature, the first 1,000 relevant results from Google Scholar were also harvested using the Publish or Perish software. Final Boolean search string (identical or adapted to each platform): (“urbanization” OR “urbanization” OR “urban population” OR “city size” OR “agglomeration” OR “urban primacy” OR “urban concentration” OR “megacity*” OR “metropolitan area*” OR “smart cit*” OR “climate-resilient cit*” OR “sustainable urban*”)

Table 1

Eligibility Criteria for Study Inclusion

Criterion	Inclusion	Exclusion
Publication language	English	All other languages
Publication type	Peer-reviewed journal articles, book chapters, working papers from recognized repositories (NBER, CEPR, IZA, World Bank Policy Research)	Dissertations, theses, conference abstracts, editorials, commentaries, textbooks, encyclopedias, statistical yearbooks, laws and regulations
Time period	1960 — 31 December 2024	Pre-1960 and post-31 Dec 2024
Topic	Explicitly examines the relationship (causal or correlational) between urbanization (or any proxy: urban population share, city size, agglomeration, primacy, density) AND economic growth/performance (GDP growth, GDP per capita, productivity, innovation) OR explicitly analyzes how smart-city interventions or climate-change constraints modify this relationship	Studies that mention cities only incidentally without measuring growth effects
Study design	Empirical (cross-country, panel, city-level, firm-level), theoretical models with clear growth implications, earlier literature reviews and meta-analyses	Purely descriptive city case studies without growth outcome

Source: Compiled by the author based on PRISMA 2020 guidelines.

AND (“economic growth” OR “GDP growth” OR “productivity growth” OR “TFP growth” OR “economic development” OR “income per capita” OR “convergence” OR “structural transformation”) AND (“empirical” OR “evidence” OR “panel” OR “cross-country” OR “causal” OR “instrumental variable” OR “threshold*” OR “nonlinear*” OR “inverted-U” OR “climate change” OR “environmental constraint*” OR “green growth” OR “decarbonization”). Filters applied: English, article/book chapter/working paper, 1960–2024.

2.2. Study Selection and Data Extraction and Quality Appraisal

The study selection process was conducted systematically, beginning with the import of all records into Rayyan QCRI for de-duplication. The titles and abstracts were then subjected to blinded double screening by two independent reviewers, which resulted in a high inter-rater agreement (Cohen’s $\kappa = 0.89$). Following this, I performed a full-text screening of the remaining articles, with all reasons for exclusion being documented. To ensure comprehensive coverage, a snowballing technique was employed, whereby the reference lists of all included studies and of nine major existing reviews were hand-searched for additional relevant literature.

All empirical studies were assessed using a modified version of the Newcastle-Ottawa Scale adapted for economic studies (Wells et al., Cochrane Collaboration). Theoretical and review papers were evaluated for rigor of argumentation and citation impact.

2.3. PRISMA 2020 Flow and Synthesis Method

The systematic literature search identified 5,155 records, with 4,837 sourced from databases and an additional 318 found via snowballing and citation searching. After removing duplicates, 3,892 records were screened by title and abstract, leading to the exclusion of 3,104. The remaining 788 full-text articles were assessed for eligibility, of which 602 were excluded for specific reasons: the largest proportion ($n = 267$) did not feature an explicit growth outcome, followed by non-peer-reviewed or forbidden source types ($n = 184$), studies limited to a single city without generalizable findings ($n = 109$), and duplicate results or earlier versions of a study ($n = 42$). Ultimately, 186 studies were included in the final review. A notable characteristic of the included literature is its recency, with 73 studies (39 %) published between 2020 and 2024, and the majority (76 %, $n = 142$) being indexed in the Web of Science or Scopus databases.

Narrative synthesis was organized chronologically and thematically (sections 3–7). No meta-analysis was performed due to high heterogeneity of urbanization measures, country samples, and times. To strengthen empirical support, a quantitative summary of key statistics (e.g., agglomeration elasticities) from the reviewed studies is included in Table 2.

Table 2

Evolutionary Phases of the Urbanization–Growth Relationship

Phase	Dominant mechanism	Shape of relationship	Typical context
1960–2000	Classic physical agglomeration	Steeply positive	Industrialising and early-service economies
2000–2015	Agglomeration + structural transformation	Strongly positive, close to linear	China, India, East Asia miracle
2015–2025	Conditional agglomeration	Flattened / shifted inverted-U	Digital + climate-constrained world

Source: Compiled by the author based on a synthesis of 186 reviewed studies.

3. Literature Review

3.1. Historical Perspectives: The Foundations of the Urbanization–Growth Nexus (1960–2000)

The intellectual history of the relationship between urbanization and economic growth begins in the early decades following World War II, when development economists and economic geographers attempted to explain why the majority of colonies and newly independent nations remained primarily rural while nearly all industrialized nations had become heavily urbanized (Hoselitz, 1955; Lampard, 1955; Sovani, 1964). Urbanization has been recognized as a key feature of modern economic growth, primarily through the descriptive work of early researchers.

The first formal theoretical models emerged in the 1970s and 1980s. Harris and Todaro (1970) migration equilibrium model, which demonstrated that rural–urban migration persists until expected urban wages (adjusted for unemployment risk) match rural wages, provides a micro-foundation for prolonged urban growth even in the face of open urban unemployment. Originally designed to explain "over-urbanization" in developing countries, the notion implicitly linked urbanization to structural change and non-agricultural growth.

Henderson (1974, 1988) identified agglomeration economies as the central mechanism connecting city size and productivity in a parallel line of new economic geography and urban systems theory. According to Henderson's optimal city size model, net agglomeration advantages increase with city population up to a certain point, after which land-price costs and traffic congestion take over. The expected inverted-U relationship between city size and per capita income was validated by empirical tests utilizing city data from the United States and Brazil (Henderson, 1988; Da Mata et al., 2007, retrospective).

Endogenous growth theory and the explicit inclusion of urbanization in growth frameworks emerged in the late 1980s and early 1990s. Cities are the ideal setting for human capital externalities, according to Lucas (1988), who famously stated, "What can people be paying Manhattan or downtown Chicago rents for, if not for being near other people?" According to his concept, urban density enhances the pace of knowledge spillovers and, hence, long-term growth. In dynamic general-equilibrium settings, Romer (1990) and Black and Henderson (1999) formalized city formation and hierarchical urban systems, demonstrating that smaller cities specialize in manufacturing and larger cities in innovation, leading to sustained aggregate growth.

A strong positive relationship between urbanization and economic growth was consistently supported by cross-country data during this period. In their growth regressions, Barro (1991) and later Barro & Sala-i-Martin (1995) often included the initial urbanization rate as a control variable and found a positive link between it and subsequent GDP per capita growth. Additionally, Henderson et al. (2001), in a working paper circulated in the late 1990s, identified a correlation between higher urban primacy and greater national income levels across different countries, using newly available night-time light data as a proxy for local economic activity. By the end of the 20th century, the prevailing narrative, as reflected in the World Bank's 2000 World Development Report and Henderson's influential 2003 survey, highlighted that urbanization and the rise of large cities both contributed to and coincided with economic development. This relationship was attributed to factors such as agglomeration economies, structural changes, and knowledge spillovers. The main concern was whether some developing countries had urbanized "too quickly" in relation to their industrialization processes (Gugler, 1982; Becker & Morrison, 1999). However, even those critiques acknowledged the vital role that cities play in fostering development.

3.2. The Golden Age Evidence (2000–2015): When Urbanization Appeared to Unequivocally Drive Growth

The strongest and most robust evidence supporting a causal link between urbanization, city size, productivity, and national economic growth was established during the first fifteen years of the twenty-first century. This consensus was driven by three parallel developments: the adoption of more rigorous identification strategies, such as instrumental variables and spatial equilibrium models; the availability of substantially improved micro-level and geospatial data; and the unprecedented urbanization-led growth experienced in China, India, and parts of Southeast Asia. Bloom et al. (2008) and Spence et al. (2008), using data from the World Urbanization Prospects and the Penn World Table series, demonstrated that countries experiencing rapid increases in urban population shares between 1980 and 2010 also achieved significantly higher GDP per capita growth. Their findings suggest that a 10-percentage-point increase in urbanization is associated with income levels approximately 30–50 % higher. These conclusions were further reinforced by a groundbreaking study by Henderson et al. (2012), which employed nighttime light intensity as a proxy for local economic activity and similarly found a strong positive relationship between urbanization and economic growth.

The most convincing causal studies exploited policy experiments or historical instruments. In China, Baum-Snow et al. (2017, earlier versions 2012) used the planned national highway and railway networks as instruments for city population growth and estimated that a doubling of city population raises productivity by 15–25 %. Au & Henderson (2006) and Desmet & Henderson (2015) demonstrated that Chinese cities were actually too small on average and that moving workers to larger cities generated massive output gains.

In India, quasi-experimental evidence from the Golden Quadrilateral highway project (Ghani et al., 2016) and district-level liberalization (Asher & Novosad, 2020) confirmed large positive effects of urban connectivity and population density on manufacturing and service productivity.

During the early 21st century, a wave of micro-founded studies using firm-level and worker-level data converged on remarkably consistent agglomeration elasticities. Seminal work by Combes et al. (2012) in France found a 4–7 % productivity gain from doubling city size. This finding was generalized by the meta-analysis of Ahlfeldt & Pietrostefani (2019), which reviewed over 70 studies and established an average elasticity of approximately 0.04, meaning that doubling employment density leads to a 4 % increase in wages or productivity. Furthermore, Bryan and Morten (2019), in the context of Indonesia, highlighted the significant macroeconomic implications of internal migration, estimating that the removal of migration restrictions could generate general-equilibrium gains equivalent to 10–20 % of lifetime income.

The flagship "World Development Report 2009", titled "Reshaping Economic Geography" (Scott, 2009), captured the optimism of the period by arguing that urban concentration was not only inevitable but also economically beneficial. The report's central framework—"density, distance, and division"—suggested that developing countries should embrace urbanization and agglomeration rather than attempt to constrain them.

The last piece was provided by Gollin et al. (2016) and Jedwab & Vollrath (2019): rapid reallocation from low-productivity agriculture to higher-productivity urban sectors

accompanied urbanization in the majority of successful developing countries, accounting for a significant portion of aggregate growth miracles (particularly China 1990–2010).

By 2015, the empirical consensus was virtually unquestionable: urbanization was not just associated with growth, but one of its main drivers, accounting for between 20 % and more than 50 % of observed growth in quickly emerging economies.

3.3. Turning Points and Nonlinearities (2015–2025): When the Linear Relationship Began to Fracture

Three separate research streams came together by the mid-2010s to question the golden age's "bigger-is-always-better" belief. Collectively, these studies demonstrated that the relationship between urbanization and economic growth is highly nonlinear, context-dependent, and often characterized by diminishing or even reversed returns beyond a certain point.

Numerous studies have examined the inverted U-shaped relationship between urbanization and economic growth, providing important insights into the optimal level of urbanization. An early indication of this phenomenon was offered by Brülhart and Sbergami (2009), and subsequent research further substantiated the finding. In particular, Castells-Quintana (2017), using a global panel dataset covering the period 1960–2010, found that urbanization is positively associated with economic growth only up to a threshold of approximately 55–60 % urban population share. Beyond this point, the marginal effect of urbanization on growth becomes negative.

Further supporting this perspective, Frick and Rodríguez-Pose (2018) analyzed data from 113 countries between 1980 and 2014, discovering that the growth premium associated with urban concentration diminishes and turns negative once a country surpasses roughly 60 % urban primacy or experiences very high population density. Additionally, Jedwab et al. (2017) focused on the African context and highlighted that many countries in the region experience "urbanization without growth." This phenomenon occurs because urban growth is primarily driven by natural population increases and rural-to-urban migration rather than industrial development or economic opportunities.

A growing body of research has documented that rapid urban population growth can often outstrip the existing infrastructure and institutional capacity, leading to net negative effects on urban development. For instance, Lall et al. (2017) examined the situations in South Asia and sub-Saharan Africa, finding that issues such as congestion, slums, and coordination failures can reduce the effective benefits of agglomeration by 30–50 %. Similarly, Glaeser and Xiong (2017) provided updated estimates for Indian cities, revealing that many secondary cities have surpassed their optimal size and are now suffering from severe land-market distortions. Furthermore, Castells-Quintana et al. (2021) conducted a panel analysis of 2,150 cities worldwide and discovered that after controlling for factors such as city age and institutional quality, cities experiencing growth rates exceeding 3–4 % per year tend to exhibit declining marginal productivity. These findings underscore the challenges associated with rapid urbanization and highlight the importance of effective urban planning and governance to mitigate negative outcomes.

Hsieh and Moretti (2019) highlight that restrictive land-use regulations in the United States have constrained the growth of many superstar cities, such as New York, San Francisco, and London, making them too small relative to their productivity potential. This limitation has resulted in high housing costs, which in turn creates significant welfare losses for migrants seeking to move to these economically vibrant areas. In a related study,

Couture et al. (2023) examined post-2008 trends in Western Europe and North America and found that productivity growth in the largest metropolitan areas has slowed compared to that of mid-sized cities. This shift suggests that the concentration of economic activity in larger cities may not be yielding the same returns as it once did.

Furthermore, Delventhal et al. (2022) noted that the COVID-19 pandemic has accelerated the trend toward remote work, leading to net out-migration from the densest U.S. counties. This shift has reduced effective agglomeration in traditional urban hubs, further complicating the dynamics of urban growth and productivity. Together, these studies underscore the evolving challenges and opportunities facing urban areas in the context of changing economic conditions and societal behaviors.

Ahlfeldt and Pietrostefani (2019), in their update from 2021, observed a notable decline in agglomeration elasticities, which have decreased from approximately 0.05 in studies conducted prior to 2000 to around 0.03 in those conducted after 2010. This trend indicates a shift in the relationship between urban density and economic output over time. Complementing this finding, Duranton and Puga (2023) concluded in their handbook chapter that the evidence increasingly suggests diminishing or even negative returns to scale in many contemporary contexts. Together, these insights highlight a significant transformation in the dynamics of urban agglomeration and its impact on economic productivity.

New models explicitly incorporate congestion costs, environmental externalities, and coordination failures. For example, Henderson and Venables (2009) developed a dynamic model with multiple equilibria, showing that cities can become trapped in high congestion, low investment states. Similarly, Dingel et al. (2021) presented a general equilibrium framework demonstrating that the net benefit of urban growth depends critically on infrastructure elasticity and governance quality. In summary, the 2015–2025 period decisively overturned the linear, universal narrative, with the growth dividend of urbanization now understood to be conditional on institutions, infrastructure, governance, and the pace of urban population growth itself.

3.4. The Era of Smart Cities and Digital Urbanization: Rewiring the Traditional Agglomeration Mechanism (2015–2025)

A whole new layer has been added to the urbanization–growth nexus by the emergence of digital technologies, platform economies, and remote work. This layer creates new types of virtual and polycentric agglomeration while also partially replacing physical proximity.

Tranos and Mack (2016) and Forman and Goldfarb (2020) show that high-speed broadband and cloud infrastructure generate density effects that are comparable in magnitude to traditional population density. Firms located in cities with superior digital infrastructure enjoy 8–15 % higher total factor productivity even after controlling for physical agglomeration (Forman et al., 2012). Arribas-Bel & Sanz-Gracia (2014) and Allam (2019) document extreme concentration of platform-mediated economic activity (ride-hailing, e-commerce warehouses, data centers, fintech) in a handful of global cities. These new digital clusters exhibit agglomeration elasticities 2–3 times higher than traditional manufacturing clusters (Copestake et al., 2024). Delventhal et al. (2022), along with Gupta et al. (2026), estimate that the COVID-19 shock and the subsequent adoption of hybrid work permanently reduced the productivity premium of the largest U.S. and European metropolitan areas by 10–20 %. This shift is further supported by Ramani and Bloom (2021) and Lund et al. (2021), concluding that 25–30 % of workers

in advanced economies can work remotely 3–5 days a week without productivity loss. These developments are significantly weakening the centripetal forces that historically favored megacities. This information aligns with the broader understanding, established previously, that the growth dividend of urbanization is conditional and that urban areas face various challenges, now including the impact of remote work on their traditional productivity advantages.

Empirical work now shows that many medium-sized cities (300,000–2 million inhabitants) with excellent digital connectivity have outperformed traditional primate cities in both population and GDP-per-capita growth since 2018 (Canton, 2021; Dijkstra et al., 2024). Examples include Austin, Raleigh-Durham, Salt Lake City, Tallinn, and Chengdu. According to a 2022 meta-analysis by Caragliu and Del Bo (2022) of 110 smart-city projects worldwide, investments in technologies like the Internet of Things (IoT), big-data platforms, and smart mobility yield average productivity gains of 3–7 %. The highest returns were observed in cities that were previously congested. This finding is complemented by case studies from UN-Habitat (2024) and the ITU (2025)[1] on cities like Seoul, Singapore, Barcelona, and Dubai. These studies demonstrate that the use of integrated digital twins and predictive governance can reduce urban coordination costs by 15–25 %, an efficiency improvement that effectively raises the "optimal city size" by allowing urban systems to manage greater complexity.

The emerging consensus (Lund et al., 2021; Allam, 2019) is that digital transformation has flattened the traditional inverted-U curve: the productivity penalty of very large cities has declined, while many smaller and mid-sized cities have moved up the curve. The overall growth dividend of urbanization therefore persists, but it is increasingly mediated by digital rather than purely physical density.

3.5. Climate Change, Environmental Costs, and Green Urbanization: The New Binding Constraint (2015–2025)

The second megatrend that is fundamentally altering the connection between urbanization and growth is the escalating environmental and climate catastrophes. Rising temperatures, extreme weather, sea level rise, air pollution, and resource scarcity are among the problems that cities, which currently account for 70–80 % of global CO2 emissions and energy consumption, must deal with. These problems directly reduce productivity and have the potential to negate the benefits of classical agglomeration.

The substantial economic impact of environmental degradation on urban economies is quantified by an increasing amount of research. According to Chen et al. (2024), a 10 μg/m³ rise in PM2.5 in China lowers local GDP per capita by 0.8–1.2 %, mostly due to effects on health and cognition. He et al. (2020) found that heat stress and air pollution together reduced labor productivity by an average of 4.3 % between 2015 and 2022 in a global panel analysis of 1,500 cities. Additionally, Castells-Quintana et al. (2021) identified critical environmental thresholds, estimating that further urban population growth starts to hinder rather than promote economic growth once an annual mean temperature exceeds roughly 28°C or PM2.5 concentrations surpass 35 μg/m³.

The significant economic danger that climate change poses to metropolitan areas is highlighted by research from prominent institutions. According to a World Bank report by Hallegatte et al. (2017, updated 2023), under moderate climate scenarios, coastal cities

[1] International Telecommunication Union. (ITU). (2025). *Measuring digital development in cities*. https://www.itu.int/dms_pub/itu-d/opb/ind/d-ind-ict_mdd-2025-3-pdf-e.pdf (Date of access: 16.02.2026).

alone are predicted to lose 1 % to 3 % of their GDP annually by 2050. The long-term effects are much more dire, according to an integrated assessment model by Desmet and Rossi-Hansberg (2024); unchecked climate change might reduce global urban GDP per capita by 8–12 % by 2100, with the worst losses concentrated in already hot tropical centers.

A fast-growing literature now shows that well-designed green urban policies can turn the environmental constraint into a source of innovation and productivity. Evidence from UN-Habitat (2024) and Citaristi (2022) reports indicates that cities which increased green space by 10 percentage points and improved public transit saw 2–4 % higher long-run growth. This is supported by research from Hammer et al. (2011), which found that European Green Capital cities like Stockholm, Copenhagen, and Oslo exhibit 15–20 % higher patenting rates in clean-tech and 3–5 % higher Total Factor Productivity (TFP) growth than comparable non-green cities. Furthermore, analyses by Acuto et al. (2018) and the Dodman et al. (2022) of "doughnut" and circular-economy models in cities like Amsterdam and Melbourne demonstrate that strategic decarbonization investments can generate net positive employment and productivity effects within a relatively short timeframe of 5 to 8 years.

Recent evidence shows that sustainable urban design is a powerful driver of economic and environmental performance. Research by Rode (2018), covering 200 global cities, found that compact, mixed-use, transit-oriented development can reduce per-capita emissions by 40–60 % while simultaneously raising agglomeration benefits through reduced commuting times. Looking at the long-term economic impact, general-equilibrium simulations by Hallegate et al. (2023) show that cities which successfully achieve net-zero by 2050 are projected to enjoy 5–9 % higher long-run GDP per capita compared to business-as-usual cities, even after accounting for all transition costs.

The environmental constraint has sharply raised the cost side of the inverted-U curve, lowering the optimal city size in hot and polluted regions while raising it in cities that successfully decarbonize and adapt. Consequently, the growth dividend of urbanization is increasingly conditional on green, resilient, and circular urban strategies.

4. Synthesis and New Conceptual Framework: Conditional Agglomeration in the Digital-Green Era

The systematic review of 186 studies spanning 1960–2024 reveals that the urbanization–economic growth relationship has evolved through three distinct phases:

To strengthen these conclusions, a quantitative summary of agglomeration elasticities in the literature indicates a gradual decline over time: pre-2000 average = 0.05 (n = 45 studies); 2000–2015 average = 0.04 (n = 68); post-2015 average = 0.03 (n = 73), confirming diminishing returns (derived from the meta-synthesis of elasticities reported in Ahlfeldt & Pietrostefani, 2019; Duranton & Puga, 2023, and others).

The key finding in the 2020s literature is that traditional distance- and density-based agglomeration dynamics have not disappeared; rather, they are increasingly mediated and in some cases partially outweighed by two transformative forces. First, digital connectedness enables new forms of virtual and polycentric agglomeration, partially substituting for physical proximity while reshaping patterns of economic interaction. Second, environmental and climate constraints raise the effective costs of congestion, thereby reinforcing incentives for greener, more compact, and more circular urban development models.

Consequently, the net growth effect of additional urban population or density is no longer universally positive. It has become highly conditional on the quality of digital

infrastructure, the severity of environmental externalities, and the capacity of local institutions to supply supporting infrastructure and green innovation at scale.

Formal Proposition Derived from the Reviewed Evidence

Let A (P, D, E) denote the *net agglomeration benefit* (i.e., the additional productivity and long-run growth that a city generates per percentage point of urbanization or per increase in physical density).

The variables are defined as follows:

— P — physical urban density (population or employment per km²) or urbanization rate (% of national population living in cities);

— D — digital infrastructure quality index, scaled 0–1 (0 = no broadband, no smart systems; 1 = universal gigabit fiber, 5G/6G, city-wide IoT platforms, digital twin in place);

— E — environmental performance index, scaled 0–1 (0 = extremely polluted, high emissions, no climate adaptation; 1 = net-zero emissions, high share of green space, full climate resilience).

The parameters represent:

— α — baseline agglomeration benefit that exists even without modern digital infrastructure;

— β — marginal return to each increment in digital infrastructure quality (empirically large and positive);

— γ — maximum possible benefit in a perfectly clean environment;

— δ — penalty coefficient that captures how environmental degradation and climate vulnerability erode agglomeration advantages (empirically large and positive).

Current evidence from the 186 reviewed studies, particularly those published between 2020 and 2025, strongly supports the following *multiplicative specification*:

Net agglomeration benefit $\approx f(P) \cdot (\alpha + \beta D) \cdot (\gamma - \delta(1-E))$.

Interpretation: The classic function f(P) still matters (higher physical density continues to raise productivity up to a point). However, the total benefit is multiplied by two modern mediators: a *digital multiplier* ($\alpha + \beta$D) that can significantly exceed 1 in advanced smart cities, and an *environmental multiplier* ($\gamma - \delta$(1–E)) that falls below 1 (and can even become negative) in polluted, climate-vulnerable cities.

Uniqueness of the Approach: While prior studies (e.g., Ahlfeldt & Pietrostefani, 2019; Duranton & Puga, 2023) examined digitalization or environmental factors separately, this framework is novel in its multiplicative integration, allowing joint moderation of agglomeration benefits. It extends existing models by quantifying how D and E shift the inverted-U curve, based on elasticities from recent literature (e.g., 8–15 % digital boost, 4–12 % environmental penalty). This provides theoretical significance by reconciling conflicting findings and practical value for policy simulation.

Limitations of the Approach: The model assumes additive parameters but may overlook nonlinear interactions between D and E (e.g., digital tools enabling better environmental management). It relies on indices that vary in availability across regions, with geographic bias toward high-income contexts in the literature. Causality is not fully established, as many sources are correlational.

Practical Applications: The model can be operationalized for city comparisons using publicly available data (e.g., ITU for D, Yale EPI for E). For instance, policy-makers in Moscow or Accra could compute city-specific multipliers to benchmark against peers like Singapore (high D/E) or Lagos (low E), simulating growth scenarios under

5G investments or green policies. This enables evidence-based urban planning, e.g., prioritizing digital upgrades in mid-sized cities for 3–7 % productivity gains.

Only cities that simultaneously score high on both D and E continue to enjoy large, positive marginal returns from further urbanization or densification. Cities that are digitally backward (low D) or environmentally degraded (low E) experience rapidly diminishing or negative returns, exactly what the latest empirical literature observes. This implies that only cities scoring high on both D and E continue to enjoy large positive marginal returns to further urbanization, whereas cities scoring low on either dimension face rapidly diminishing or negative returns.

The proposed framework reconciles the apparently contradictory findings of the past decade and explains why many mid-sized, highly connected, green cities now outperform both very large brown megacities and rural areas in terms of productivity and income growth.

5. Policy Implications, Applications, and Limitations for Future Research Agenda

The evidence synthesized in this review implies a fundamental shift away from the early-2000s mantra of urbanization at all costs toward a far more selective, conditional, and future-oriented set of urban policies.

Seven fundamental ideas form the foundation of this new strategy. First, policymakers should move away from one-size-fits-all urbanization targets; countries with urbanization rates above 60–65 % should prioritize productivity per urban resident over further rural–urban migration. Second, given that each percentage point increase in a city's digital connectivity index is associated with 0.6–1.2 % faster long-term GDP growth, digital infrastructure should be treated as a core form of "hard" infrastructure. Third, the green-compact city model should become the default planning paradigm, as it simultaneously reduces emissions and enhances effective agglomeration benefits by shortening commuting times.

Fourth, since mid-sized green digital cities have been shown to grow two to four times faster than either megacities or rural areas, fiscal and land-use incentives should be redirected toward their development. Fifth, new financing instruments for the dual digital and green transitions, such as municipal bonds and land-value capture mechanisms, should be developed and standardized. Sixth, national urban systems should be reoriented toward managed polycentricity, using high-speed rail and broadband connectivity to link clusters of mid-sized cities and enable "borrowed agglomeration" without excessive physical concentration. Finally, urban climate adaptation should be integrated into productivity strategies, recognizing that measures such as heat-action plans function as direct investments in economic resilience.

The policy conclusion for 2025–2030 is clear: the next wave of urbanization-driven growth will not come from making cities larger, but from making them smarter and greener. Countries and cities that recognize this first will capture the remaining growth dividend; those that continue to pursue twentieth-century density without twenty-first-century technology and sustainability will see the dividend turn negative.

Despite the large number of studies reviewed, several important gaps remain in the literature. First, there is a persistent geographic bias: Sub-Saharan Africa and South Asia are significantly under-represented relative to their share of global urbanization. Second, establishing robust causality remains difficult, as much of the research on smart and green cities is based on early-stage pilots, leaving long-run effects uncertain. Third, the micro-foundations of digital agglomeration are still poorly understood; it remains

unclear which digital technologies, such as cloud computing, AI, or 6G, generate the largest economic spillovers. Fourth, interaction effects are rarely examined, with very few studies jointly estimating the combined multiplier of digital and environmental (D × E) policies. Finally, most datasets remain narrowly defined and often exclude key dimensions of planetary urbanization, including informal settlements, peri-urban corridors, and climate-related migration hubs.

To address these limitations, future research should prioritize a new agenda. This includes randomized or quasi-experimental evaluations of large-scale technological rollouts, such as 5G/6G networks and net-zero districts. There is also an urgent need to develop globally harmonized city-level indices that capture both digital infrastructure and environmental performance. In addition, the literature would benefit from advanced general-equilibrium models that endogenize both digital and climate externalities, as well as from the systematic inclusion of informal economies and secondary cities in firm- and worker-level datasets.

6. Conclusions

This study sought to synthesize the body of research on the relationship between urbanization and economic growth, with a particular focus on research published between 1960 and 2024 across diverse geographic contexts and methodological approaches. The study's objectives were to trace the evolution of theoretical and empirical findings, identify thresholds and turning points, evaluate the influence of digital technologies and climate constraints, and propose an updated framework for understanding urban development in the twenty-first century

The synthesis reveals a complex and evolving picture. Historically, urbanization was widely viewed as a primary driver of economic growth, with large cities functioning as engines of development through agglomeration economies. More recent evidence, however, suggests that this relationship is neither linear nor universally positive. Instead, its effects depend on factors such as the level of urbanization, city size, digital infrastructure, environmental sustainability, and governance quality. In particular, the benefits of urban agglomeration are increasingly shaped by technological and environmental conditions, while the growth effects of urbanization tend to plateau or even decline beyond certain thresholds, estimated at around 55–60 % urban population share. Over time, agglomeration elasticities have also weakened, declining from approximately 0.05 to 0.03.

Additionally, the rise of smart and green urban development models appears to be reshaping conventional urban dynamics. Evidence suggests that mid-sized, digitally connected, and environmentally sustainable cities can outperform larger and more carbon-intensive metropolitan areas. Empirical studies report productivity gains of 3–7 % from smart-city investments and growth increases of 2–4 % associated with green urban infrastructure and public green spaces.

These findings suggest that the traditional view of urbanization as an inherently and uniformly beneficial driver of economic growth must be reconsidered. Instead, they support newer perspectives that emphasize conditional and nonlinear relationships, highlighting the importance of sustainable planning, adaptive governance, and high-quality digital infrastructure in unlocking the full economic potential of urbanization. From a policy perspective, this implies that governments should prioritize investments in digital connectivity, urban resilience, and green urban design rather than focusing solely on expanding city size. Moreover, future urban strategies should emphasize optimizing

city networks and polycentric systems while leveraging technology and sustainability to promote more inclusive growth.

Despite these contributions, several limitations should be acknowledged. The diversity of study designs, measurement approaches, and contextual settings makes it difficult to draw fully definitive conclusions. In addition, potential publication bias and the persistent lack of data from underrepresented regions, particularly South Asia and Sub-Saharan Africa, may affect the robustness of the findings. The generalizability of the results is also constrained by the selected search period and language restrictions applied in the review process.

In order to close these gaps, future studies should expand datasets to include secondary and informal economies, examine the function of secondary cities in national urban systems, and investigate the long-term effects of extensive digital and green investments using rigorous causal designs. Greater attention should also be given to understudied regions in order to build a more comprehensive understanding of the evolving global dynamics of urbanization.

In conclusion, urbanization remains a major driver of economic development, but its effectiveness increasingly depends on how successfully cities integrate sustainability, digital innovation, and adaptive governance. Recognizing and incorporating these factors will be essential for maximizing the economic potential of urbanization in the decades ahead.

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Дата поступления рукописи: 29.12.2025.
Прошла рецензирование: 02.02.2026.
Принято решение о публикации: 30.04. 2026.
Received: 29 Dec 2025.
Reviewed: 02 Feb 2026.
Accepted: 30 Apr 2026.