

THE RELATIONSHIP BETWEEN THE WEALTH OF THE COUNTRY AND THE QUANTITY AND DEVELOPMENT OF SMART CITIES

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Purpose: The primary purpose of this study is to investigate and analyze the relationship between a country's wealth and the number and development of smart cities in its territory. This study aims to understand how a country's economic status affects its ability and willingness to invest in smart city initiatives.

Design/methodology/approach: The article uses a literature search. This study will adopt a mixed approach, combining quantitative and qualitative analysis. Statistical data on GDP, investments in smart city technologies, and urban development indicators from various countries will be used.

Findings: In research, the application of artificial intelligence in smart cities identified several key areas where AI has a significant impact: traffic and transport management, energy management and sustainable development, public safety, waste and natural resource management, citizen services, and spatial planning and urban development. These results can serve as a basis for further research and development of AI implementation strategies in urban contexts.

Originality/value: The study revealed several critical conclusions regarding the relationship between the country's wealth and the number and development of smart cities. There is a significant correlation between GDP per capita and the level of investment in smart city infrastructure and technologies. Wealthier countries are more likely to initiate and implement advanced smart city projects, investing their financial resources in innovative technologies and sustainable urban solutions.

Keywords: smart cities, GDP, smart city index.

Category of the paper: Research paper.

1. Introduction

In the face of the dynamic changes taking place in the world in the 21st century, cities are becoming not only centers of human activity but also laboratories of innovation and social change. In this context, the "smart city" concept has gained importance as a model for future urban development. Smart cities, using advanced technologies, strive to optimize urban functions, improve residents' quality of life, and increase resource and service management efficiency. However, a key question in global development is to what extent a country's wealth influences the number and development of these innovative cities.

The first step in analyzing this phenomenon is to understand what precisely the term "smart city" means. This concept is defined in many ways in the literature on the subject. Still, most definitions agree that smart cities use information and communication technologies (ICT) to improve operational efficiency, manage urban resources, and increase citizen involvement in city life. These technologies cover a wide range of solutions, from advanced traffic management systems through intelligent energy management systems to digital platforms for communication between residents and city authorities.

Another essential aspect is understanding how the wealth of a country affects the ability to implement and maintain smart city infrastructure. Rich countries often have more financial resources that can be allocated to investments in modern technologies and infrastructure. However, wealth is not the only factor that determines the success of smart cities. Other factors, such as government policies, education levels, innovation culture, and society's willingness to adapt to new technologies, also play a crucial role. However, it is worth paying attention to the fact that the development of smart cities is not only a matter of financial investments. It is also a process that requires a change of thinking among decision-makers and residents. Education and public awareness about the benefits of smart city solutions are crucial for their effective implementation and acceptance by society.

This article seeks to understand the complex relationships between the state's economy and the aspirations and implementation of the smart city concept. The purpose of this article is not only to examine the relationship between a country's wealth and the development of smart cities but also to understand whether a country's wealth can influence long-term sustainable development and improve the quality of life of city residents. The article consists of a review of the literature on gross domestic product. The second part concerns smart city indicators. This section overviews the most popular indicators and their brief characteristics. The third part compares the Cities in Motion Index (CIMI) and gross domestic product in individual countries.

2. Gross domestic product in the world

GDP, or Gross Domestic Product, is one of the fundamental economic indicators used to measure the total value of all goods and services produced in a given country during a specific time, usually a year. GDP is widely used as a measure of the size of a country's economy and as an indicator of its productivity and health. GDP is often used to assess the size and health of a national economy, providing a basis for international comparisons and assessment of economic progress. A high GDP usually indicates a strong economy and is seen as a sign of a country's prosperity. However, GDP does not consider income inequality within a country, which means that high GDP does not always translate into a high standard of living for all citizens.

GDP per capita, which divides total GDP by population, is used to assess a country's average level of well-being. Countries with a high GDP per capita are often considered more prosperous and developed. However, significant social and economic inequalities may exist even in countries with high GDP per capita. GDP is also used to assess the effectiveness of monetary and fiscal policies, and its growth is often seen as an indicator of economic success.

Table 1.
GDP in the twenty richest countries in the world

1	United States	25,439,700
2	China	17,963,171
3	Japan	4,232,174
4	Germany	4,082,469
5	India	3,416,646
6	United Kingdom	3,089,073
7	France	2,779,092
8	Russian Federation	2,240,422
9	Canada	2,137,939
10	Italy	2,049,737
11	Brazil	1,920,096
12	Australia	1,692,957
13	Korea, Rep.	1,673,916
14	Mexico	1,465,854
15	Spain	1,417,800
16	Indonesia	1,319,100
17	Saudi Arabia	1,108,572
18	Netherlands	1,009,399
19	Türkiye	907 118
20	Switzerland	818 427

Source: Own study based on: <https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDRO%2F046439%2FGDP.xlsx&wdOrigin=BROWSELINK>

In globalization, GDP is essential in analyzing and comparing economies worldwide. Countries pursue GDP growth because it brings greater economic power and influence on the international stage. GDP growth is also related to improvements in infrastructure, health, education, and other critical aspects of society. However, excessive emphasis on GDP growth may lead to neglecting other vital elements, such as sustainable development, environmental protection, and social well-being. Table 1 shows the GDP of the twenty wealthiest economies in the world.

3. Smart city indices

Smart City indices play a crucial role in shaping the future of cities. Not only do they enable you to measure progress and identify areas for improvement, but they also stimulate competition and cooperation between cities worldwide. By focusing on diverse dimensions such as infrastructure, technology, public management, environment, community, and economy, these indices provide a comprehensive picture of a city's ability to adapt to modern challenges. Indicators, a set of measurable criteria, allow for assessing, comparing, and improving various aspects of urban life, from technology and innovation to sustainable development and urban management. The most popular indicators measuring the level of smart cities are the Broadband Penetration Rate, Air Quality Index, Renewable Energy Utilization Rate, Urban Mobility Index (Vidović 2019), Waste Management Index, and Cities in Motion Index (CIMI). These indicators are widely used to evaluate and compare smart cities worldwide, reflecting their technological progress, sustainability, mobility, and environmental management.

Broadband Penetration Rate (Leogrande, 2021) is an index showing what percentage of the population has access to broadband internet in a given area. That is a crucial indicator for smart cities because high availability and internet connection quality are necessary to implement and effectively use various smart city technologies. Broadband Penetration Index The rate is significant for supporting innovation and technology, economic development, education, and access to information. It shows the city's digital infrastructure assessment, so it is an essential tool for assessing the city's readiness to adopt and implement smart city solutions and the overall digital accessibility and inclusion in a given area.

Another smart city index is the Air Quality Index (AQI) (Wojtylak 2009), which is the simplest way to determine the level of air pollution on a scale from 0 to 500. The higher the index, the more polluted the air. Air quality assessment primarily covers the level of suspended dust PM_{2.5} and PM₁₀, but also some gaseous pollutants - sulfur dioxide (SO₂), ozone (O₃), nitric oxide (NO), carbon monoxide (CO), and benzene, which are most often the result of fuel combustion. Measurements are made continuously (automatically or manually) or periodically.

Advanced mathematical methods are used to assess air quality. The collected data on the concentrations of individual pollutants are compared with the so-called reference levels that create standards. It is a critical index in the context of smart cities. Air quality has a direct impact on the health of residents. High concentrations of pollutants can lead to health problems such as respiratory and cardiovascular diseases and even contribute to premature death. AQI monitoring allows us to identify and respond to unsafe levels of contaminants. Smart cities strive for sustainable development, including minimizing negative environmental impacts. AQI is an indicator that helps assess the effectiveness of environmental policies and activities to reduce pollutant emissions. As a result, AQI is not only an indicator of the state of the environment but also a tool enabling smart cities to make informed decisions that affect residents' quality of life and sustainable urban development (Kuang, 2016).

Renewable Energy Utilization Rate (Kuang, 2016) is a metric used in the context of smart cities to assess the extent to which a city uses renewable energy sources compared to traditional energy sources. The index reflects the city's commitment to sustainability and reducing its carbon footprint using cleaner and more sustainable energy sources. It is usually measured as the percentage of a city's total energy consumption from renewable sources such as solar, wind, hydropower, biomass, or geothermal. Therefore, the renewable Energy Utilization Index Rate is essential in assessing and promoting sustainability in smart cities, highlighting their commitment to reducing carbon footprints and promoting clean energy technologies (Giffinger, 2020).

The Urban Mobility Index is an essential tool for smart cities that allows for the assessment and continuous improvement of transport systems toward greater efficiency, sustainability, and innovation (Liponhay, 2023; Ali, 2021). In particular, it allows for assessing improvement in the quality of life by reducing commuting time availability of services and jobs. It is also essential in determining the sustainable development of cities because it helps assess how well a city copes with the challenges of congestion, exhaust emissions, and energy consumption in transport. A high score on the index indicates effective traffic management and the promotion of sustainable forms of transportation, such as public transport, cycling, and walking (Liszewski, 2012).

The Waste Management Index, an indicator (Mishra, 2022) used to assess the effectiveness of waste management systems in cities, is very important in the current reality. In the context of smart cities, this index is crucial because effective waste management is essential for sustainable urban development, environmental protection, and improving residents' quality of life. The index is significant when assessing recycling rates because it measures the percentage of recovered and reused waste. In addition, it also considers the effectiveness of activities aimed at reducing the amount of waste produced. By managing waste effectively, cities can significantly reduce greenhouse gas emissions, soil and water pollution, and other negative environmental impacts. Effective waste management is critical to sustainable urban development, saving resources, and minimizing environmental negative impacts.

Another index - the Cities in Motion Index (CIMI), is a vital tool for assessing and comparing cities worldwide, highlighting their performance in various key areas. It is a valuable tool for urban decision-makers, researchers, and investors interested in development and innovation in urban areas. This index helps you understand what factors contribute to cities' success as intelligent and sustainable places to live, work, and invest. This index evaluates cities based on various dimensions such as technology, urban governance, sustainability, mobility, community, economy, and more. The Cities in Motion Index is an aggregated measure based on indicators from the following areas: human capital, social cohesion, technology, international profile, urban planning, mobility and transportation, environment, governance, and economy. It allows you to compare cities worldwide, offering insight into how different cities cope with urbanization and globalization challenges. It provides policymakers, urban planners, and researchers with valuable information that can be used to formulate urban development policies and strategies. It helps identify areas where cities can improve their actions for sustainable development, innovation, and improving residents' quality of life.

4. Cities in Motion Index and gross domestic product in individual countries around the world

Smart city indices and a country's gross domestic product should be closely linked. The complex dynamics between economic development and urban innovation demonstrate that. GDP, as a measure of the size of an economy and its efficiency, often correlates with investments in infrastructure and technologies necessary for smart cities. Wealthier countries with higher GDP usually have more significant financial resources that can be allocated to developing smart cities, including innovative technologies, sustainable urban solutions, and digital infrastructure. Figure 1 shows the gross domestic product in individual countries of the world.

GDP is the primary comparative indicator between countries, enabling comparison of their standard of living and economic potential. GDP growth may result from factors such as increased labor productivity, investments, or new technologies. Although GDP is an important indicator, it does not consider many factors, such as quality of life, social equality, or environmental impact. Therefore, it should not be the only criterion for assessing the country's economic condition.

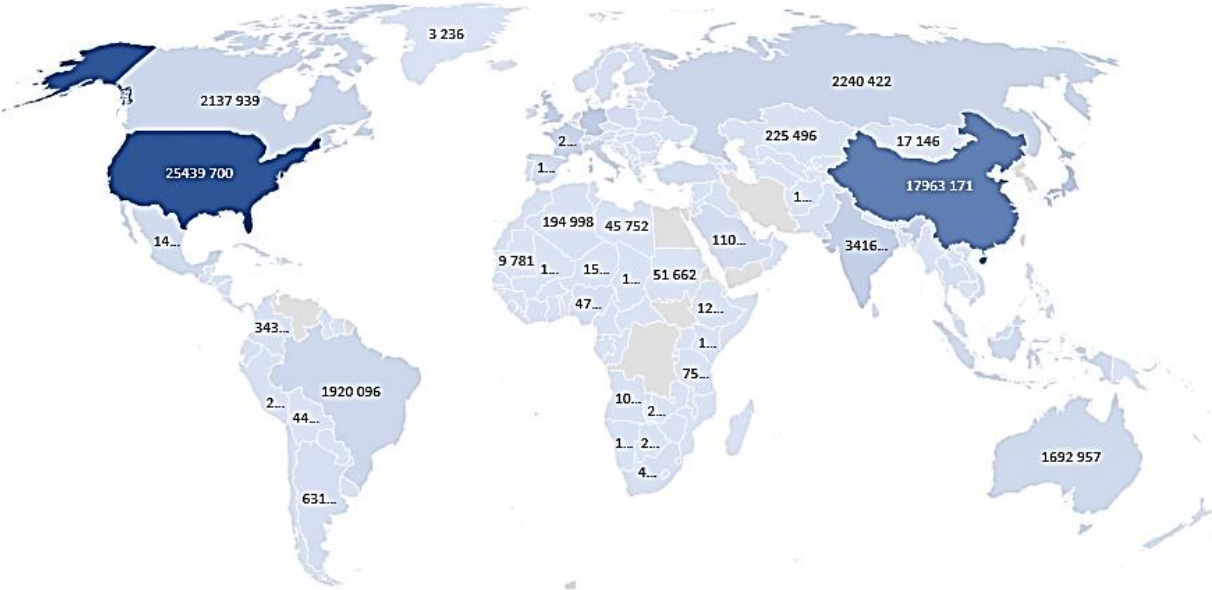


Figure 1. Global GDP in individual countries.

Source: Own study based on: [https://view.officeapps.live.com/op/view.aspx?src=https %3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDR0046439%2FGDP.xlsx&wd Origin=BROWSELINK](https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fdatacatalogfiles.worldbank.org%2Fddh-published%2F0038130%2FDR0046439%2FGDP.xlsx&wdOrigin=BROWSELINK), 10.09.2023.

Smart city indices such as Cities in Motion assess cities across various dimensions, including technology, urban governance, mobility, environment, social cohesion, and economy. These indicators often show that cities in countries with higher GDP perform better in many areas. For example, access to advanced technologies such as the Internet of Things (IoT), artificial intelligence (AI), and big data is often greater in wealthier countries, translating into better city management and services for residents.

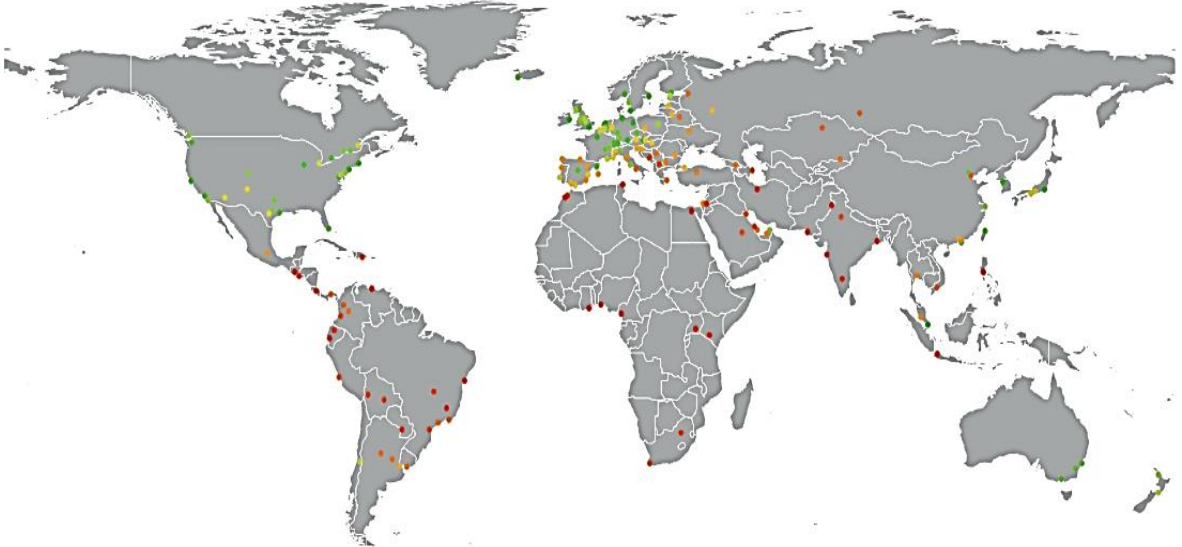


Figure 2. Smart cities.

Source: Own study based on: IESE Cities in Motion Index <https://www.iese.edu/media/research/pdfs/ST-0633-E.pdf>, 10.09.2023.

Table 2.
GDP in the twenty richest countries in the world

Country	Smart city amount
United States	18
China	6
Japan	3
Germany	8
India	4
United Kingdom	8
France	5
Russian Federation	3
Canada	5
Italy	5
Brazil	6
Australia	3
Korea, Rep.	1
Mexico	1
Spain	10
Indonesia	1
Saudi Arabia	1
Netherlands	3
Turkey	2
Switzerland	4

Source: Own study based on: IESE Cities in Motion Index, <https://www.iese.edu/media/research/pdfs/ST-0633-E.pdf>, 10.09.2023.

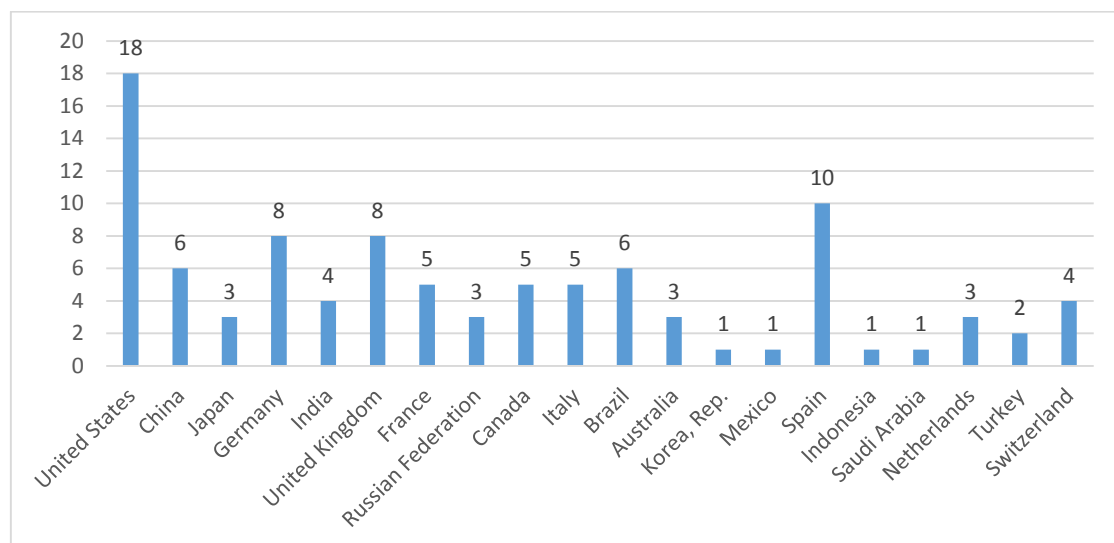


Figure 3. Smart cities.

Source: Own study.

The analysis of the data presented in the table and graph indicates an interesting dissonance: the number of smart cities is not always proportional to the size of the GDP of a given country. This fact emphasizes that high GDP may indicate economic potential but is not an explicit guarantee of success in developing smart cities. Several other factors play a crucial role in this dynamic.

First, efficient use of resources is essential. Cities in countries with higher GDP may have more financial resources, but how these funds are used is crucial. Investments in smart city technologies must be purposeful and focused on long-term benefits for residents, not just short-term economic gains. Innovative approaches to urban planning are equally important. The development of smart cities requires creative thinking and readiness to experiment with new solutions. In this context, cities in countries with lower GDP often demonstrate the capacity to innovate as they have to cope with limited resources and often more complex socio-economic challenges. The involvement of local communities is another critical factor. The development of smart cities is not just about technology; it's also about people and their needs. Cities involving their residents in planning and implementing smart city solutions often achieve better results. Residents can provide valuable information about local needs and challenges, translating into more effective and user-friendly solutions.

In some cases, cities in lower GDP countries are making significant progress in smart city solutions. That often happens through creative use of available resources, international cooperation, and focusing on specific challenges such as mobility or waste management. These cities usually take a more integrated and holistic approach to development, including public-private partnerships, community-based initiatives, and low-cost technologies.

Developing smart cities is a complex process that requires more than just solid financial investments. It requires strategic planning, innovation, social involvement, and adapting to local conditions and needs. High GDP can be helpful, but it is not the only or most important factor determining success in creating intelligent, sustainable, and citizen-friendly cities.

5. Conclusions

The conclusions from the article on the relationship between the wealth of the country and the number and development of smart cities are multidimensional and emphasize the complexity of this relationship. First, the analysis showed a clear correlation between the level of GDP per capita and investments in infrastructure and technologies necessary for the development of smart cities. Countries with higher GDP tend to invest more in innovative technologies, which translates into more advanced and integrated smart city solutions.

However, high GDP is not the only factor determining success in developing smart cities. Innovation, strategic planning, community engagement, and international cooperation proved equally noteworthy. In some cases, cities in lower GDP countries have shown significant progress in smart city solutions, often by creatively using available resources and focusing on specific challenges. High GDP can also lead to increased urbanization and associated challenges like pollution, traffic congestion, and social inequality. Smart cities in wealthier

countries often need to address these issues using innovative technologies and urban management approaches to improve residents' quality of life and sustainable development.

Overall, this study highlights that while a country's wealth significantly impacts smart city development, other factors such as innovation, strategic planning, community engagement, and international cooperation are also crucial. High GDP may support the development of smart cities, but it is not the only factor determining their success. In the future, it will be essential to balance economic growth with the principles of sustainable development, environmental protection, and improving residents' quality of life.

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