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Smart City: Definitions, Dimensions, and Initiatives

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Abstract: **對於什麼是智慧城市仍存在諸多誤解**
本研究旨在探討智慧城市概念中不同的定義與維度如何被歸類

Purpose: *The smart city is an increasingly popular topic in the sustainable development of the city. However, there is still misunderstanding about what smart cities are. This study examined how different definition and dimensions included in the smart city concept can be categorized and how does a smart initiative make European cities smarter.*

個案研究
文獻回顧

Design/Methodology/Approach: *The paper attempts to answer the above questions through literature review and case study methods. The case study was used to present the actions of municipal authorities aimed at making cities smarter.*

Findings: *Smart city is difficult to define unequivocally due to its multidimensional character. When defining a smart city, most authors emphasize the role of information and communication technologies in city development. Urban centers are also defined in terms of human and social capital and institutions. In contrast, nowadays, there is a wide consensus at on accepting six dimension of smart city concept. According to this the development of the city is expected to make investments in economy, environment, governance, living, mobility, and people. Smart initiatives depend to a large extent on local factors. Therefore, the challenge for city authorities is to choose the most optimal city development strategy in the given economic, technological, and social conditions. In Europe, smart initiatives concern the greening of cities and the activation of elderly and disabled people.*

Practical Implications: *The article offers useful insights for both practitioners and scientist interested in smart city initiatives. Smart city is characterized by democratism, because community, research, and development centers as well as institutional and economic entities are interested in it. The implementation of the smart concept means innovative and sustainable urban development in harmony with the natural environment, without violating social cohesion, while respecting limited resources to meet stakeholder expectations.*

Originality/Value: *The results of the study contribute in the cognitive sense to the smart city concept. Comprehensive definition of smart city is proposed. Smart city is a city that combines information and communication technologies, social infrastructure (human and social capital) and public institutions to dynamize its economic, social, environmental, and cultural development.*

作者定義智慧城市指的是一個 結合資訊與通訊科技、社會基礎建設以及公共機構的城市，藉此促進其經濟、社會、環境與文化的發展動能

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為了因應這些問題，「智慧城市」作為一項現代化概念被提出，主張以整體性發展視角看待城市治理。
然而，「智慧城市」的概念至今仍未有明確定義。

1. Introduction

城市發展策略的最終預期，就是提升居民的生活水平

Urban centres are crucial for the dynamics of the development of any region and the national economy. The city is a complex system created by divergent objectives, needs and interests of different stakeholders, as well as development factors. According to Brodziński, Kozłowski and Michalak (2018), the development is defined as a process of positive quantitative and qualitative changes taking place in each area. It is determined by the capabilities of satisfying the needs of the city's inhabitants, which requires availability and the ability to use local resources (Pawłowska, 2015). The expected effect of the city's development strategy is to improve the standard of living in the city (Wrana, 2013).

Dameri (2013) argues that cities are moving towards more friendly urban spaces, using advanced technologies to face up to many problems of city life. As they operate in a system influenced by changing regional and national factors, they evolve with their environment (Słodczyk, 2000). Cities are witnessing numerous processes directly affecting their development. Increasing metropolization, urbanization and population in urban areas, while increasing economic, demographic, social and environmental problems in cities, pose a challenge for city managers, architects, and urban planners (Eremia, Toma, and Sandulec, 2017; Ramaprasad, Sánchez-Ortiz, and Syn, 2017; Pašalić, Ćukušić, and Jadrić, 2021; Yin, Xiong, Chen, Wang, Cooper, and David, 2015; Stanowicka, 2015).

The *smart city* is a modern concept that addresses the above problems. It represents the idea of a holistic approach to development. However, smart city concept is still unclear. The purpose of the paper is to find out (1) how multiple definition and dimensions included in the smart city concept can be categorized and (2) how does a smart initiative make European cities smarter. To achieve research aims the paper is divided into few parts. Section 2 and 3 presents an understanding of smart cities by analyzing definition and application domains. In section 4 examples of smart initiatives in Europe, including Poland, are shown. Finally, the conclusion of this paper is given in Section 5.

因為定義不明確，目前研究主要有四類核心
1. 技術導向　2. 人本導向
3. 制度導向　4. 綜合/混合導向

2. Definitions of Smart City

So far, a universal and commonly accepted definition of smart city, that would fully explain the essence of the concept, has not been developed. This problem is important because, it becomes difficult to define the shame of the city's development strategy as well as measure its performance (Kozłowski and Suwara, 2021; Patel and Bhagat 2019; Albino, Berardi, and Dangelico 2015). Given the leading component around which the smart city is explained, four groups of definitions can be identified. The first includes definitions that link the city with technologies (technological orientation). The technological dimension of the definition is due to the use of technological infrastructure, in particular modern information, and

本文的研究目的是探討以下兩點：
如何對「智慧城市」中多樣的定義與構面進行分類？
智慧化措施（smart initiatives）如何讓歐洲城市變得更智慧？
為達成上述目的，本文共分為幾個部分：
第2、3節：解析智慧城市的定義與應用領域；
第4節：展示歐洲（包括波蘭）的智慧城市行動實例；
第5節：研究結論。

communication technology (ICT), to improve the quality of life in the city. According to this, smart city may be defined as:

明確的地理區域，透過 ICT、物流等技術協作，提升市民在參與、環境品質與智慧發展等層面的福祉

– a well-defined geographical area, in which advanced technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of prosperity, inclusion and participation, environmental quality and intelligent development (Dameri, 2013);
the urban center of the future - safe, protected, ecologically friendly and efficient - because all structures (e.g., power, water, transport) are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms (Hall, Bowerman, Braverman, Taylor, Todosow and Wimmersperg, 2000).

強調市民的教育、知識、文化與自我發展

The second group includes definitions relating to education, learning and knowledge of people, which are indicated by some authors as key forces driving the development of the city (human orientation). Within the human dimension, a smart city is a city that inspires, shares culture, knowledge, and life, and motivates its inhabitants to create and develop their own lives (Rios, 2008) and metropolitan areas with a large share of the adult population with higher education (Winters, 2010). The next group covers definitions of a smart city that emphasize the institutional factors of urban development (institutional orientation). Within the institutional dimension, smart city refers to cities that are engaged in multitude initiatives to create better environmental, social and economic living conditions and to enhance their attractiveness and competitiveness (De Jong, Joss, Schraven, Zhan, and Weijnen, 2015) and an integrated system in which human and social capital interact, using technology to efficiently achieve sustainable development and a high quality of life built on partnership of all the stakeholders (Monzon , 2015).

強調政策、治理與公共管理的整合

The last group consists of definitions called hybrid. They link the technological, human, and institutional dimensions of smart city. Smart city is defined as:

透過人力與社會成本、交通與ICT的投資，推動經濟成長與生活品質提升

– a city where investments in human and social capital as well as traditional (transport) and modern (ICT) communication infrastructure stimulate sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance (Caragliu, Del Bo, and Nijkamp, 2011),
– a sustainable and effective city with high quality of life, aiming to successfully undertake urban challenges by application of information and communication technologies within its infrastructure and services, cooperation between its key stakeholders (citizens, universities, government, industry), integration of its core domains (environment, mobility, governance, community, industry, and services) and investment in social capital (Mosannenzadeh and Vettoriato, 2014).

整合環境、交通、治理、社區、產業與服務六大領域，並推動跨部門合作與社會資本投資

The multidimensional definition of smart city indicates that smart city represents holistic approach to development, focusing on its numerous determinants. The literature is dominated by definitions focused on the information and communication technologies. Ramaprasad, Sanchez-Oritz and Syn (2017) explain it by the fact, that ICT are used to monitor, control, and communicate urban services. Winkowska, Pino and Pejć argue that information and communications innovations implemented in the city are primarily intended to serve the interests of its inhabitants (Winkowska, Szpilko and Pejć, 2019). According to Hall (2002) the smart city development strategy utilizes modern technologies to improve the quality of life in urban spaces as well as the natural environment and to ensure high-quality city services.

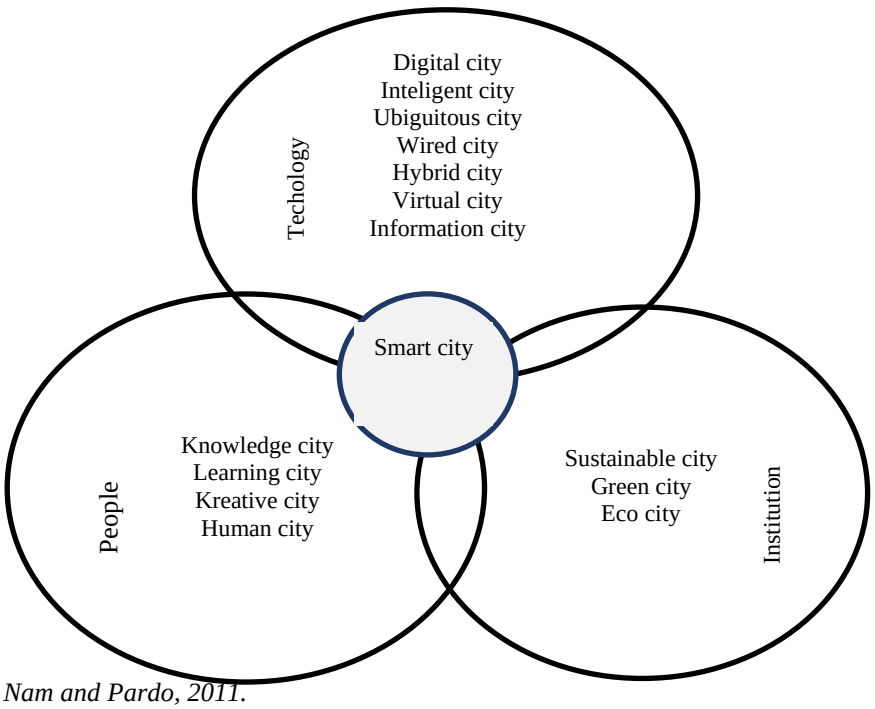
批評智慧城市常被誤用為其他標籤，如「數位城市」、「智能城市」、「有線城市」等，容易混淆概念實質。

Often pointed out the source of a smart city definition problem is the mistaken replacement of the word smart with other adjectives, such as "intelligent", "digital" or "wirred" (Kozłowski and Suwara, 2021). It needs to be highlighted that label assigned to a city indicate technological (e.g., digital city), human (e.g., learning city) or institutional (e.g., eco-city) nature of the instrument used in the city's development (Nam and Pardo, 2011). Combining various labels (Figure 1) with the smart city, it turns out that although they overlap in some areas, they are interpreted differently. If the terms refer to more detailed and less inclusive city levels, the smart city concept often includes them (Albino, Berard. and Dagelico, 2015).

智慧城市尚無統一定義，常見四種取向：技術、人本、制度、綜合。
文獻多偏重科技導向，但當代研究主張應更重視人與制度面向。

Figure 1. *Technology, human and institutional attributes of smart city*

智慧城市 != 單一科技應用，應被視為一種整體性治理與永續發展策略。
可納入第二章「智慧城市的構面分類」段落，並用表格對照四種取向與代表學者。



Source: *Nam and Pardo, 2011.*

3. Smart City Components

Many structural elements of a smart cities are indicated. Vishnivetskaya and Alexandrova (2018) claim that they are interacting between each other and thus manifoldly increase the contribution of each one owing in the city's development to synergy effect. In the component explaining the essence of the smart city, government, people, and infrastructure are popular, while education and energy are less frequently indicated (Table 1). Each component itself contains sub-components that are further described by a set of measures.

智慧城市定義: 一個以現代資訊與通訊技術為基礎，整合經濟、人民、生活、環境、治理與交通流動的城市系統

Although there is no agreement on the exact definition of a smart city, the six dimensions have been identified. It leads to leads to the conclusion that smart city is a city that, based on modern information and communication technologies, integrates economy, people, living, environment, governance, and mobility. Lombardi, Giordano, Farouh and Yousef state that those dimensions are based on "theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and participation of citizens in the governance of cities (Lombardi, Giordano, Farouh and Yousef, 2012).

智慧經濟:ICT被應用於發展電子商務與電子企業

1. *Smart economy* refers to the competitiveness of the city focusing on innovation, entrepreneurship, trademarks, productivity and flexibility of the labour market, and integration into the domestic market. Information and communication technologies (ICT) are used to develop e-business and e-commerce and to enhance opportunities related to the production and service delivery and innovations as well as new products, services, or business models.

智慧人民: 涉及市民的教育程度與專業素養，ICT被應用於提升人民創造與創新力

2. *Smart people:* It relates to the qualifications and education of the inhabitants of the city, as well as social interactions related to integration and public life and openness to the world. ICT serves to increase people's creativity and innovation and to increase the availability of education and trainings.

智慧治理:
有效率的公共政策
電子政務，促進民主與公共服務改善，支援公共機關決策

3. *Smart governance*: It is described mainly by effective and efficient public administration, quality of public services and and the participation of residents in making decisions about the city. Information and communication technologies are used in e-administration, to improve democratization and services delivery, as well as support decisions made by public authorities.

智慧交通/流動性:
服務、資訊與交通系統的可獲得性和可接近性

4. *Mobility* refers to the availability and accessibility services and information and communication technology as well as sustainable transport. Electric public busses are just one example.

智慧環境:
居住條件、汙染控制與資源管理、環境保護
有效的廢棄物管理、
再生能源的使用、
綠色都市規劃等。
ICT 被應用於強化城市的生態系統與環境監測能力。

5. *Smart environment* refers to the natural conditions of living in the city (e.g., green areas), pollution and resource management (e.g., reuse and replacement of resources) and environmental protection. Solutions proving a smart environment encompass, for example effective waste management,

use of renewable energy sources and green urban planning. Information and communication technologies are used to improve the city's ecological systems.

智慧生活:
城市管理者應特別關注居民的健康、安全、文化與生活條件。

Smart living encompasses different aspects of quality of life. City authorities should pay special attention to health, safety, cultureand living conditions of the residents. An important aspect is also stimulating tourism and information pertaining to entertainment events, spending free time and the nightlife. ICT support social initiatives are used to create new or improve the existing lifestyles as well as to improve safety and healthy of inahabitant (Patel and Bhagat, 2019; Camero and Alba, 2019; Neirotti, De Marco, Cagliano, Giulio, and Scorrnaro, 2014).

ICT 可支援社會性倡議，創造或改善既有的生活型態，並強化居民的安全與健康

Table 1. *Components of smart city*

Author	Components	Author	Components
Neirotti, De Marco, Cagliano, Giulio and Scorrano, 2014	- natural resources and energy - buildings - transport and mobility - living - government - economy and people	Vishivetskaya and Aleksandrova, 2018	- smart business - smart living - smart education - smart citizen - smart government - smart infrastructure - smart utility - smart mobility - smart environment
Camero and Alba, 2019	- smart economy - smart environment - smart governance - smart living - smart mobility - smart people	Sikora-Fernadez, 2013	- knowledge economy - ICT - sustainable development - social capital - co-managemnt - quality of life
Lombardi, Giordano, Farouh i Yousef, 2012	- smart governance - smart economy - smart human capital - smart environment - smart living	Mosannezadeth i Vettorato, 2014,	- services - transport - community - government - energy - buidings
Nam i Pardo, 2011	- technology - people - institution	Anthopoulos, 2017	- smart government - smart people - smart environment - smart living - smart economy - smart mobility - smart infrastructure - smart transport - smart services

Source: *Neirotti, De Marco, Cagliano, Giulio and Scorrano, 2014, p. 28, Vishnivetskaya and Alexandrova, 2018, p. 2, Camero and Alba 2019, p. 86, Lombardi, Giordano, Farouh and Yousef, 2012, p. 139, Mosannenzadeh and Vettoriato, 2014, p. 689, Nam and Pardo, 2011, p. 284, Anthopoulos, 2017, pp. 9-11, 13, Sikora-Fernadez, 2013, p. 86.*

The dimension of smart city demonstrates that city development depends not solely on hard infrastructure (physical capital). It is also shaped by the availability and quality of intangible capital (human and social capital). Modern information and comunictaion technology are required to the city. It is functioning depends on access to the communication network, mobile devices and infrastructure connected with them (Czupich, 2019). Furthermore, ICT help cities respond more quickly to changing needs and requirements of residents and optimize services.

However, when creating value for stakeholders, it is necessary for the local authorities to work closely with inhabitants and other stakeholders in defining desired services, prioritizing needs, and quickly delivering and reducing service costs (Kumar, Singh, Gupta, and Madaan, 2020). It should accelerate the city's development. In the context of people's role in the development of the smart city, it is important to promote investment in human capital and to expand soft skills among the society (Stawasz, 2015).

4. Smart City Initiatives in Europe

評分面向:人力資本、經濟、治理、社會凝聚力、環境、交通與運輸、城市規劃、國際影響力，以及科技

Smart cities are widespread on all continents. Although the term appeared in the early 1990s, the beginning of a dynamic growth in the aplication of the concept (Allam and Newman, 2018; Anthopoulos, Janssen, and Weerakkody, 2016) dates to 2008 (Yin, Xiong, Chen, Wang, Cooper, and David, 2015). This year, IBM launched the "Smarter Planet" project (Palmisano, 2008). The rankings show an upward trend in the number of smart cities, with the dominance of Northern and Western Europe. According to IESE Business School Ranking is based on the Cities in Motion Index. Nine dimensions are assessed, i.e., human capital, economy, governance, social cohesion, environment, mobility and transportation, urban planning, international projections, and technology. 174 cities from 80 countries were included in the study (Índice IESE Cities in Motion, 2020), there are 6 European cities in the "TOP 10" smart cities. These are London, Paris, Reykjavik, Copenhagen, Berlin, and Amsterdam (Índice IESE Cities in Motion, 2020).

In 2020, London was the smartest city in the world (Índice IESE Cities in Motion, 2020). The organization of the Summer Olympics in 2012 by London was the impulse to implement many smart projects in the city. Innovative solutions were applied in sports and city infrastructure. The construction of passive buildings (e.g., Copper Box, London Velopark), i.e., buildings characterized by low energy demand, the use of passive energy sources and heat recovery in ventilation systems, allowed to reduce the costs of organizing the Olympics by more than 30%, compared to the Beijing Olympics. Ecological smart initiatives also include powering the London City Hall with unconventional energy sources, paving slabs generating electricity, the Blackfriars solar bridge, the London Array wind farm located at the mouth of the Thames, the paid entry system to the city center (free for e-vehicles), tax benefits of purchasing electric cars, as well as vehicle charging stations and Barclays Cycle Hire (Szymańska and Korolko, 2015).

其智慧發展部分源於 2012 年倫敦奧運的主辦契機，當時實施了大量創新方案，包括：
被動式建築（如 Copper Box、London Velopark）：透過使用低耗能設計、再生能源與熱回收系統，大幅降低奧運設施的營運成本（比北京奧運少 30%）；
生態建築與再生能源：市政廳使用替代能源，電力發電鋪面、Blackfriars 太陽能橋、泰晤士河口的風電場 London Array；
智慧交通措施：市中心收費政策（電動車免費）、購買電動車的稅務優惠、充電站與 Barclays 公共自行車租賃等。

綠色建築政策、
低碳排暖氣系統、
水力與風力發電項目（如 Middelgrunden 海上風電場）

哥本哈根：碳中和

Copenhagen is another city that implements projects in the field of environment. The city authorities set a goal of achieving carbon neutrality by 2025. It is implemented through green construction, low-emission heating and energy generation from water and wind farms, e.g., Middelgrunden project (Szymańska and Korolko, 2015; Larsen, Soerensen, Christiansen, and Vølund 2015).

In Berlin "SmartCity Strategy Berlin" was introduced to create a friendly environment for entities operating around innovative solutions. Comprehensive support and advice were provided. The "EBikePendeln" project was also carried out in the city - electric bike rental and charging infrastructure (Instytut Łączności, 2017; Czowala, 2016).

In Barcelona (26th position in the IESE ranking in 2020), innovative projects were implemented around smart living and smart people. Social initiatives are aimed to prevent of social exclusion of seniors and disable people. This is served by architectural solutions, a 24/7 free service to help the elderly, disabled or lonely (Telecare) and the project "Radars", which aims to communicate with the seniors and increase their activity (Tota, 2017).

Warsaw, ranked 54th by IESE, is the city that most actively implements smart solutions in Poland. The capital offers free Wi-Fi access in public places, the ability to monitor the degree of pollution via mobile applications and websites, or apps indicating free parking spaces. Its residents also have access to information on the city's finances and an online platform through which they can submit any smart ideas. The key solutions in the field of the smart environment are Veturilo bike rental, sustainable public transport, charging network, recyclers, anti-smog pavements and application "Million Trees", aimed at spurring residents' attitudes toward environment (Knight, 2018; Klimczak, 2020; Demiańczuk, 2019).

5. Conclusions

Smart city is a modern concept, facing the contemporary problems of urban life, that is intended to ensure the sustainable development of the city. Studies highlights the lack of consensus regarding the definition of this term. This problem is important because, in the absence of a universal and generally accepted definition of smart city, defining the shame of the city's development strategy, and measuring its performance is not easy. The essence of the concept is best reflected in definitions representing holistic approaches to the development of the city.

Thus, smart city is a city that combines information and communication technologies with human and social capital and public institutions to dynamize it is economic, social, environmental, and cultural development. This requires smart investments in the city's economy, its inhabitants (competence, qualifications, interaction), the functioning of public administration and urban democratization, the environmental

「智慧城市」是一項面對當代都市生活挑戰的現代化概念，其目的是確保城市的永續發展。
多項研究指出，對於智慧城市的定義仍缺乏共識，而這種模糊性也導致城市難以清晰地制定發展策略，
並對施政績效進行衡量。

不論城市的規模、地理位置或文化背景為何，世界各地的城市政府、居民、公部門與企業皆對智慧城市展現高度興趣。然而，實際推行的智慧解決方案往往不盡相同，這些差異源自文化多樣性、社會意識、對研究部門的投資程度、以及國家／地區／城市的社經發展水準與資源分配狀況。

quality of urban space, mobility (accessibility of services, ICT, sustainable transport) and quality of life in the city (health, education, safety, culture).

Building the city's development strategy in line with the smart city concept is important because cities play a key role in social and economic phenomena occurring all over the world and have a global impact on the environment and human life. The interest of urban authorities, communities, public institutions, and business in the smart city is observable in many cities, regardless of their size, geographical location, or cultural environment. However, the smart solutions they implement are not the same. This is due to cultural diversity, social awareness, investment in the research sector and the level of socio-economic development of country / region / city, correlated with available resources, which can be allocated in smart city areas.
Alhough cities' experience in implementing the smart city concept shows that cities are diverse in terms of smart initiatives, city governments share the same objective. They are motivated by the desire to improve the quality of public services and the quality of life in urban spaces. Farelnik and Stanowicka (2016) notice that city is smart if the quality-of-life improvement is accomplished due to the involvement of high-quality human and social capital and modern transport and ICT infrastructure as well as governance that sould be based on participatory model of management and the sustainable development rules. Smart initiatives in Europe focus on greening cities to address the growing problems of their pollution and climate change, and tackling social exclusion, especially for the seniors and disabled. Polish cities tend to implement single, already tested smart solutions in other European cities. They mainly concern mobility and ecology projects, due to the possibility of receiving EU funding (Kozłowski and Suwara, 2021).

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