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Smart cities as *mortal engines*: Competing for generations Y and Z through livability and digital technologies

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ABSTRACT

In recent years, the rise of smart cities has marked a transformative era in urban development, redefining the way cities interact and compete for residents, businesses, and innovation, and contributing to reshaping migratory dynamics. This study explores the intricate dynamics of urban attractiveness and competition in the context of cities' smart initiatives, where advancements in digital technologies and urban livability converge to influence contemporary migratory patterns. However, despite the rhetoric of smartness and the celebratory images and outcomes of smart cities on a global scale, there is still a significant gap in understanding the effects and interactions with different individuals and behaviors. Drawing upon the push and pull theory, we empirically analyze a panel dataset of 30 Italian cities over a 13-year period (2009–2021) using a dynamic Generalized Method of Moments (GMM) approach. Our findings reveal that while both smart living and digital advancement positively influence urban attractiveness, Generation Y is more responsive to digital implementation and urban livability than Generation Z. Moreover, we identify a complementary effect, where cities combining high levels of smart living with strong digital infrastructures exhibit higher attractiveness for both generations. These insights contribute to the literature on smart cities and generational migration, providing practical implications for policymakers on how to strategically enhance urban attractiveness.

1. Introduction

In the past decades, there has been a growing interest in the development and conceptualization of the smart city as well as the political legitimacy of the phenomenon. On one side, this conceptualization has led to a reorganization of the urban environment by policymakers and governments worldwide (Caragliu et al., 2011; Linde et al., 2021; Vanolo, 2014). On the other side, the development of the smart city, driven by globalization and digital development, acts as a new economic and social force for urban growth, altering the way cities compete and interact with one another (Bakıcı et al., 2013, p. 135; Christofi et al., 2021, p. 965; Taylor Buck et al., 2017). In this context, cities globally compete to become attractive for internal and external users, advancing in sustainable, efficient, and inclusive urban development, concepts considered as pillars in contemporary smart city development (Albino et al., 2015). Today, 54 % of the global population is estimated to reside in cities.[1] However, according to the United Nations -World Urbanization Prospects- by 2050, 70 % of the global population will live in metropolises and megalopolises at the expense of smaller cities and urban areas that will gradually diminish.[2] In a fantasy book entitled *Mortal Engines: Hungry City Chronicles*, Philip Reeve (2001) imagined giant "*traction cities*" devouring smaller ones to sustain their power. This science fiction metaphor resonates with today's academic debate, as cities increasingly compete for human capital, talent, business, tourism, and innovation (Christofi et al., 2021, p. 951). Cities orchestrate resources, services, and infrastructure to create a tailor-made environment for their users. Specifically, driven by advancements in digital technologies (Techno-centric) and urban liveability (Human-centric), cities shape the urban environment to attract and retain human capital and businesses, considered key factors in urban dynamics (Chandler & Saxenian, 1995; Fujita & Thisse, 2003; Knudsen et al., 2008; Yap, 1977).

The implementation of smart city initiatives, along with the

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[1] Source: https://www.urbanet.info/world-urban-population/

[2] United Nations, Department of Economic and Social Affairs - Population Dynamics - World Urbanization Perspect 2018. Available at: https://population.un.org/wup/

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increasing role of digital technologies and urban livability, can influence how users perceive cities and engage with their urban environment. While the direct impact on migratory preferences remains an evolving area of research, existing studies suggest that smart city features contribute to shaping urban attractiveness and may play a role in contemporary geographical patterns (Betz et al., 2016; Kummitha & Crutzen, 2019; Winters, 2011). However, not all users perceive the city and the tools utilized within the smart city framework (e.g., digital services, advanced infrastructures, social media) in the same manner. This variance in perception gives rise to a plethora of ethical and social considerations when implementing smart cities. On one side, from an entrepreneurial perspective, cities invest in services and infrastructure to enhance human capital attractiveness (potentially at the expense of other cities) by offering an efficient, sustainable, and advanced environment (Kummitha, 2018; Wiig, 2016). However, on the other side, this approach may contrast with the ethical and social responsibilities cities hold within society. Unlike businesses, which can choose their target users, cities must adopt a comprehensive perspective, encompassing all users regardless of age, gender, religion, political orientation, and technological proficiency, promoting advancements that are as inclusive as possible (Cornelius & Wallace, 2010; De Guimarães et al., 2020; Paskaleva, 2011). This perspective gives rise to a myriad of views on the actual implementation of cities, which must place individuals at the core of their development strategies.

While it is challenging to categorize the uniqueness of individuals, studying the different generations provides an intriguing framework for clustering groups with similar intrinsic characteristics. These groups, shaped by comparable economic, historical, and technological contexts, often display shared thought patterns and behaviors (Cennamo & Gardner, 2008; Dolot, 2018; Mannheim, 1952). This clustering of individuals has significantly influenced our understanding of generational shifts and their interplay with economies, urban environments, innovation, and social structures. In this vein, as a primary force in future urban development, smart city initiatives must consider different generations' characteristics in present and future urban dynamics. Thus, building on the previous discussions, we assume that the techno-centric and human-centric approaches in urban dynamics have influenced migratory patterns for different generations, altered balances, and shaped new developmental trajectories for cities. In this line, this research draws upon the Push and Pull theory, commonly used to explain floating populations and migratory patterns (Khalid & Urbański, 2021; Krishnakumar & Indumathi, 2014). The objective is to examine the synergies between digital implementation and the livable services encompassed in the smart living dimension, with two generations, Y and Z, considered the most active in contemporary migration.[3] The novel aspects of this research are numerous. While there is significant interest in the relationship between different generations, technology, and evolving roles within society (Cennamo & Gardner, 2008; Njøs et al., 2020; Roth-Cohen et al., 2022), studies exploring the relationship between the urban environment in attracting different generations are lacking. Moreover, despite smart cities heavily investing in (i) digital advancement and (ii) services and infrastructure to enhance urban livability, it remains unclear which user categories engage with these factors and how different generations perceive them in terms of attractiveness (Marchesani et al., 2022; Sage et al., 2013). Furthermore, to our knowledge, no studies have examined the relationship between Generation Z and Generation Y and cities. This highlights that in an increasingly competitive urban context, there is still a significant gap between theory and practice in smart city development (Nakano & Washizu, 2021; Romão et al., 2018; Taylor Buck & While, 2017). Untangling this relationship not only offers a new and current perspective but also prompts myriad considerations regarding the increasingly entrepreneurial urbanism perspective of cities.

Entrepreneurial urbanism refers to the increasing competition among cities to attract human capital, businesses, and investments by leveraging digital advancements and urban liveability. This concept aligns with the broader shift toward a corporate vision, where cities strategically deploy smart city initiatives to enhance their attractiveness (Christofi et al., 2021; Kummitha, 2018; Wiig, 2016). While smart city research often focuses on technological implementation, less attention has been paid to how these initiatives shape migratory choices, particularly for younger generations. In this study, we frame the localization of Generations Y and Z within the competitive urban landscape, illustrating how digitalization and liveability interact to position cities as entrepreneurial actors in the global urban hierarchy. Consequently, the following research question (RQ) is proposed:

RQ. *How do the digital and urban livability advancements in the dynamics of smart cities influence the migration patterns of Generation Y and Generation Z?*

Applying a quantitative research approach focusing on the Italian context, a nation at the forefront of European smart city policies, this paper aims to achieve a nuanced understanding of how cities move and compete with each other, giving rise to entrepreneurial urbanism, explained through the interaction between smart cities with Generation Y and Generation Z. The final objective is to advance the discussion on smart city development in several ways highlighting novel aspects into the smart city and generational debate. First, empirical evidence is presented to contribute to the debate concerning the attractiveness of cities in relation to Generation Z and Generation Y, approaching the research from an entrepreneurial and competitive perspective. Second, an evolutionary debate on cities is proposed (in contrast to the ethical principle of social inclusivity in cities), which contributes to the entrepreneurial urbanism perspective discussed in the paper's conclusions. Third, theoretical contributions are made to refine the understanding of the push and pull theory in the digital age. Apart from the theoretical contributions, this study offers practical implications for policymakers and governance in their interactions with different generations, providing suggestions and fostering discussions on how to orchestrate these factors within the dynamics of smart cities. These insights not only provide academics and practitioners with an opportunity to generate new perspectives but also contribute to the debate on the ethical and social value of smart cities in contemporary society.

2. Literature review

The concept of a smart city, characterized by its progressive evolution in services, technology, and infrastructure with the ultimate aim of enhancing the city's efficiency, sustainability, and livability, has attracted considerable attention over the years (Albino et al., 2015; Caragliu et al., 2011; Vanolo, 2014). It has become central to discussions on urban, social, innovative, and economic development. However, the multifaceted nature of this term has given rise to an array of definitions, each with its unique nuances and implications (Albino et al., 2015, p. 3). Giffinger et al. (2007), in one of the earliest definitions, describes a smart city as one that "*well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and actions of self-decisive, independent, and aware citizens. It builds on the search and identification of smart solutions which allow contemporary cities to enhance the quality of the services provided to citizens*". In this context, smart city development does not consider digital technologies but prioritizes the inhabitants and city users at the heart of its transformation. However, while Giffinger's definition places citizens at the center of the city's development and its inhabitants, there has been a shift in the conceptualization of smart

[3] In 2021, the 'Registry Office for Transfer of Residence' across the 30 cities included in the sample recorded 326,125 new registrations. These were distributed as follows: 26 % were attributed to Generation Z (born from 1997 onwards), 53 % to Generation X (born between 1980 and 1996), and the remaining 21 % were from Generation Y and earlier cohorts (born before 1980).

cities toward a focus on technology as a vehicle of this transformation (Nam & Pardo, 2011; Paskaleva, 2009). This new perspective of the city paradigm, driven by globalization and internationalization, positions technology as a building stone of future urban development. It not only shapes the trajectory of urban growth but also interacts with continental (i.e., European Policies) and worldwide (Sustainable Development Goals SDGs) policies and objectives, alters the city's relationships with external entities and its influence on both national and international levels (Christofi et al., 2021, p. 965). In this line, Bakici, Almirall, & Wareham (2012, p. 139) capture this shift by defining a smart city as a "*high-tech intensive and advanced city that connects people, information, and city elements using new technologies to create a sustainable, greener city, competitive and innovative market, and an increased life quality*." Despite these differing perspectives, what remains clear is that the quality of urban life and the needs of the people are central to these initiatives. The ultimate objective is to cultivate a citizen-centric and techno-centric socio-economic environment, transforming cities into attractive and competitive urban centers capable of attracting and retaining human capital (Caragliu et al., 2011; Hollands, 2015; Marsal-Llacuna et al., 2015; Vanolo, 2014).

In the evolving landscape of smart city development, the ongoing debate between techno-centric and citizen-centric approaches remains a focal point in both academic and political spheres(Angelidou, 2014; De Falco et al., 2019; Trencher, 2019). At this intersection, it becomes crucial to examine the role of emerging generations that engage with and help shape the trajectory of smart cities. These generations should not be viewed homogeneously; instead, their distinct intrinsic and societal characteristics must be considered, as they play a pivotal role in influencing the broader socio-economic context (Roth-Cohen et al., 2022).

2.1. Intercepting generations Y & Z in the smart city development

Starting from the early sociological discussion (Mannheim, 1952), it is evident that each person is unique and irreplaceable. Nonetheless, numerous attempts have been made to categorize and define groups of individuals, leading to the conceptualization of the term 'generations'. Such groups, shaped by similar economic, historical, and technological contexts, often exhibit common thought patterns and behaviors (Cennamo & Gardner, 2008; Dolot, 2018; Mannheim, 1952). Delineating exact generational boundaries remains a contentious task, with a significant portion of research focused primarily on North America and the United Kingdom (Cennamo & Gardner, 2008, p. 896). To situate the Italian case, it is important to acknowledge that generational dynamics may differ across contexts such as Asia or Latin America, where cultural, economic, and policy environments shape distinct migration patterns and responses to smart city initiatives.

In this study, we focus on two distinct generations: Generation Y and Generation Z. Typically born between 1980 and 1994, *Generation Y* is characterized by their formative years of relative prosperity and intrinsic familiarity with technology (Roth-Cohen et al., 2022). Generation Z, born between 1995 and 2010, is still the subject of ongoing debate, but is generally defined as the first fully digital-native cohort (Dolot, 2018; Roth-Cohen et al., 2022). Yet, their existence within an era dominated by the internet, smart devices, and digital media is undeniable.

Despite these differences, within the realm of smart cities, the dynamic between citizen-centric and digital-centric development can follow divergent paths. Whereas *Generation Z,* transitions effortlessly between real and virtual domains, *Generation Y* tends to oscillate more consciously between these spheres, valuing face-to-face interactions while still being deeply engaged with digital platforms (Roth-Cohen et al., 2022). Several studies suggest that the interactions of younger generations with urban and digital environments have already influenced smart city dynamics over the years and may continue to shape their evolution in the future (Betz et al., 2016; Faggian et al., 2017; Winters, 2011). Early discussions by Winters (2011) highlight how age and education levels play a crucial role in shaping who moves to and from smart cities, reinforcing the importance of generational differences in urban attractiveness and smart city engagement. This interaction will alter the migratory and localization dynamics of various generations, subsequently influencing the equilibrium of urban trajectories.

2.2. A push and pull theory perspective on urban attractiveness

Urban attractiveness and migration are complex and multifaceted phenomena that arise not only from economic reasons but also from social, political, cultural, environmental, health, education, and transportation factors (Black & Henderson, 1999; Crevoisier & Rime, 2021; Knudsen et al., 2008). The push and pull theory offers a framework to understand the migration dynamics that occur both on an international scale and within cities, and it is particularly applicable to the analysis of urban attractiveness (Gries et al., 2016; Krishnakumar & Indumathi, 2014). This theory highlights the interplay between the factors that push individuals to leave their homes (push factors) and those that attract them to a new location (pull factors). Push factors, such as the lack of job opportunities, inadequate living conditions, or political persecution, drive people away from their homes. In contrast, pull factors, including job opportunities, improved living conditions, advanced urban environment as well as political and religious freedom, draw individuals to new destinations (Krishnakumar & Indumathi, 2014, p. 9).

In the context of smart cities, the push and pull theory provides valuable insights into the factors that influence people's perceptions of cities as attractive places to live and build their future lives (Sinkiene & Kromolcas, 2010; Winters, 2011). In this line, factors such as demographic and social variables contribute to shaping the perception of urban environments (Neirotti et al., 2014). Indeed, demographic factors play a significant role in shaping the needs and perceptions of a city. For example, technologically adept users may prefer cities with advanced technological infrastructure, while families and less digitally connected users may favor services or amenities that align with their specific needs (Rojas-Méndez et al., 2017, p. 18). As a result, different generations (*Y*, and *Z*) may perceive and evaluate the attractiveness of a smart city based on their own needs and preferences. These factors include their level of readiness to adopt new technologies, their perception of the city's technological environment, and their specific social needs. In addition to demographic and social variables, the urban attractiveness of a smart city is shaped by its ability to offer an integrative, inclusive, and socially responsible environment (Marchesani et al., 2022; Romão et al., 2018). Drawing from recent perspectives on urban attractiveness, which emphasize livability and technology as central facets, urban attractiveness can be defined, following (Florida, 1995, 2002) as a city's ability to offer desirable amenities and services to all its users, encompassing residents, businesses, and visitors. This includes creating a digital- and user-centric urban environment that caters to the needs of both locals and visitors, enhancing the city's competitiveness and attractiveness, and fostering local prosperity and growth (Christofi et al., 2021; Gil-Garcia et al., 2018; Marchesani et al., 2023).

Smart city projects, driven by technology implementation and institutional support, seek to improve the relationship between cities and their citizens. In this process, attracting and retaining local and incoming human capital is both the engine and the objective of smart city projects (Kummitha & Crutzen, 2019, p. 45). The institutional environment plays a pivotal role in managing and guiding the relationship between the city and its users, establishing a supportive cognitive institutional environment (Abid et al., 2022). Thus, fostering urban attractiveness becomes essential for cities to attract and retain human capital, particularly from rural areas and less-developed cities.

2.3. Smart living dimension into the urban dynamics

Smart living practices, defined by Vanolo (Vanolo, 2014, p. 887) as "*practices that involving the quality of life, imagined and measured in terms of availability of cultural and educational services, tourist attractions, social cohesion, healthy environment, personal safety and housing*", place at the core of the smart city concept, encompasses various social aspects of urban life. These practices involve offering an advanced educational system, health services, health hubs for hospital and emergency care, public spaces for interaction, and facilitating labor and social integration (Camboim et al., 2019; J. H. Lee et al., 2014). Smart living is intrinsically linked to the idea of social inclusion and urban migration, a theme that has been extensively discussed in the literature (Nguyen et al., 2022; Parrilli et al., 2019; Roy, 2011; Wiig, 2016). While smart living practices may yield various positive outcomes for the urban environment, it is important to note that not all users may be interested in or inclined toward this dimension. This interaction is intrinsic among users who engage with the city; for instance, tourists or workers might be less interested in the smart living aspect and more drawn to mobility or sustainability (Rucci et al., 2022; Shafiee et al., 2021). At the same time, the environmental perception of Generation X and Y can influence this relationship. For example, students and youth users from Generation Z, referring to Florida's perspective (2002; 2012), might be more attracted to a bohemian context that enhances their creativity and potential. In contrast, Generation Y might be more inclined toward environments suitable for permanent settlement, driven primarily by economic considerations and job opportunities (Abid et al., 2022; M. Alam & Siddiqui, 2023). Furthermore, they may value environments that offer advanced services related to education, safety, and health, reflecting the essence of smart living (Neirotti et al., 2014; Vanolo, 2014).

Despite the users' characteristics and perceptions, it is also important to consider the cities' characteristics and practices. Despite the growing trend of smart cities and the institutional support in Europe (Antenozio et al., 2024; Caragliu et al., 2011; Caragliu & Del Bo, 2019), not all cities may be equipped, both in terms of governance and infrastructure, to invest in and enhance this particular dimension. While city planners ambitiously aim to transform urban areas into sustainable and citizen-centric environments, the roadmaps guiding these efforts often fall short (Ibrahim et al.,2018). This view underscores two contrasting paradigms: (i) the imperative for a holistic and systematic planning framework that equips cities with comprehensive preparation across every infrastructural aspect during and after their transformation (Ibrahim et al., 2018; Leitheiser & Follmann, 2020; Linde et al., 2021), and (ii) the cities that proactively align with and surpass these standards, thus enhancing their 'liveability' quotient to meet both residents and external users, will secure a distinct competitive advantage over their counterparts (Christofi et al., 2021; Taylor Buck & While, 2017). This vantage not only enables them to attract a larger population, often at the expense of less prepared cities, but also intensifies the ongoing urban competition for a different range of users (Glaeser, 1999; M. Porter, 1998; M. E. Porter, 1996). In this line, advancing smart living practices may affect Generation Y, which may place greater emphasis on services related to education, schools, and safety. At this stage in their life, they often prioritize access to quality educational institutions, secure environments, and a vibrant work ecosystem with strong job integration as essential components for their personal, professional, and family development (Cennamo & Gardner, 2008; Civelek, 2018). At the same time, Generation Z might have a strong interest in educational facilities, a vibrant cultural environment, and technological advancements in the city (Dolot, 2018). This generation has grown up with technology and is more likely to engage with smart devices and services that enhance their daily lives (Liu et al., 2019; Roth-Cohen et al., 2022). They might be more receptive to digital transformations yet may show reduced emphasis on health systems and service integrations such as childcare and elderly care, which aren't their primary concerns during their migration path.

Building on the previous discussion, we posit that cities with well-developed smart living practices are generally inclined to attract new residents who find an environment tailored to their needs. However, the interaction between various social and demographic characteristics and the development trajectories of smart cities is complex. Although the impact of these policies is generally positive at all levels, there are groups (divided by different generations) that may be more or less sensitive to these dynamics. Given these considerations, the following hypotheses are proposed:

H1. *The higher the level of smart living practices in the city, the higher the effect of urban attractiveness to Generation Z new residents.*

H2. *The higher the level of smart living practices in the city, the higher the effect of urban attractiveness to Generation Y new residents*

2.4. Digital advancement and urban attractiveness

Contemporary cities embed digital and technological solutions to advance internal efficiency, sustainability, and liveability, but also to meet users' needs and to shape the perceived value for users and stakeholders, becoming a pivotal factor in smart city development (Camboim et al., 2019; Caragliu & Del Bo, 2019). Indeed, digital and technological advancement is viewed as the primary value driver in the smart city evolution, enabled by the expanding adoption of information technologies (IT) and the Internet of Things (IoT) to enhance services, products, and efficiency through real-time control systems (Kummitha, 2018). This evolution also serves to bridge the gap between citizens' urban environment and policymakers within the smart city framework (Goodspeed, 2015; Simmons et al., 2018). Concurrently, the advancement of digital technologies presents a challenge for cities, given that not all users possess the appropriate digital readiness (Margherita et al., 2023; Ibrahim et al., 2018; Kummitha & Crutzen, 2019), and demographic and social contexts are key factors influencing perceptions and strategic usage of digital advancements in cities (Datta & Odendaal, 2019; Hollands, 2015, 2020). These technologies must be tailored to and embraced by a diverse user base, including citizens, businesses, and entrepreneurs.

At the current stage, digital implementation in cities fosters increased engagement between citizens and urban environments, shaping cities' strategic growth by cultivating continuous stakeholder relationships (Gagliardi et al., 2017). In light of this, we identify digital advancement in cities as instrumental in shaping the trajectories of "smart" cities, positing that the progression of these practices in cities influences urban appeal for users and long-term residents. The notion of digital advancement is broad and encompasses different areas and tools as measurement indicators within an urban context (Abid et al., 2022; Marchesani et al., 2023; Spicer et al., 2021). For instance, it includes online services and social media platforms (Molinillo et al., 2019; Wiig, 2016; Yigitcanlar et al., 2020) as measurement tools of the grade of smart destination. Moreover, urban innovation literature considers a wide array of indicators that pertain to factual parameters of local development, such as the number of public Wi-Fi (Hampton & Gupta, 2008) or the availability of municipal Open Data (Gagliardi et al., 2017). It also encompasses aspects related to technology usage and access by users, including broadband access and the number of app downloads (Giglio et al., 2019). The escalating demand among citizens for heightened interaction with urban development, combined with advancements and investments in ICT and improved government-citizen relations, is intrinsically linked to technological deployment and its influence on city strategies (Pereira et al., 2018). Consequently, the successful digital implementation and technology adoption by city governance, users, and stakeholders have emerged as crucial factors in smart city evolution and urban appeal (Christofi et al., 2021). Notably, the IoT provides a distinctive opportunity for residents and potential residents to offer customized services and infrastructure to suit stakeholder needs, enhancing societal engagement with cities on both micro and macro scales (Soares et al., 2021).

Building on the previous discussion, this study aims to explore cities' capacity to create value for potential citizens lending to competition in local and international environments, suggesting that digitally advanced cities are more willing to attract and retain new residents. Central to this notion is the application of IoT and ICT, which has fundamentally transformed urban dynamics previously rooted in local development (Linde et al., 2021; Vanolo, 2014) A city's appeal is intrinsically tied to its ability to deliver essential services that foster growth opportunities, generate economic value, and create a citizen-centric environment (Trencher, 2019). Potential inhabitants are discerning and seek cities that function efficiently and purposefully. In terms of city appeal, advanced digital implementation, high-quality services, and competitive smart city development elevate these urban centers to prominent positions on both national and international stages (Chatterjee & Kar, 2015; Kumar et al., 2016). However, different generations may interact with and react differently to the digital implementations in cities (Roth-Cohen et al., 2022). Thus, given these considerations, the following hypotheses are proposed:

H3. *The higher the level of digital advancement in the city, the higher the effect of urban attractiveness to Generation Z new residents.*

H4. *The higher the level of digital advancement in the city, the higher the effect of urban attractiveness to Generation Y new residents.*

Previous research has indicated a complementarity between digital technology advancement and smart city projects (Abid et al., 2022; Caragliu & Del Bo, 2019; Cledou et al., 2018; Hatuka & Zur, 2020; Kummitha & Crutzen, 2019; Marchesani et al., 2022, 2023; Mouton & Burns, 2021; Spicer et al., 2021), implying that the return on one variable increases as the other variable increases. In this study, we hypothesize that the effect of livability will enhance urban attractiveness for both Generation Z and Generation Y, leading to an increase in urban appeal. This expectation is rooted in the smart city literature (Caragliu & Del Bo, 2019; Linde et al., 2021; Marchesani et al., 2023), which posits that to reap the benefits of internal implementation (organization) and external outcomes (attractiveness), cities must invest in digital implementation. Such investment in digital implementation reflects various smart city dimensions and influences the perceptions of both internal and external users. Without such advancement, it becomes challenging, if not impossible, to develop smart city practices that have a direct impact on users (Caragliu & Del Bo, 2019; Vanolo, 2014). In other words, not all smart cities are expected to benefit equally from the advancement of urban livability (smart living practices) in terms of urban attractiveness. Cities that invest more in digital implementation should experience greater benefits from the effects of local practices related to the localization of current and future inhabitants (Abid et al., 2022; Kummitha, 2018).

Therefore, a combination of citizen-centric and digital-centric practices is crucial for orchestrating the current dynamics of smart cities (Christofi et al., 2021; Lee & Lee, 2014). Technology, when combined with citizen-centric city development, highlights the role of technology as a connector, which should not be viewed as an outcome but rather as a strategic tool in smart city development. In this line, according to Marchesani et al. (2023, p. 10), smart cities' internal dynamics must extend *beyond mere digital technology advancement to seek effective outcomes that maximize co-alignment and the associated potential benefits*. This alignment varies depending on the generations involved and their degree of responsiveness to technology. Building on this debate, we posit that:

H5. *Digital Advancement and Smart Living dimensions are complementary in affecting urban attractiveness to Generation Z new residents.*

H6. *Digital Advancement and Smart Living dimensions are complementary in affecting urban attractiveness to Generation Y new residents*

3. Methodology

3.1. Sample of analysis

The empirical analysis focuses on 30 Italian cities over 13 years from January 1, 2009, to December 31, 2021. The focus on the Italian context is supported by several considerations: (i) Italy ranks among the highest countries in Europe, along with Spain, the UK, and Germany, in terms of the number of individual smart city initiatives (Caragliu & Del Bo, 2019, p. 375); (ii) it occupies a central position in the academic debate on smart cities and is fully committed to implementing smart urban policies (Vanolo, 2014, p. 884); and (iii) Italy constitutes a prominent empirical focus for examining the strategic effects of smart city development in Europe (Christofi et al., 2021, p. 961).

To ensure high heterogeneity and conformity with European standards, we constructed our sample following the probability-proportional-to-size sampling approach (Levy & Lemeshow, 2008) and considered four different structural and economic characteristics. Specifically, we defined the "stratification" of the sample based on four distinct levels, including geographical location, economic factors, and population size. This stratification ensured that the sample included a diverse range of cities with varying characteristics. By selecting cities with probabilities directly proportional to their attributes within the different strata, we could assess a representative sample capturing the complexities and diversities of urban dynamics across Italy. This approach contributes to a broader understanding of urban studies in Europe (Caragliu et al., 2011; Caragliu & Del Bo, 2019; McCann & Ortega-Argilés, 2015; Paskaleva, 2009).

The final sample includes 30 cities, ranging from Urbino with 14,884 residents to Rome with 2,582,000 residents, covering 61 % of the main 100 Italian cities in terms of population, which is considered a representative sample of the country (Levy & Lemeshow, 2008). The selected cities, in alphabetical order, are: Bari, Bergamo, Bologna, Cagliari, Caserta, Catania, Cosenza, Florence, Foggia, Genoa, Lecce, Messina, Milan, Modena, Naples, Palermo, Parma, Pavia, Perugia, Pisa, Reggio Calabria, Rome, Salerno, Siena, Trento, Turin, Urbino, Venice, Verona, and Brescia. This distribution includes large, medium-sized, and medium-small cities, ensuring representation across diverse strata.

3.2. Data collection and variables

This research utilizes city-level variables and includes data from several national (ASIA, Assoaeroporti, AGCOM, ISTAT, IPS, ANPR, MIUR, Wi-Fi Italia, and SPRAR) and international (EUROSTAT, FPA, and OECD) databases. Table 1 summarizes the variables considered in the empirical analysis, highlighting each single variable, describing the variable, its source, and operationalization in the model.

3.2.1. Dependent variable

The dependent variables in our study consider new residents, structured in two levels (*Generation Z* and *Y*), to take into account different characteristics and to investigate the interaction of various generations with contemporary smart city development (Delbosc et al., 2019; Liu et al., 2019; Roth-Cohen et al., 2022). For the construction of these variables, we relied on the annual registrations for new residents from the registry offices of the cities under examination (Registrations and cancellations at the registry office for transfer of residence - RC). In *Generation Y*, we refer to those born between 1980 and 1994. In *Generation Z*, we included those born in 1995. In reference to Generation Y, we considered the entire panel (13 years). As for Generation Z, we focused on the year 2014, which marks the year when Generation Z reached the age of majority in Italy. To ensure that migration decisions reflect individuals capable of independent relocation, we consider only new residents who were at least 18 years old at the time of migration. This threshold aligns with legal adulthood and the typical period in which individuals make independent migration decisions.

Table 1
Variables description.

Variable	Model	Description	Data - Source	Operationalization of the variables
New residents Z	DV	New residents born from 1 January 1995 arriving annually from other cities based on registration in the cities' register (ANPR)	ANPR	Number of new residents operationalized over the population of the city yearly
New residents Y	DV	New residents born post between 1980 and 1994, arriving annually from other cities based on registration in the cities' register (ANPR)	ANPR	Number of new residents operationalized over the population of the city yearly
Elderly assistance	Index (SL)	Number of public and private elderly reception services	ISTAT-IPS	Number of elderly reception services operationalized over the population in the city yearly
Hospital Emigration	Index (SL)	Number of hospital emigrations to other regions for ordinary hospitalization	ISTAT-IPS	Number of hospital migrations operationalized over the population in the city yearly
Childcare	Index (SL)	Number of public and private services for childcare in the city	ISTAT	Number of public and private services for childcare over the population of the city yearly
Health Care	Index (SL)	Number of public and private hospitalization services in the city	ISTAT	Number of hospitalizations operationalized over the population in the city yearly
Health personnel	Index (SL)	Number of employees in public and private hospitals	ISTAT-IPS	Variable operationalized over the population in the total number of private and public hospitals in the city yearly
Job integration	Index (SL)	Number of new residents who work permanently in the city and new residents who found a job in the first six months	ISTAT	Number of workers operationalized over the population in the city yearly
Coworking area	Index (SL)	Number of coworking services	FPA- OECD	Number of coworking services operationalized over the total companies in the city yearly
Education Development	Index (SL)	Number of services implemented in the educational field (public schools, courses, master's)	MIUR	Number of services operationalized over the population yearly
Hospitality seekers and refugees	Index (SL)	Number of receptions of political and needy refugees in the city tutored and reported by the local authorities	SPRAR	Number of refugees operationalized over the population in the city yearly
Online services	Index (DI)	Number of online services in cities	ISTAT	Number of online services in the city operationalized over the population of the city yearly
Broadband access	Index (DI)	Percentage of the population with ADSL access	AGCOM	Standardize over the population yearly to construct a constant variable.
Municipal App	Index (DI)	Municipal App download number (Android)	ISTAT	Number of Download operationalized over the population of the city yearly
Home-banking diffusion	Index (DI)	Number of home-banking users in the city	ISTAT	Number of home banking users over the population of the city yearly
Digital transparency	Index (DI)	Number of Open-Data report related to cities' investments	ANAC	Number of Open-Data operationalized over the total investment of the city yearly
Digital openness	Index (DI)	Number of public access databases	FPA	Number of Public databases operationalized over the population of the city yearly
Public Wi-Fi access-point	Index (DI)	Number of access points in the city	ISTAT - Wifi-Italia	Number of Public Wi-fi access points operationalized over the population of the city yearly
Public Wi-Fi Users	Index (DI)	Number of users of public Wi-Fi in the city	ISTAT - Wifi-Italia	Number of Wi-Fi single access to public Wi-fi operationalized over the population of the city yearly
IoT development	Index (DI)	Investment in R&D and innovation in the city	ISTAT	Number of Investment in R&D operationalized over the population of the city yearly
Population	CV	Descriptive number of the total population in the city yearly	ANPR-ISTAT	Natural logarithm of the variable
GDP	CV	Gross Domestic Product produced in each city in the year n considered	EUROSTAT - ISTAT	Total amount of GDP operationalized over the population of the city yearly
City Size	CV	Size of the city, considering that 300,000 is the threshold between medium and large cities.	ISTAT	Dummy variable structure as (1) cities with a population greater than 300,000 and (0) cities with a lower population
City Development	CV	Cities' economic development considering the GDP per capita. Specifically, less and well economic development is <30.000€ per capita, high development >30.000€ according to the European Commission	ISTAT	Dummy variable structure as: well- and medium-economic developed cities (0) and well-economic developed cities (1)
Out Migration	CV	Total number of residents moving annually from the city taken into consideration to other cities based on registration in the cities' register (ANPR)	ANPR	Number of out residents operationalized over the population of the city yearly
Rental Price	CV	Average annual price per m^2 for rentals in the city	Immobiliare.it	Natural logarithm of the variable
Airports	CV	Total number of airports in cities and nearby areas (50 Km)	Assoaeroporti	Variable operationalized over the population of the city yearly
Employment	CV	Percentage rate of employment in the city (over 30 years)	ISTAT	Variable operationalized over the population of the city yearly
Total Firms	CV	Total number of companies active in the city, based on registration on the Chamber of Commerce	IBS	Variable operationalized over the population of the city yearly
R&D Public	CV	Total amount of public sector investments in R&D in city yearly	ISTAT	Number of total R&D investments operationalized over the population in the city

Legenda: DV (Dependent Variable), Index SL (Smart Living), Index DI (Digital Implementation), CV (Control Variable); Database: ANPR: Anagrafe Nazionale della Popolazione Residente, Assoaeroporti (assoaeroporti.it); ISTAT: Italian National Institute of Statistics; FPA: European Financial Planning Association; AGCOM: Autorità per le Garanzie nelle Comunicazioni; EUROSTAT: Statistical office of the European Union; MIUR: Italian Ministry of University Education and Research; IBS (Italian Business Register); IPS: Sistema Statistico Sanitario; Wi-fi Italia (wifiitalia.com); SPRAR: Protection system for asylum seekers and refugees;

Consequently, for Generation Y, we included data from 2009 onward for individuals born between 1980 and 1994. For Generation Z, we considered data starting from 2014, as this marks the point when the first individuals of this cohort reached adulthood, ensuring consistency in measuring migration patterns. This approach prevents the inclusion of individuals who are too young to make independent relocation choices and allows for a more accurate analysis of generational migration dynamics. Both variables were operationalized based on the net resident population, excluding outgoing residents within the same generation. Structuring the variable in this way allowed us to identify the incremental margin for each generation in the cities under study over the years. To ensure a more consistent and robust analysis, mitigate potential bias values, and facilitate comparisons across different cities, we employed logarithm transformation.

Considering the entire dataset, over the 13 years taken into consideration, there were 3,523,903 new registrations at the registry office for transfer of residence from other cities recorded in the 30 cities considered (326.125 in 2021). Specifically, in the last year considered in our research (2021), there was an average increase of 5.63 % in these cities despite a decrease in Italy's total population. The total registration within the cities under consideration in 2021 is divided as follows: 26 % belonged to Generation Z, 53 % to Generation Y (born between 1980 and 1994), and the remaining 21 % were from Generation X and earlier cohorts (born before 1980). Table A2 in the Appendix, following recent researches (Mejía et al., 2020; Mora et al., 2018), reports the comparative distribution of Smart Living and Digital Advancement across Italian cities. This preliminary evidence illustrates territorial heterogeneity and provides the basis for the generational analysis developed in the subsequent econometric models.

3.2.2. Independent variables

In this research, we consider two independent variables: *Smart Living* and *Digital Implementation*. The first independent variable, *Smart Living,* measures the livability of each city according to the smart city literature (Neirotti et al., 2014; Vanolo, 2014; Vázquez et al., 2018). It encompasses various aspects of urban life, including inclusivity, integrative capacities, and available social services within a human-centered context (Hatuka & Zur, 2020; Tura & Ojanen, 2022). To quantify the *Smart Living* dimension, we constructed an index based on multiple indicators, reflecting diverse variables such as healthcare, childcare, elderly care, education, hospitality, job integration, and working services (refer to Table 1). This selection of variables is grounded in the smart city literature, as the Smart Living dimension represents a comprehensive category that not only encompasses services for citizens and stakeholders but also integrates and supports residents and users in urban development practices (Lytras & Visvizi, 2018; Vanolo, 2014).

The second independent variable, *Digital Implementation*, aligns with the broader concepts of smart cities and the Internet of Things (IoT). It includes technological and urban service practices. To evaluate this variable, we proposed an index based on a set of indicators encompassing variables such as digital openness, public Wi-Fi, home banking diffusion, digital transparency, digital openness, and municipal app usage (refer to Table 1). This variable was constructed based on relevant literature and encompasses not only the technological development of cities but also the perception and adoption of these practices by diverse users and stakeholders (Abid et al., 2022; J. Lee & Lee, 2014; Li & Liao, 2018; Marchesani et al., 2023). For both *Smart Living* and *Digital Implementation,* this research considers an index based on the variables reported in Table 1 based on smart city literature (Caragliu et al., 2011; Kummitha, 2018; Marchesani et al., 2023, 2025) and the policy debate. To construct and validate the robustness of our indices, we applied a Principal Component Analysis (PCA). Following the approach proposed by Bro and Smilde (2014) we conducted diagnostic tests to assess factorability. Specifically, the Kaiser-Meyer-Olkin measure confirmed sampling adequacy (KMO = 0.78 for *Smart Living*; 0.74 for *Digital Implementation*), and Bartlett's test of sphericity was significant at $p < 0.001$ for both indices. PCA retained the first two components with eigenvalues greater than one, which together explained 65 % of the variance for Smart Living and 62 % for Digital *Implementation.* Indicator loadings were consistent in sign and magnitude, ensuring that higher scores represent greater livability or digital advancement. To ensure robustness, we also compared PCA-derived weights with equal-weight indices, finding correlations above 0.90 between the two approaches. Finally, all indices were normalized annually within a [0,1] range and re-standardized to mitigate temporal shifts and ensure comparability across years. This procedure guarantees statistical accuracy and conceptual coherence in capturing the both indices within a specific interval where a value approaching 0 indicates low development and a value nearing 1 signifies high development.

3.2.3. Control variables

In evaluating the model, city characteristics and the urban and economic environment were controlled for based on the existing literature to mitigate potential biases and ensure robust results (Black & Henderson, 1999; Boix & Trullén, 2007; Holmes et al., 2000). Specifically, with regard to city characteristics, the model includes controls for city population, Gross Domestic Product (GDP) per city, and two dummy variables to assess city size and development. To account for the degree of out-migration, the model also considers the number of residents leaving the city each year, as reflected in the city's registration records, and re-registered in another city. Furthermore, we assess the impact of the real estate market on migration to the cities, controlling for the annual cost of renting houses in the cities (Cheung & Yiu, 2022; Vivant, 2013).

In terms of the economic environment, the model considers the employment rate, which is viewed as one of the primary factors affecting migration. In addition, the model controls for the total number of active firms in the city on an annual basis. As further controls, the model incorporates private R&D investments, which are closely associated with urban entrepreneurial development (M. N. Alam et al., 2020; Backman & Lööf, 2015), and the presence of airports as a measure of a city's openness (Gambardella et al., 2009). These controls enable an assessment of the potential influences of both the city and the economic environment on the model.

3.3. Estimation model

In this study, the dynamic Generalized Methods of Moments (GMM) approach is employed. Various estimation techniques, including Generalized Least Squares (GLS), Ordinary Least Squares (OLS), Two-Stage Least Squares (2SLS), and Fixed Effects (FE) or Random Effects (RE) models, are initially considered to analyze the impact of the independent variable and its interaction on the dependent variable. A comparative assessment of these methods reveals the advantages and disadvantages of each technique (Breitung & Salish, 2021; Hooper et al., 2008; Roodman, 2009b). To validate the choice of GMM, several tests are conducted, including the Akaike Information Criterion (AIC) for model selection (Sakamoto et al., 1987). GMM consistently outperforms other methods, displaying lower AIC values and suggesting a better model fit (Hooper et al., 2008). The Hausman test is also performed to compare GMM's efficiency against FE/RE models, confirming GMM's suitability (Bond & Arellano, 2012; Breitung & Salish, 2021). A Heteroscedasticity test reveals that GMM effectively manages heteroscedasticity (Baum et al., 2003).

GMM is selected based on its capacity to address endogeneity, heteroscedasticity, and the dataset's characteristics. The panel dataset includes a broad cross-section (30 cities) and a relatively short time frame (13 years), encompassing both time and city-fixed effects (L. F. Lee & Yu, 2014; Roodman, 2009a; Windmeijer, 2005). Following Roodman's approach, internal instruments from lagged variables are considered to prevent over-identification (Roodman, 2009a, 2009b). Multicollinearity is examined using descriptive statistics, correlations, and the variant inflation factor (VIF) reported in Table 2. With a maximum VIF value below 2.92, the model does not exhibit multicollinearity issues (Akinwande et al., 2015). The stability of the model with multicollinear variables is verified, and the robustness of the results is assessed through diagnostic tests, including endogeneity, autocorrelation, and heteroskedasticity controls, discussed in the results section (Bond & Arellano, 2012; Breitung & Salish, 2021).

Table 2
Correlation Matrix.

	Variables	Vif	Mean	Min	Max	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
[1]	New Residents Z	1.87	0.441	0.235	0.752	1														
[2]	New Residents Y	1.68	0.568	0.198	0.670	–	1													
[3]	New Residents X	1.93	0.129	0.032	0.218	–	–	1												
[4]	Smart Living (SL)	2.41	0.554	0.116	0.886	0.242	0.103	0.098	1											
[5]	Digital Implementation (DI)	2.27	0.632	0.130	0.919	0.187	0.166	0.132	0.376	1										
[6]	Population	3.22	1.434	0.443	2.603	0.231	0.265	0.189	0.212	0.237	1									
[7]	GDP	2.45	1.760	0.558	3.453	0.302	0.354	0.218	0.223	0.284	0.226	1								
[8]	City Size	1.33	0.355	0	1	0.124	0.155	0.173	0.109	0.143	0.201	0.156	1							
[9]	City Development	1.73	0.290	0	1	0.176	0.348	0.277	0.144	0.153	0.332	0.329	0.287	1						
[10]	Out Migration	1.88	0.664	0.293	0.988	−0.214	−0.136	−0.302	−0.278	−0.188	0.238	−0.137	−0.253	−0.217	1					
[11]	Rental Price	3.48	0.525	0.195	0.927	0.125	0.045	0.145	0.432	0.287	0.311	0.195	0.224	0.176	1.087	1				
[12]	Airports	1.93	0.432	0.301	0.837	0.119	0.155	0.132	0.197	0.121	0.182	0.136	0.209	0.194	0.144	0.133	1			
[13]	Employment	1.77	0.765	0.452	0.798	0.130	0.157	0.199	0.215	0.250	0.194	0.166	0.216	0.175	0.170	0.098	0.135	1		
[15]	Total Firms	2.06	0.536	0.317	0.803	0.241	0.221	0.206	0.198	0.234	0.201	0.187	0.154	0.213	0.198	0.214	0.247	0.172	1	
[15]	R&D Investment	1.98	0.671	0.214	0.965	0.175	0.177	0.324	0.255	185	0.412	0.094	0.125	0.166	0.308	0.206	0.182	0.160	0.144	1

3.3.1. *Endogeneity concern*

In this study, several tests were conducted to control for potential endogeneity and assess the stability of the GMM approach. The Roodman GMM dynamic approach was employed, incorporating a one-year lagged-dependent variable as an instrument to test the persistence of the dependent variable (Roodman, 2009c). Diagnostic tests were included to ensure the validity of dynamic GMM estimations. The Sargan test, the Arellano and Bond test, and the Wald Chi-Square test were utilized to ensure the consistency of the GMM model (Magazzini & Calzolari, 2020). The Sargan test was applied to check for over-identification, and the results supported the consistency of the estimates (Sargan, 1958). The Arellano and Bond test was used to control for autocorrelation in the idiosyncratic disturbance term of the model (Bond, 1991; Bond & Arellano, 2012). The application of AR (1) and (2) tests indicated no endogeneity issues affecting the findings. Additionally, the Wald Chi-square test was employed to assess the model's validity and robustness, and it supported the significance of the smart living variable in the model. The results of these tests are presented in Table 3, along with the applied controls. Table A1 in the appendix displays the GMM model for the total number of new residents in the city. The consistency between the test results and model estimations confirms the robustness of the findings and the absence of endogeneity problems.

4. Results

In this section, we highlight the results and corroborate our hypotheses. Before turning to the hypothesis validation and the detailed analyses, we provide a preliminary descriptive exploration of how *Smart Living* and *Digital Implementation* interact with Gen Y and Z within our sample analysis. Across the Italian urban context. Figs. 1 and 2 display the average values of the two indices across the 30 cities in the sample, considering both Generations Y and Z together. These visual insights underline how structural differences across the urban landscape may shape the way younger generations interact with city-level conditions. This step enables us to position Generations Y and Z within their broader urban context before examining in detail how they respond separately to *Smart Living* and *Digital Implementation* in the empirical models.

Table 3 highlights the results from the GMM models. We conducted stepwise robust regressions to determine the empirical model (Agostinelli, 2002), incorporating the primary effects, control variables, and interactions. Model I and V highlight the interaction between the solely dependent variable and independent variables. Model II and VI represent our empirical model estimated with all the controls. Models III, IV, VII, and VIII highlight the interaction between *New Residents (Z* and *Y)* and *Smart Living* and *Digital Implementation*. Finally, Models V and X highlight the interaction between *New Residents (Z and Y)* and *Smart Living*, including the moderating effect of *Digital Implementation* (*SL*DI),* to assess the complementary effect in the model. In performing this process, no significant incongruities were observed in the signs of the relationships, both in terms of direction and strength. For each step, we also monitored the incremental contribution of the added variables.

Models III and VIII provide divergent results in supporting Hypotheses I and II, which assume a direct effect of *Smart Living* practices on *New Residents (Z and Y)* in the city. Specifically, while the parameter for *Smart Living* is positive and partially significant for explaining the relationship with the attractiveness of *Generation Z* ($\beta = 2427$; $p = 0,072$), the relationship with *Generation Y* is positive and statistically significant ($\beta = 3661$; $p = 0,002$).

These results underscore that, although the smart living dimension is influential in the locational choices of *Generation Z*, it represents only a marginal determinant in their migratory dynamics. Conversely, the presence of an advanced urban environment in terms of livability, educational services, social cohesion, a healthy environment, personal safety, and housing strongly influences the migration choices of *Generation Y*. This generation tends to settle in a more advanced citizen-centric smart city. In structuring the variable, the *smart living*

Table 3
GMM results.

	New Resident Z					New Resident Y				
	(I)	(II)	(III)	(IV)	(V)	(VI)	(VII)	(VIII)	(IX)	(X)
New Residents Z ((n-1)	0.322*** [0.155]	0.318*** [0.147]	0.302*** [0.138]	0.311 [0.122]	0.297*** [0.079]					
New Residents Y (n-1)						0.562*** [0.069]	0.573*** [0.071]	0.541*** [0.080]		0.518*** [0.084]
Smart Living (SL)	0.446* [0.223]		0.464* [0.268]		0.488* [0.262]	0.466 [0.286]		0,354*** [0.262]		0.361*** [0.287]
Digital Implementation (DI)	0.255** [0.234]			0.246** [0.252]	0.221* [0.208]	0.315*** [0.232]			0,386*** [0.228]	0.383*** [0.206]
DI*SL	0.213* [0.145]				0.198* [0.173]	0.385*** [0.253]				0.422*** [0.191]
Population		0.902* [0.448]	0.864* [0.437]	0.871** [0.399]	0.786** [0.399]		0.956** [0.416]	0.904** [0.486]	0.889** [0.399]	0.897** [0.424]
GDP		0.644*** [0.243]	0.628** [0.277]	0.632*** [0.253]	0.642** [0.261]		0.534** [0.266]	0.534** [0.282]	0.582** [0.244]	0.546** [0.282]
City Size		−0.236* [0.412]	−0.215 [0.371]	−0,209 [0.348]	−0.241 [0.314]		−0.214* [0.438]	−0.324* [0.388]	−0,316 [0.401]	−0.326* [0.444]
City Development		0.233** [0.214]	0.255** [0.248]	0.305** [0.271]	0.276** [0.212]		0.264** [0.234]	0.308*** [0.222]	0.285** [0.258]	0.286*** [0.189]
Out Migration		0.376** [0.090]	0.377*** [0.079]	0,388*** [0.105]	0.409*** [0.155]		0.556*** [0.246]	0.424*** [0.236]	0,417*** [0.198]	0.422*** [0.242]
Rental Price		0.216* [0.087]	0.305** [0.085]	0,359*** [0.096]	0.467** [0.121]		0.341** [0.206]	0.382** [0.215]	0.341** [0.177]	0.398** [0.188]
Airports		0.199* [0.058]	0.193* [0.065]	0.187* [0.090]	0.179* [0.081]		0.353* [0.096]	0.243* [0.124]	0.266* [0.083]	0.228* [0.082]
Employment		0.087** [0.043]	0.215** [0.067]	0.184** [0.086]	0.211** [0.056]		0.254** [0.063]	0.242*** [0.083]	0.225** [0.079]	0.238*** [0.092]
Total Firms		0.488* [0.070]	0.499* [0.205]	0.370** [0.157]	0.326** [0.236]		0.452** [0.146]	0.466** [0.126]	0.468* [0.161]	0.480** [0.140]
R&D Public		0.325* [0.215]	0.341** [0.277]	0.287** [0.189]	0.375** [0.255]		0.323*** [0.214]	0.364*** [0.236]	0.277** [0.209]	0.366*** [0.248]
City Effect	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Year Effect	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*	*Included*
Warld Chi^2	*147.34*	*154.91*	*153.12*	*151,65*	*159.78*	*172.55*	*178.34*	*173.38*	*771.99*	*183.72*
AR(2)	2.89	2.22	2.53	2.44	2,60	2.77	3.02	3.18	2.98	3.27
P-value	0.105	0.124	0.129	0.109	0.134	0.110	0.119	0.131	0.131	0.129
Hensen Test	44.16	48.94	51.21	50.05	54.59	63.24	65.67	69.14	68.54	70.46
P-value	0.135	0.143	0.184	0.177	0.190	0.174	0.157	0.169	0.155	0.204
N° Observation	210	210	210	210	210	360	360	360	360	360
N* City	30	30	30	30	30	30	30	30	30	30

Legenda: New Residents Z and Y as a Dependent Variable (DV) $p < 0.10$; [Standard errors in parentheses]
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

dimension also considers the job integration of the new residents, which is a primary determinant in migration patterns (Dotti et al., 2013). Thus, we also control for this factor in the model through economic indicators (*Total firms* and *Employment*) to reduce potential biases. These indicators exhibit greater significance for *Generation Y* compared to *Generation Z*.

Models IV and IX support Hypotheses III and IV, which assume a direct effect of *Digital Implementation* on *New Residents (Z and Y)* in the city. Specifically, this finding underscores an intriguing observation regarding urban attractiveness. The parameter for *Digital Implementation* is positively and significantly associated with the urban attractiveness for both *Generation Z* ($\beta = 2989$; $p = 0{,}053$) and *Generation Y* ($\beta = 4078$; $p = 0{,}001$). In particular, an increase in city *digital implementation* positively affects the attractiveness for both *Generation Z* and *Y*. However, it is noteworthy that *Generation Y* is more sensitive to the digital dynamics in cities compared to Generation Z (Dolot, 2018; Eastman et al., 2014; Roth-Cohen et al., 2022). This is surprising given the extensive literature on the close association between Generation Z and technology in society. This observation invites compelling discussions about the possibility that policymakers, governance entities, and smart city technicians, largely belonging to Generation Y, might find it easier to connect to the same generation than to a different (and maybe advanced) one, such as Generation Z.

Finally, Models V and X provide support for Hypotheses V and VI. To test the complementary effect of *Digital Implementation* in the interception between *Smart Living* practices and *urban attractiveness*, we introduced the interaction effect (*Smart Living x Digital Implementation*) for both *Generation Z* and *Y*. Model V shows that the parameter for *Smart Living* directly affects the attractiveness of *Generation Z* ($\beta = 2.158$; $p = 0.068$ and *Generation Y* ($\beta = 3.889$; $p = 0.001$) and the introduction of *Digital Implementation* (*Digital Implementation*Smart Living*) is complementary, positive and statistically significant for the attractiveness of both *Generation Z* ($\beta = 1.978$; $p = 0.070$) and *Generation Y* ($\beta = 2.221$; $p = 0.001$). These results imply that, in this interception, city trajectories may yield a divergent outcome over the years. Initially, it is observed that even though smart living practices have a partially positive impact on Generation Z, the progression of digital implementation only marginally augments the perception of the smart living dimension for them. Contrarily, *Generation Y* is not just positively influenced by the city's smart living dimension (*H2*) and the digital implementation (*H4*), but as posited in *H6,* the urban attractiveness for this generation is intensified in cities with high levels of smart living combined with robust digital implementation. This, in turn, amplifies their perception of the smart living dimension, contributing to enhancing the urban attractiveness of Generation Y users. Figs. 3 and 4 display the incremental effect of the complementarity between *Smart Living* and *Digital Implementation* on the attractiveness of *Generation Z* and *Y*.

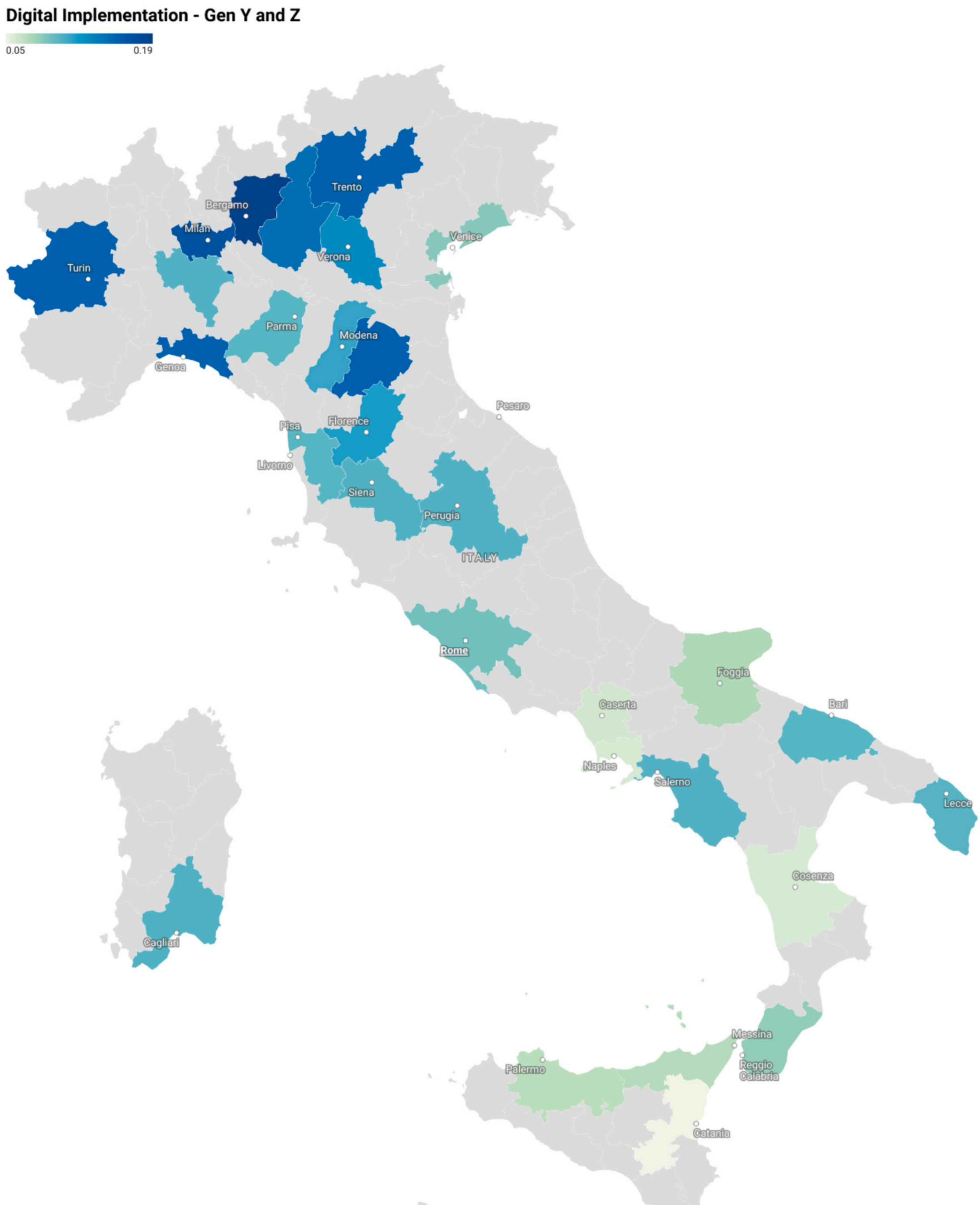

Fig. 1. Choropleth map of the interaction between Digital Technologies and Gen Z & Y.
Note: Authors own elaboration using (https://app.datawrapper.de). Digital Advancement index (average values, 2010–2022) across the 30 Italian cities considered. Darker blue shades indicate higher digital implementation levels in relation to Gen Y and Z. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

These results confirm the existing relationship (and pave the way for future scenarios regarding possible interactions) between Generations Z and Y. This outcome sparks a debate on effectively orchestrating these dynamics in future cities. While it is imperative to consider the positive effects of these practices on the newer generations (Z and Y), there is also a pressing need not to overlook generations less tethered to the technical nuances inherent in smart cities. This further emphasizes the ethical dilemma underlying the development of the current urban environment (Datta, 2015; Datta & Odendaal, 2019; Hollands, 2020).

5. Discussion and conclusion

In a competitive urban arena reminiscent of *Mortal Engines*, cities behave like great moving machines, advancing relentlessly to secure resources, talent, and innovation. They reorganize their structures, upgrade their technologies, and refine their livability features to capture the attention of desirable generations, propelling themselves forward in the global hierarchy. Our results show, however, that this competitive race does not engage all cohorts equally. Generation Z, despite its digital-native status, appears less responsive to technological

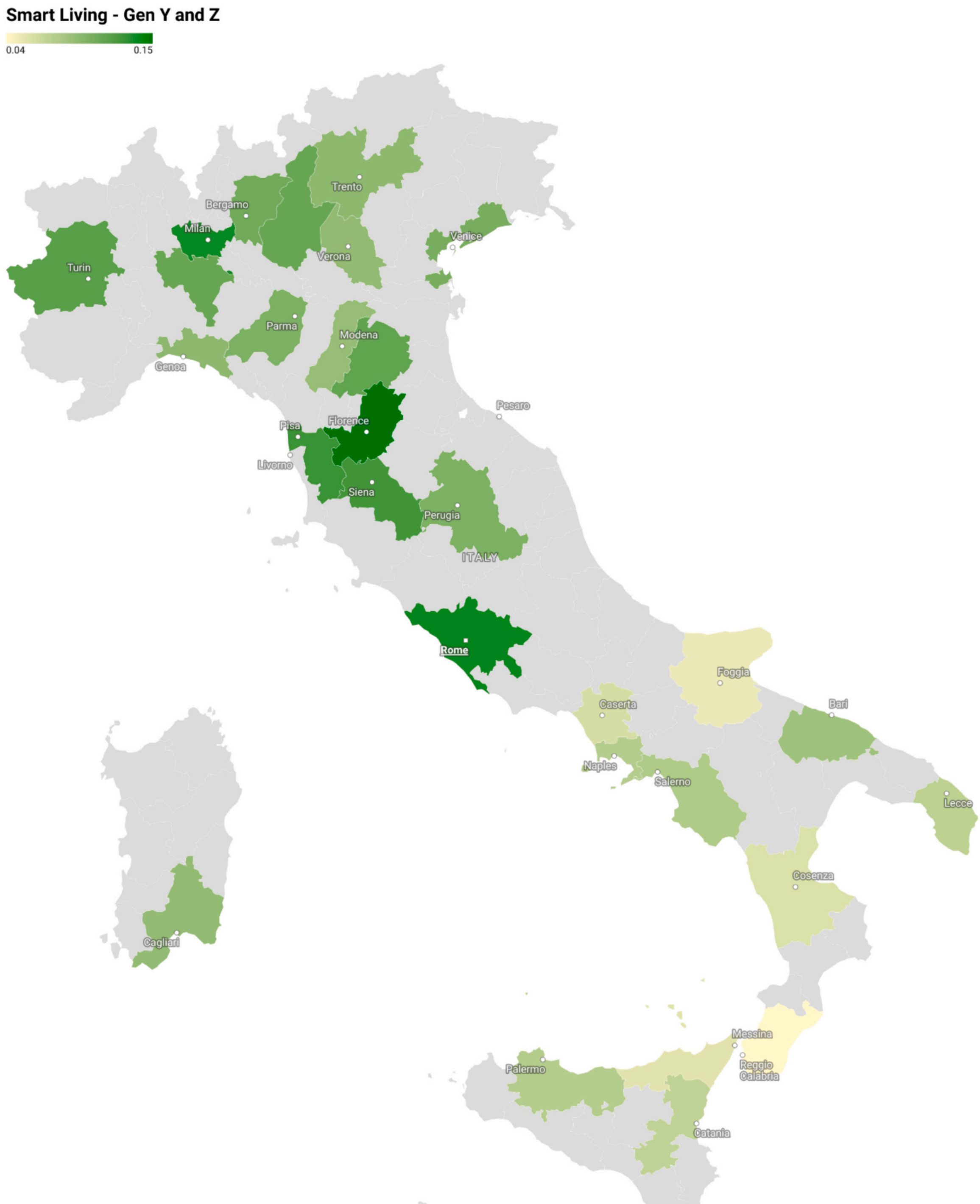

Fig. 2. Choropleth map of the interaction between Smart Living and Gen Z & Y.
Note: Authors own elaboration using (https://app.datawrapper.de). Smart Living index (average values, 2010–2022) across the 30 Italian cities considered. Darker green shades indicate higher Smart Living interaction levels with Gen Z and Y. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

infrastructure and urban livability, perhaps because such features are part of their baseline environment and therefore no longer perceived as distinctive. In contrast, Generation Y matured during the transition from pre-digital to digital society, experiencing urban transformations as an evolutionary process that redefined opportunities in work, education, and social life. Their responsiveness is further explained by the fact that many actors currently designing and implementing smart city strategies (i.e., policymakers, planners, and professionals) belong to (or are closer to) Generation Y, creating a co-evolutionary alignment between policy supply and generational demand.

Since the early 1990s, the evolution of smart living policies has been inseparable from Generation Y, a cohort that has both driven and been shaped by this transformation. This counterintuitive result highlights the importance of considering generational saturation and baseline expectations: while Gen Z may view digital and livability features as standard and take them for granted, Gen Y remains more attuned to

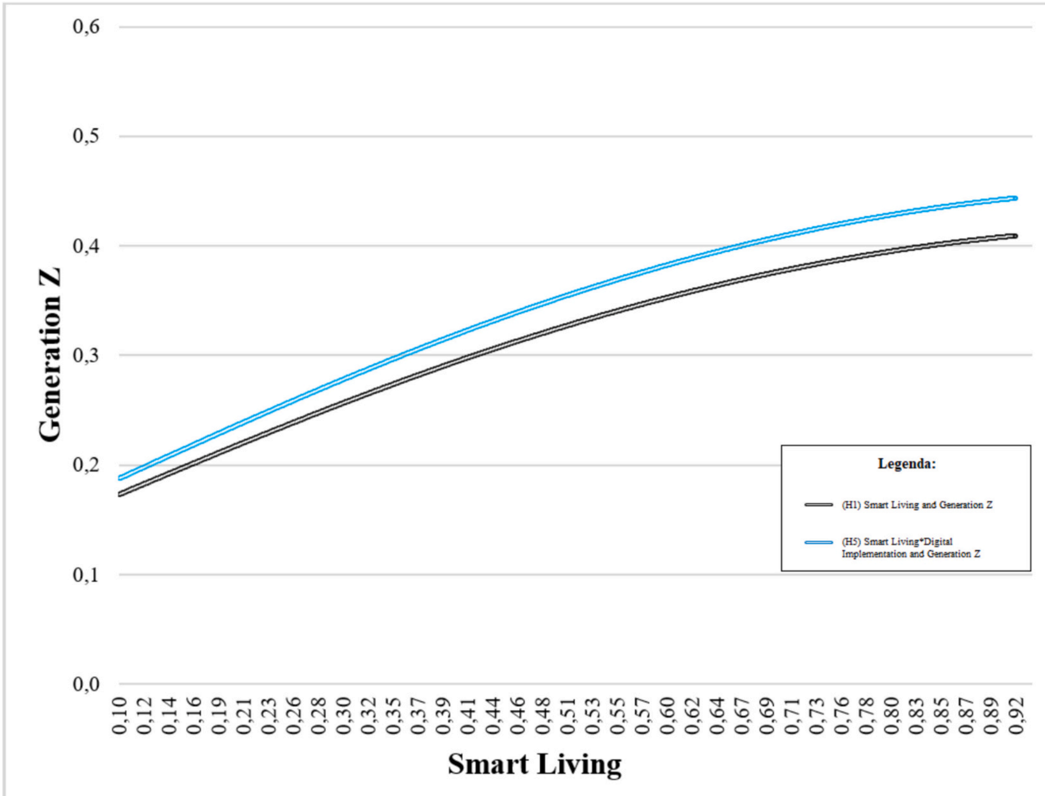

Fig. 3. Interaction between Z generation.

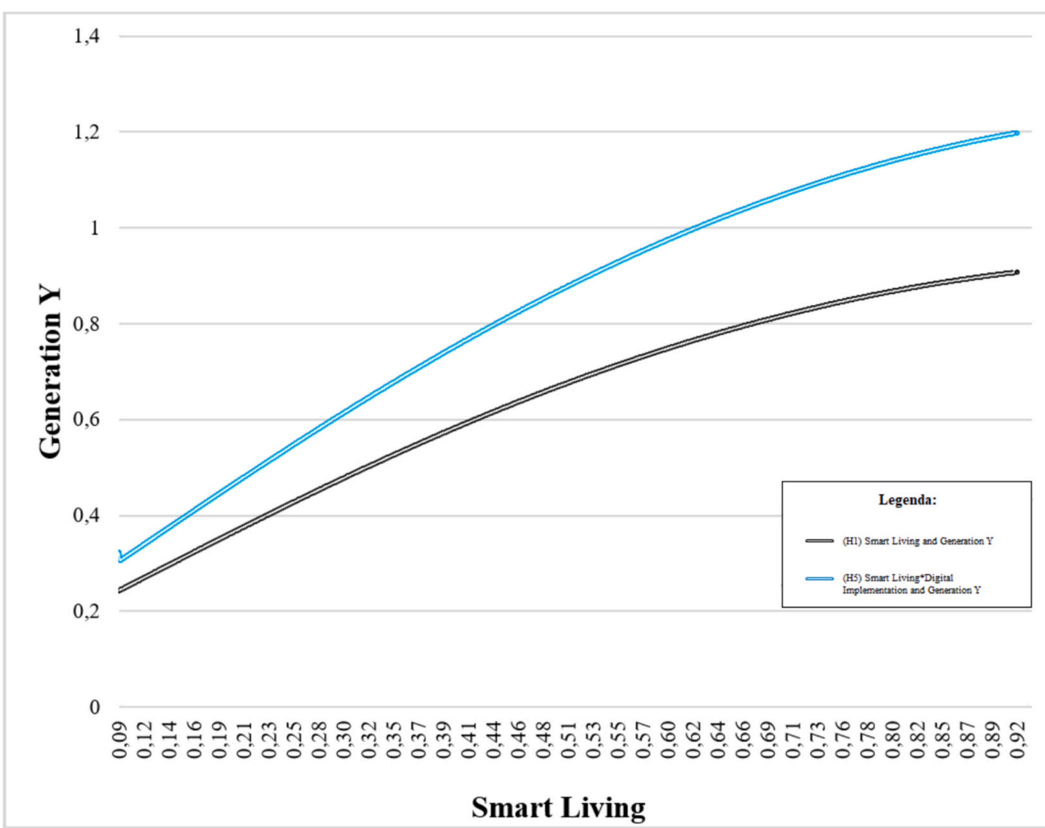

Fig. 4. Interaction between Y generation.

these transitions because they directly shaped their life course. This discourse guides us toward a competitive vision of cities, where the internal evolution of smart cities and their relationship with present and future users influence their dominance over the territory, and where urban policies must adapt to the evolving expectations of younger cohorts (i.e., sustainability or liveability).

It is anticipated that cities will become the primary hubs for people, businesses, and innovation at the expense of rural areas and less developed cities. This perspective of "*city devouring city*" can be seen through the lens of entrepreneurial urbanism (Kummitha, 2018; Wiig, 2016). From a forward-looking perspective, this sees cities competing against each other for resources, growth, and survival, much like companies in the market. This competition might lead to the concentration of resources in successful cities, potentially leaving others struggling or declining, thus accentuating disparities in economic growth and urban development (Datta, 2015; Kummitha, 2018; Taylor Buck & While, 2017). However, this evolution may give rise to a social paradox between competition and inclusivity. On the one hand, the drive for cities to embrace technological innovation and optimize services can foster healthy economic growth, elevate living standards, and attract new generations crucial for long-term vitality (Marchesani et al., 2022, p. 1).

Nonetheless, this race for advancement can inadvertently generate internal tensions and urban imbalances (Appio et al., 2019, p. 12). Two significant issues arise from this paradox. First, as cities evolve as entrepreneurial entities, the inclination to offer the best services to users (citizens) who could generate greater value emerges (Marchesani et al., 2023; Paskaleva, 2009). Nevertheless, a city's essence transcends mere market principles, encompassing inclusivity and social responsibility. Striking a balance between the attractiveness of new generations and upholding the collective inclusivity role of cities becomes a complex ethical predicament. Second, creating a competitive environment where advanced cities obtain more funding and wield greater attractiveness to new generations contrasts with the social, inclusive, and ethical roles cities symbolize (Datta, 2015; Grossi & Pianezzi, 2017; Hollands, 2015). While competition can drive growth, it may widen the gap between prosperous cities and those less equipped, contradicting the principle of equitable urban development. These dilemmas underscore the necessity to reconcile the competitive drive of cities with their responsibilities as societal entities. The challenge lies in fostering innovation and growth while ensuring that the benefits of progress remain accessible to all generations, past and future, within society.

5.1. Theoretical and literature contributions

This study contributes to the theoretical understanding of migration patterns in smart cities by explicitly linking the Push and Pull Theory to the entrepreneurial competition among cities. While traditional applications of the Push and Pull Theory emphasize economic and social factors in migration decisions (Krishnakumar & Indumathi, 2014), we extend this perspective by incorporating the strategic role of smart city initiatives. Specifically, our findings highlight that smart living and digital advancement function as pull factors, attracting new residents, particularly Generation Y, to cities that invest in these dimensions (Gries et al., 2016; Krishnakumar & Indumathi, 2014; Ogamba, 2019). However, these same dynamics may also act as push factors for individuals who do not benefit equally from smart city transformations, reinforcing disparities between digitally advanced cities and those lagging behind. This dual role of urban policies underscores the growing importance of Entrepreneurial Urbanism, where cities strategically orchestrate digitalization and livability to gain competitive advantages in attracting human capital. Future research should further explore how these urban dynamics differentially affect various socio-economic groups beyond Generations Y and Z, integrating additional dimensions of inclusivity and equity within the smart city discourse.

Moreover, this research makes a significant contribution to the existing literature by expanding the exploration of migration patterns into the digital age (Faggian et al., 2017; Faggian & McCann, 2009; Romão et al., 2018), offering new and insightful perspectives on the interplay between generations, digital advancements, and urban development. Additionally, this study advances the research on new generations in society (Cennamo & Gardner, 2008; Liu et al., 2019; McNichols, 2010; Roth-Cohen et al., 2022) by examining their roles from a novel perspective within the context of smart cities. Furthermore, it extends the current discourse on smart cities by addressing both the competitive aspect of smart city development and urban attractiveness (Caragliu et al., 2011; Christofi et al., 2021; Marchesani et al., 2023; Taylor Buck & While, 2017) and contributing to the critical debate surrounding smart cities (Datta, 2015; Datta & Odendaal, 2019; Hollands, 2020). Moreover, the paper delves into the ethical dimensions of technology's role in society (Bakici et al., 2012; Kummitha, 2018, 2020), extending the ongoing ethical and social discussions about the roles of smart city entities within the contemporary societal landscape. Expanding these academic discourses, this paper also contributes to the ethical and ideological discussion centered around the evolution of cities from an entrepreneurial perspective and its ethical implications in society (Datta, 2015; Grossi & Pianezzi, 2017; Kummitha, 2018). This exploration aims to enhance the current understanding of competitive urban dynamics while considering the ethical considerations necessary for the holistic development of cities.

5.2. Practical implications

Cities will host more than 70 % of the world's population by 2050. While this prospect prompts cities to adopt smart city strategies to manage and organize in urban contexts and compete to gain this population, the imperative to establish inclusive smart cities further compels urban planners to create an accommodating environment for all users, regardless of their characteristics. While stakeholders in the city, such as citizens, businesses, and tourists, constitute key factors in urban dynamics and tend to maximize their emerging benefits from a specific urban context, the role of governments and policymakers must transcend mere utilitarian considerations and embrace a more comprehensive and ethically informed perspective.

Specifically, within this evolving and competitive landscape, policymakers must ensure a robust regulatory framework and practical strategies supporting present, past, and future generations (Gagliardi et al., 2017; L. Mora et al., 2023). This research demonstrates smart city strategies' efficacy in enhancing livability and digital advancement and their impact on key migratory categories, such as Generation Z and Y. In this regard, this study provides practical implications and guidance for policymakers and governance entities regarding the impact of this development and the varying sensitivities of different generations.

Policymakers and practitioners should cultivate a comprehensive understanding of how advancements in livability and digital technology foster real engagement with all generations and users (Linde et al., 2021). To achieve this, there is a necessity to expand institutional perspectives to include other generations, both within the city and in response to the external demands of new generations (e.g., Generation Z). The concept stems from the notion that policymakers primarily belong to Generation Y and X and thus may find it easier to create services and connect with Generation Y, which is less digitally advanced compared to Generation Z. Therefore, policymakers and governance bodies should contemplate expanding their internal decision-making structures to integrate emerging generations as internal driving forces and, hypothetically, as future strategic outcomes.

Beyond highlighting generational sensitivities, our results also stress the need for urban governance to move from rhetorical smart city strategies toward actionable policies that balance competitiveness with inclusivity. This implies strengthening coordination among municipal departments, aligning digital investments with housing and mobility policies, and institutionalizing monitoring frameworks to evaluate how *Smart Living* and Digital Advancement translate into real migration outcomes. Such measures would enable policymakers not only to compete for talent but also to ensure equitable urban development across cohorts.

Lastly, amidst these substantial migratory dynamics within cities, the development of urban entrepreneurship, and the escalating competitiveness among cities, the fundamental role of cities as societal hosts should not be overlooked. This perspective transcends mere inter-city competition and necessitates an ethical and inclusive foundation in the development of cities within the present and future society.

5.3. Limitations and future avenues

This work is not without limitations. First, limitations of this analysis stem from the fact that different countries adhere to distinct policies, and there exist varying perceptual disparities among different generations all around the world. Moreover, the creation of the variables pertaining to the smart living dimension and digital implementation, while built on the relevant literature, could be further expanded in terms of depth and levels (e.g., digital services, digital infrastructure, digital adoption). Additionally, we recognize that other relevant smart city dimensions, such as mobility and environmental sustainability, were not included in this study due to data constraints and the study's focus on digitalization and urban livability. Future research could integrate these aspects to provide a more comprehensive understanding of the relationship between smart cities and migration patterns.

Second, relating to generation, the study of generations is rooted in sociological foundations (Mannheim, 1952; Roth-Cohen et al., 2022), and its scope could be broadened to encompass emerging generations with novel investigations, particularly focused on incoming generations like the Boomer and Alpha cohorts. Moreover, numerous factors impact the migration patterns across different generations, such as universities and cultural events for Generation Z and employment integration and economic power for Generation Y. While efforts were made to control the economic and urban environment, it could present limitations in the interpretation of the results.

Third, while our study provides empirical evidence that Generation Y appears more sensitive to smart living initiatives and digital implementation than Generation Z, we acknowledge that this finding may be partially influenced by the temporal structure of our dataset. Since Generation Z's migration behavior is only observed from 2014 onward, it is possible that their long-term preferences for smart city attributes are not yet fully captured. Future research with extended longitudinal data could provide a more comprehensive understanding of generational differences in urban attractiveness.

Fourth, although we consider education development as a factor contributing to urban livability and job integration within the livability variable, a more granular analysis distinguishing between migration for work and migration for education could provide deeper insights. This distinction may be particularly relevant for Generation Z, who may be more strongly influenced by access to higher education. Future research could explore this aspect further to better capture the role of educational opportunities in shaping migration.

Fifth, since our analysis relies solely on the localization of Generations Y and Z as a proxy for urban attractiveness, we also acknowledge that migration patterns may be shaped by diaspora dynamics and return migration flows from abroad, particularly in contexts where cultural and family ties remain strong. These processes could influence how younger generations perceive urban attractiveness and deserve further investigation in future research to complement our longitudinal analysis.

Sixth, while our study provides empirical evidence on the role of digital implementation and smart living in shaping migration patterns, we acknowledge that a quantitative approach has inherent limitations in fully capturing the nuances of smart city initiatives. To deepen our understanding of how smart cities appeal to different generations, future research should integrate qualitative approaches, such as interviews or ethnographic studies, to explore the lived experiences of urban residents and their perceptions of digital services. In this line, while our study relies on an observational panel design, future research could benefit from experimental or quasi-experimental approaches. For instance, comparing cities exposed to specific digital or livability policy interventions with matched control cases would provide a design-based assessment of causal effects. Such extensions would complement our longitudinal findings and enrich the understanding of how Smart Living and Digital Advancement shape generational migration dynamics.

Finally, an expanded ethical exploration of competitiveness and entrepreneurial urbanism should encompass not only economic and technological aspects but also delve into the broader social impact of such policies on the fabric of society. This extended perspective will enable policymakers and urban planners to craft strategies that not only enhance urban competitiveness but also ensure that the resulting progress is equitable, inclusive, and aligned with the collective well-being of diverse generations and the broader community.

CRediT authorship contribution statement

Filippo Marchesani: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Francesca Masciarelli:** Writing – original draft, Data curation, Conceptualization. **Andrea Prencipe:** Writing – original draft, Conceptualization.

Declaration of competing interest

None.

Appendix

Table A1
GMM Results for total new residents.

	New Residents				
	(I)	(II)	(III)	(IV)	(V)
New Residents ((n-1)	0.463***	0.468***	0.472***	0.456***	0.419***
	[0.140]	[0.165]	[0.151]	[0.147]	[0.104]
Smart Living (SL)	0.577*		0.563*		0.502*
	[0.246]		[0.289]		[0.280]
Digital Implementation (DI)	0.303*			0.298*	0.285**
	[0.316]			[0.325]	[0.316]
DI*SL	0.287*				0.253**
	[0.177]				[0.165]

(continued on next page)

Table A1 (*continued*)

	New Residents				
	(I)	(II)	(III)	(IV)	(V)
Population		1.043**	1.015**	0.988**	0.923**
		[0.531]	[0.528]	[0.516]	[0.506]
GDP		0.772***	0.744**	0.752***	0.740**
		[0.243]	[0.277]	[0.253]	[0.261]
City Size		−0.116*	−0.175*	−0,185*	−0.139*
		[0.302]	[0.314]	[0.295]	[0.299]
City Development		0.236**	0.251**	0.301**	0.268**
		[0.233]	[0.227]	[0.224]	[0.218]
Out Migration		0.570**	0.567**	0,523**	0.496**
		[0.125]	[0.119]	[0.131]	[0.130]
Rental Price		0.288*	0.353**	0,361**	0.401**
		[0.109]	[0.099]	[0.093]	[0.105]
Airports		0.292*	0.285*	0.270*	0.283*
		[0.116]	[0.123]	[0.119]	[0.115]
Employment		0.174***	0.162***	0.170***	0.153***
		[0.067]	[0.085]	[0.089]	[0.077]
Total Firms		0.621**	0.610**	0.592***	0.586**
		[0.232]	[0.229]	[0.217]	[0.216]
R&D Public		0.284**	0.271**	0.269**	0.250**
		[0.244]	[0.254]	[0.161]	[0.175]
City Effect	*Included*	*Included*	*Included*	*Included*	*Included*
Year Effect	*Included*	*Included*	*Included*	*Included*	*Included*
Warld Chi^2	*163.28*	*161.75*	*160.15*	*158.64*	*154.59*
AR(2)	2.65	2.48	2.60	2.35	2,71
P-value	0.123	0.134	0.159	0.107	0.115
Hensen Test	41.54	45.92	47.83	49.12	50.33
P-value	0.168	0.151	0.170	0.146	0.190
N° Observation	360	360	360	360	360
N* City	30	30	30	30	30

Legenda: Total new residents as a Dependent Variable (DV) $p < 0.10$; [Standard errors in parentheses].
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table A2
Comparative Distribution.

Geographic Stata	Example	Smart Living (0–1)	DI (avg., 0–1)	Generational flow
Northern metropolitan areas	*Milan, Turin, Bologna*	0.72	0.81	Gen Y > Gen Z
Northern medium/small cities	*Trento, Parma, Bergamo*	0.68	0.74	Balanced
Central cities	*Rome, Florence, Pisa*	0.65	0.69	Gen Y > Gen Z
Southern metropolitan areas	*Naples, Bari, Palermo*	0.55	0.58	Gen Z > Gen Y
Southern medium/small cities	*Cosenza, Lecce, Reggio Calabria*	0.48	0.51	Limited inflows

Note: Values are normalized indices ranging from 0 (lowest level) to 1 (highest level), computed as annual averages for the period 2010–2022. Reported generational inflows (Gen Y, Gen Z) are based on city-level migration data and indicate the predominant cohort in each group of cities. The generational inflow are indicative averages that illustrate the relative heterogeneity across urban contexts prior to the econometric analysis.

Data availability

Data will be made available on request.

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