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The impact of digital technologies and social media on the urban attractiveness of smart cities

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ABSTRACT

Smart city initiatives use digital technologies to enhance user experiences and improve the attractiveness of urban environments. However, little is known about how these technologies influence a city's ability to attract different types of newcomers, and even less about the role of social media in this process. This work examines how a city's use of social media influences the relationship between the effect of digital technology implementation and the urban attractiveness for national and international newcomers. Focusing on three types of national and international newcomers (i.e., citizens, students, and tourists) to a city, we present and test a model of how social media curates, broadcasts, and accelerates information flows about the availability and value of smart city technology to newcomers. Using novel data from 30 Italian cities (2010–2021), we find support for this model, with digital technologies having a curvilinear impact on urban attractiveness, and that social media extends the threshold of this impact. Moreover, we find that these effects differ for national and international newcomers. These findings challenge smart city scholars and practitioners to reconsider the 'more is better' narrative that assumes increasing technology implementation is always beneficial, highlighting instead the value of contingency-based approaches over one-size-fits-all technological determinism.

1. Introduction

Smart cities are high-tech intensive, and advanced cities that connect people, information, and city elements using new technologies to create a sustainable, greener city, competitive and innovative commerce, and increased life quality (Bakici et al., 2012, p. 139). In Europe alone, more than 240 cities with populations exceeding 100,000 are implementing smart city initiatives, and this trend is expected to grow rapidly.[1] These initiatives help to improve urban efficiency, sustainability, and equality (Bakıcı et al., 2013; Caragliu and Del Bo, 2019; Marsal-Llacuna et al., 2015; Vanolo, 2014) and make cities more attractive to users. They use digital technologies such as sensors for real-time monitoring of urban infrastructures, open data analytics to inform strategic decision-making, online services that enhance accessibility to public amenities, and artificial intelligence (AI) to optimize resource management and predict future needs (Masik et al., 2021; Silva et al., 2018). These technologies collect and provide data to deliver more user-centric city services that appeal to citizens, entrepreneurs, students, and tourists (Boes et al., 2016; Hollands, 2020; Kummitha, 2018).

Although the promise of smart cities has been widely discussed, limited empirical research has investigated how digital technologies affect urban attractiveness for national and international newcomers. While related concepts such as citizen engagement (Kummitha, 2024) and digital inclusion (Wiig, 2016) have been explored, urban attractiveness is a broader phenomenon that reflects a city's capacity to attract and interact with external users whose relationship with the city is initiated rather than inherited (Florida, 2003, 2004). In defining urban attractiveness for cities, Florida (2004) highlights that it depends on multiple factors, including urban amenities, the innovative environment, and social integration. However, our understanding of the mechanisms through which digital technologies impact these factors and enhance urban attractiveness is under-theorized and empirically under-examined (Crevoisier and Rime, 2021; Hollands, 2020; Kummitha, 2018).

In our study, we examine how smart city digital technology implementation influences urban attractiveness for such newcomers. This is

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important as these technologies shape first impressions and access to the city (Florida, 2003; Florida et al., 2017). A newcomer's ability and readiness to adopt and interact with digital technologies play a key role in shaping how people in a city perceive, access, and utilize smart city services (Kummitha, 2018). Our study also examines how a city's use of social media influences the relationship between the effect of digital technology implementation and the urban attractiveness for national and international newcomers. We do this because even though social media are frequently integrated into smart city strategies, its effects on helping digital technology to enhance smart city attractiveness have received little empirical attention (Molinillo et al., 2019; Yigitcanlar et al., 2020; Yuan et al., 2020). We argue that three social media mechanisms namely *curation*, *broadcasting,* and *acceleration* (Kietzmann et al., 2011) shape the information flows about the availability and value of smart city technology to newcomers. *Curating* refers to the tailoring of communication and services to newcomers' profiles and needs (Alam et al., 2022); *broadcasting* increases the visibility of digital technologies implementation in smart cities and draws attention from different newcomer groups (Karimikia et al., 2022); and *accelerating* involves the rapid dissemination of real-time information that facilitates engagement with smart city initiatives (Etter et al., 2019). These three mechanisms are realized through various social media platforms that enhance the visibility and perceived usability of digital technologies implementation, promoting the circulation of information and increasing urban attractiveness, particularly for tourists, students, and citizens (Molinillo et al., 2019; Yuan et al., 2020).

In sum, our study focuses on two research questions: *To what extent does the implementation of digital technology in smart cities enhance urban attractiveness for national and international newcomers?* and *How does the adoption of social media platforms by cities affect the relationship between digital technology implementation and urban attractiveness across national and international newcomers?* To examine these questions, we first present a model and hypotheses that unpack the causal effects underlying our research questions. We then test the hypotheses using a dynamic Generalized Method of Moments (GMM) estimation model to analyze longitudinal data (2010–2021) for 30 smart city projects in Italy, a country considered a key test case in Europe for smart city development (Caragliu et al., 2011; Caragliu and Del Bo, 2019). For the first question, we find a curvilinear relationship, with digital technology initially increasing a city's attractiveness to both national and international newcomers. For the second question, we find that social media does enhance the impact of smart city digital technology on a city's attractiveness to both national and international newcomers. Out results, theoretically extend smart city research by reframing digital technology implementation not only as a matter of service efficiency but also as a strategic driver of urban attractiveness, highlighting curvilinear and contingent effects across different newcomer groups. Practically, our results show how cities can leverage social media as a complementary tool to digital technologies, providing policymakers with guidance on how to balance technological advancement and communication strategies to enhance their appeal to both national and international newcomers.

2. Conceptual framework and hypothesis development

2.1. Smart cities: digital technology implementation and urban attractiveness

We define digital technology implementation in smart cities as the use of digital devices, systems, and resources to improve the efficiency of user-city bilateral interactions in a city (Chatfield and Reddick, 2019; Keshavarzi et al., 2021; Mouton and Burns, 2021). These interactions typically involve the city sharing information about itself with users and users sharing information about themselves with the city, so as to help generate user-centric city policies, projects, and services (Abid et al., 2022; Allam and Dhunny, 2019; Goodspeed, 2015; Marchesani and Ceci, 2025). It is widely assumed that these digitally empowered interactions increase a city's urban attractiveness for a specific user: newcomers. Newcomers include citizens who remain long-term (Nesti and Graziano, 2020; Nikki Han and Kim, 2021; Romão et al., 2018), students who stay for the short-medium term (Faggian et al., 2007; Winters, 2011), and tourists who visit short-term (Buhalis, 2020; Romão et al., 2018). However, as Kummitha (2020) and Datta and Odendaal (2019) highlight, the lack of evidence for this assumption about the impact of digital technology on urban attractiveness for newcomers remains a major research gap.

Motivated by this gap, we focus on how digital technology can make cities more appealing to the three newcomer types (i.e., citizens, students, and tourists). We focus on newcomers rather than existing residents as digital technology implementation plays a crucial role in shaping the urban experience of those who approach the city for the first time (Zhu & Alamsyah, 2022). Rather than treating urban attractiveness as a static perception shared by all users, we focus on those for whom digital services act as a determinant of access to the city. We focus on these three newcomer types as they vary in the duration of their stay in the city and share a common dependence on digital technologies to engage with administrative procedures, mobility services, educational platforms, and tourism infrastructure (Hatuka and Zur, 2020; Marchesani et al., 2023; Xu et al., 2024). Digital technology enables the delivery of smart services in transportation, public safety, and waste management (Guo and Zhong, 2022), as well as education (Marchesani et al., 2022), tourism (Shafiee et al., 2021), and administrative interaction (Linders, 2012), thereby enhancing the city's accessibility and attractiveness for both short-term and long-term newcomers. Each newcomer type views these digital solutions as a signal of a city's openness, innovation, and efficiency (Silva et al., 2018; Alruwaie et al., 2020). Furthermore, these newcomer types generate income flows and behavioral dynamics that influence local service demand and digital access (Manitiu and Pedrini, 2016), highlighting their strategic role in the relationship between digital technology implementation and urban attractiveness.

Residents, by contrast, are already located in the city. They form their views of the city by living in it over time, shaped by path-dependency, accumulated knowledge, and social interaction (Hatuka and Zur, 2020; Nakano and Washizu, 2021; Trencher, 2019). While digital technology can also affect their experience, their relationship with urban services is less contingent on first impressions and more resilient to short-term changes (Alruwaie et al., 2020). As Vargas-Sánchez (2020) and Romão et al. (2018) suggest, the expectations of long-term residents and those of newcomers may diverge, particularly when digital systems prioritize visitors' convenience over community stability. For this reason, our focus on newcomers aims to reflect a conceptual boundary examining the urban attractiveness as the ability to generate new inflows (Crevoisier and Rime, 2021; Florida, 2012). This allows us to isolate the mechanisms through which digital technology implementation acts as a driver of urban selection across user types whose interaction with the city is initiated, not inherited (Dezi et al., 2018).

While we assume a link between digital technology implementation and urban attractiveness, we suggest that this relationship rises to a peak and then declines. This is because an excessive focus on digital technology implementation may not be accessible to those newcomers who are not technologically savvy (Hollands, 2020; Kummitha and Crutzen, 2017; Marchesani et al., 2023). For example, when services like transportation or healthcare are accessible only through smartphone apps, populations without access to such technology may be excluded (Secinaro et al., 2022, p. 307). Also, when considering the moderating effect of social media, this technology has a dark side whereby privacy issues and addictive use are concerns for users (Baccarella et al., 2018). Consequently, advancements in digital technology implementation can reach a point where they can exacerbate social inequalities and create a digital divide (Kummitha, 2018), negatively affecting urban attractiveness to both current and potential users (Nakano and Washizu, 2021).

As the impact of digital technology implementation on urban attractiveness will likely vary depending on the type of newcomer interacting with a city's digital technologies, we now explain how the (inter)nationality of newcomers could impact urban attractiveness. National newcomers (i.e., users from within the same country) include domestic students and tourists, and citizens relocating within their country. As they are likely to share the same language and cultural norms as their new host city, this helps facilitate their integration (Thrift and Olds, 1996). For these newcomers, digital technologies serve to access to already familiar services, improving administrative efficiency, transport convenience, or education-related processes (Khatoun and Zeadally, 2016). Thus, digital technologies implementation plays a supporting role in strengthening their embeddedness in the urban ecosystem (Bouzguenda et al., 2022). International newcomers, by contrast, face greater informational and linguistic barriers that amplify their reliance on digital platforms to access basic services, navigate unfamiliar systems, and communicate with the local environment (Ferraris et al., 2020; Jovicic, 2019). For these newcomers, smart city technologies act not only as facilitators but also as enablers of access by mobilizing individuals to adopt new technologies and by shaping newcomers' initial impressions and perceived usability of the city (Nicholds et al., 2017). Features such as multilingual interfaces, mobile-friendly design, and real-time support are particularly important for newcomers (Alam et al., 2022).

This differentiation in underlying mechanisms is particularly relevant when considering that the positive impact of digitalization may not increase indefinitely. Research warns that an overemphasis on technology can lead to exclusionary effects, such as cognitive overload, reduced human interaction, or barriers for digitally marginalized populations (Datta, 2015; Hollands, 2020; Kummitha, 2018; Marchesani et al., 2023). In this line, we expect that digital technology implementation enhances urban attractiveness for both national and international newcomers up to a certain point, after which the perceived complexity or overload of high levels of digitalization may reduce its effectiveness, depending on the origin of the newcomers. Thus, we posit the following hypotheses:

H1. : Digital technology implementation in smart cities is curvilinearly related to urban attractiveness.

H1a. : Digital technology implementation in smart cities is curvilinearly related to urban attractiveness for national newcomers.

H1b. : Digital technology implementation in smart cities is curvilinearly related to urban attractiveness for international newcomers.

2.2. Social media platforms and smart city urban attractiveness

The role of social media in shaping smart city urban attractiveness has been the subject of mixed findings in the literature. On one hand, a wide body of studies has emphasized its potential for smart cities to enhance visibility, participation and users' responsiveness (Kumari et al., 2020; Yuan et al., 2020; Zhou and Wang, 2014) allowing smart cities to enhance social and digital perceptions of place and model human activities, ultimately enhancing the impact of digital technologies (Yuan et al., 2021, p. 130). On the other hand, several critical works point to the limited capacities of local governments to adapt their social media strategies to diverse populations, especially international newcomers (Molinillo et al., 2019; Wiig, 2016; Yigitcanlar et al., 2020).

In the context of smart cities, social media platforms such as blogs, social networking, applications, and multimedia sharing services are used to strengthen relationships with users and establish a direct institutional channel for communicating initiatives and activities (Yuan et al., 2020). This strengthening happens as these highly interactive platforms allow individuals and communities to share, co-create, discuss, and modify user-generated content, helping users and their data feed into smart city technologies (Kietzmann et al., 2011; Yuan et al., 2020). Focusing on newcomers, we propose that a smart city's use of social media platforms will positively moderate the impact of digital technologies implementation on urban attractiveness in three ways.

First, social media acts as an interface layer that *curates* digital policy communication by enabling cities to tailor information and services to newcomers' specific characteristics and needs (Alam et al., 2022; Reddick et al., 2017), affecting the engagement and adoption of other smart city digital technologies. For example, social media is useful for sharing and collecting information on the needs of residents and newcomers, such as access to government services and programs (Alruwaie et al., 2020). Social media can provide newcomers with personalized information about public transportation, healthcare, and education services tailored to their location, preferences, and demographics. At the same time, it helps build and maintain a lasting connection with residents and newcomers over time (Alam et al., 2022; Bonsón et al., 2015).

Second, social media platforms serve as a *broadcasting* infrastructure, spreading awareness about smart city digital technologies. Specifically, social media is often the first channel that newcomers use to interact with a city (Karimikia et al., 2022, p. 9). For example, students who are particularly attuned to social media and digital technologies are more inclined to use these platforms as primary sources for news and information, expecting rapid and personalized content. Consequently, cities utilize trending social media platforms to enhance student engagement and provide access to essential information, thereby fostering better interactions with this demographic (Bal et al., 2015; Benneworth and Herbst, 2015). In this sense, *broadcasting* amplifies visibility and initial newcomer engagement with smart city technology.

Third, social media platforms *accelerate* the flow of information by pushing updates in real time and fostering dynamic interactions with newcomers (Etter et al., 2019; Molinillo et al., 2019; Yuan et al., 2020). Almost instantaneously, social media can collect and cater to the immediate information needs of different newcomers on things such as city transportation, cultural events, attractions, and operations (Boivin and Tanguay, 2019; Uşaklı et al., 2017; Yuan et al., 2020). For example, due to the short-term interaction, utilizing social media enables governments to offer tourists personalized, location-based information, thereby enriching their experience and promoting tourism while also fostering improved communication between governments and tourists (Buhalis and Amaranggana, 2016; Vu et al., 2019). This acceleration role amplifies the effect of digital technologies implementation by fast-tracking interactions between newcomers and smart city services, thereby strengthening the link with urban attractiveness.

Taken together, these *curating, broadcasting*, and *accelerating* mechanisms suggest that social media can positively moderate the impact of digital technologies on urban attractiveness. However, we suggest this impact has limits. This is because cities can often fail to effectively use social media to address the diverse languages, behaviors, and cultural needs of international newcomers (Alam et al., 2022; Guillamón et al., 2016; Molinillo et al., 2019; Yuan et al., 2020). For instance, Molinillo et al. (2019, p. 247) examined engagement in Spanish cities and found that social media platforms such as Facebook, Twitter, and Instagram were used only at a basic level. These cities faced communication and branding challenges that limited the effectiveness of their communication strategies in conveying smart city features to international newcomers (see: Kumari et al., 2020; Yuan et al., 2020; Zhou and Wang, 2014). Consequently, we suggest social media will likely have a stronger impact on how digital technologies enhance urban attractiveness for national newcomers who already share the local language and culture. In contrast, international newcomers may face linguistic and cultural barriers that can limit the extent to which social media strengthens the positive relationship between digital technology implementation and urban attractiveness. (Etter et al., 2019; Molinillo et al., 2019; Wiig, 2016; Yigitcanlar et al., 2020). Therefore, while social media generally has a positive influence, its effect varies depending on newcomers' origins. Thus, we hypothesize:

H2. : The adoption of social media platforms by cities positively affects the relationship between digital technology implementation and urban attractiveness.

H2a. : The adoption of social media platforms by cities positively affects the relationship between digital technology implementation and urban attractiveness for national newcomers.

H2b. : The adoption of social media platforms by cities positively affects the relationship between digital technology implementation and urban attractiveness for international newcomers.

Fig. 1 is the model for all the hypotheses in our study.

3. Methodology

3.1. Sample and data collection

We used a panel-dataset created by merging primary and secondary data from national and international sources to construct the variables and test our hypothesis. National sources include AGCOM, ANPR, IBS, NSC, ISTAT, MIUR, WifiItalia.it, and Assoaeroporti.it, while international sources comprise Booking.com, FPA, and EUROSTAT. Regarding primary data, to construct the *Social Media* and *Museum and Events* variables, data were retrieved from the official websites of each municipality and historically reconstructed using the Wayback Machine, following a retrospective procedure detailed in Section 3.2.2. Table 1 provides a comprehensive overview of all variables used in the model, including their descriptions, sources, and operationalization.

The sample of analysis is 30 Italian cities over 12 years (2010–2021), selected to ensure equal representation across the territory and guarantee the heterogeneity of the sample of analysis. The sample is characterized by medium and large cities, as well as cities with varying levels of economic development, categorized based on territorial identity considered in NUTS3[2] in the European Union policies. Specifically, to ensure the equal distribution and representativeness of the sample, we apply the probability-proportional-to-size sampling population (Levy and Lemeshow, 2008). Using this method, we selected 30 cities based on three factors: localization (South, Center, and North), city size (medium and large), and economic status (economically developed or in transition). This stratified sampling approach captures the diverse characteristics of cities within the country, thereby improving the representativeness and applicability of our results across different types of cities and accounting for the heterogeneity of cities within the reference context. Moreover, the Italian context is currently considered a relevant test case in the smart city debate (Vanolo, 2014, p. 884) and constitutes an empirical focus for prominent discussions considering the relationship between smart city implementation, citizens, and stakeholders (Caragliu et al., 2011; Grossi and Pianezzi, 2017; Vanolo, 2014). In addition, this context of analysis meets the current competitive driver in smart city literature, mainly focused on Europe and North American countries, and represents a central context to evaluate city attractiveness and urban competitiveness in terms of incoming users and citizens (Christofi et al., 2021, p. 961; Taylor Buck & While, 2017).

We used two types of indices (Composite and Herfindahl-Hirschman index) that weigh the value of individual variables and ensure the homogeneity of the variables in constructing our model and their suitability with our model approach. Table 1 describes the variables, highlighting their description, source, type of variable, and operationalization.

3.2. Estimation model

Given the nature of our sample, which includes time series with cross-sectional data, our approach started from panel data estimations to assess the dynamics of the model (Bond and Arellano, 2012). This approach allowed us to handle the principal issues embedded in panel data, such as constant unobserved heterogeneity (city-specific differences that do not change over time) and endogeneity concerns (Bond and Arellano, 2012; Elhorst, 2003). To handle this issue, we considered the lagged term of the dependent variable and estimated our regressions using a dynamic Generalized Method of Moments (GMM). This method generated consistent and efficient estimates of the parameters of interest, allowing us to control the lagging effect and reduce possible endogeneity concerns (Roodman, 2009; Windmeijer, 2005). Moreover, GMM estimations allowed us to statistically control for lagged values of the dependent variable, heteroscedasticity, and autocorrelation (Roodman, 2009). In doing so, GMM estimations provided a general framework within which to take into account possible statistical inference (Lee and Yu, 2014). Further tests, econometric concerns, and robustness tests are presented in the "*results*" section to guarantee the robustness of our results.

3.2.1. Dependent variable

To construct the *urban attractiveness* variable (and sub-variables *national-* and *international* urban attractiveness), we considered the distribution of incoming *Citizens, Students,* and *Tourists* yearly to aggregate a set of values into a single summary value, operationalizing it on both a single city and an overall sample of the analysis. Specifically, building on a set of databases (ISTAT, MIUR, and ANPR), we measured the distribution of different types of newcomers from other cities and regions (*national*), and countries (*international*) to a specific city to assess the urban attractiveness over the year. This methodology allowed us to accurately capture the dynamic movement of various newcomers within and outside the country and provided insights into the local and temporal distribution patterns of different newcomers. By aggregating these distributions, we quantified the yearly urban attractiveness of a city. Detailed procedures and the specific metrics used in constructing this variable are elaborated in Table 1. In considering the dynamic distribution of newcomers, we also controlled *citizens'* and *students' outflow* to other cities, including these variables as controls in the model. Fig. 2 highlights the (i) distribution of our sample analysis and (ii) a map of the mobility network (inflow and outflow), useful to visualize the dynamics of our dependent variable built using a mapping approach. The creation of this index allowed us to quantitatively measure the urban attractiveness over 12 years and build a unit of measurement representing the movement of newcomers at national and international levels.

3.2.2. Independent variables

The independent variables are *Digital Technologies Implementation (DTI)* and *Social Media. DTI* interacts as an explanatory variable, and *Social Media* as an interaction variable. *DTI* measures a city's deployment of digital infrastructure and services to enhance the efficiency, accessibility, and responsiveness of its operations and user interactions, in line with smart city principles (Caragliu and Del Bo, 2019; Kummitha, 2020). Specifically, *DTI* reflects how digital technologies are implemented to manage and deliver public services, enable citizen access to information, and optimize urban systems (Gil-Garcia et al., 2016; Mora et al., 2023). For this variable, we constructed a composite index comprising nine variables (see Table 1) covering *Online Services, Broadband Access, Public Wi-Fi, Municipal APP, Home-banking diffusion, Digital transparency, Digital Openness, Social public administration,* and *IoT Development*. This multidimensional approach aligns with prior literature (Abid et al., 2022;

[2] NUTS 3 is a classification of territorial units used by the European Union for statistical purposes. It stands for "Nomenclature of Territorial Units for Statistics" and refers to the third and lowest level of territorial classification within the NUTS hierarchy. They are often used in research and policy analysis to understand regional disparities and the impact of policies at a more local level, as highlighted by the European Union. Source: https://ec.europa.eu/regional_policy/sources/studies/regions_indust_trans_en.pdf.

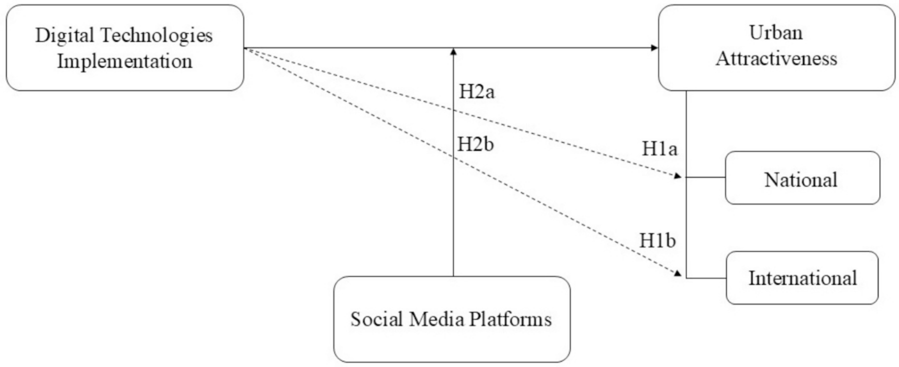

Fig. 1. Model of the impact of smart city digital technologies implementation on urban attractiveness.

Bakici et al., 2012; Kontokosta and Johnson, 2017; Marchesani et al., 2023), allowing us to quantitatively assess the digital technologies implementation in smart cities. From this index, we measured the variable, firstly, by standardizing the measurements to ensure homogeneity across the variables. Secondly, we tested the standardization to evaluate the stability of the measures within the index, such as standardizing with z-scores. Thirdly, we aggregated comparative values using the means to assess the index based on the variables considered. This process produces an index that ranges [0,1], where values close to 0 indicate a low level of DI and values close to 1 indicate a high level of DI in each city annually. Finally, to assess the construction of our index, we also tested this measure using two econometric approaches (Principal Component Analysis and Sensitivity Analysis) that confirm our variable's stability. Those additional tests are not reported in the manuscript but are available from the authors upon request.

To measure the interaction variable considered as the cities' adoption of *Social Media* platforms, we considered primary data collected through a retrospective (Wayback Machine)[3] that enabled us to reconstruct the adoption of social media in the cities over the years. Through this software, we collected and recorded the official social network platforms implemented in each city from 1 January 2010 to 31 December 2021. In doing this, we applied the following procedure. First, we identified the social network proposed by each city by only considering the social media accessible through the official website of the municipalities to guarantee methodological rigor. Second, we only considered the social media platforms that emerged from our sample analysis (Facebook, YouTube, Instagram, TikTok, LinkedIn, Twitter (now called X), Telegram, and Medium). Therefore, important social media platforms such as WeChat, VKontakte, and Snapchat were excluded from this analysis as they were not used by any city under examination. Ultimately, using the Wayback Machine, we went back yearly to the past and retrieved data on the social network platforms following the previous procedure, starting from 1 January 2010 to 31 December 2021 to quantitatively assess the social network adoption over the years. Finally, to construct the *Social Media* adoption variable, we implemented the Herfindahl–Hirschman concentration index (HHI), which was useful for measuring the homogeneity/heterogeneity of social media platforms adopted by each city over the years. Low values implied a heterogeneous adoption of social networks focusing on multiple platforms. Otherwise, high values of the variable indicated homogeneous use of digital platforms, focusing mainly based on a few well-established platforms.

[3] The Wayback Machine, (also known as the Internet Archive), is a digital archive of the World Wide Web and other digital content. It allows users to access archived versions of websites, including those that have been taken down or changed over time. *Source: https://archive.org*.

3.2.3. *Control variables*

To minimize the potential impact of urban, economic, and human capital differences on the results, controls are included at each level of aggregation. For human capital-specific control, due to the interaction with the dependent variable, we control for *population*, *students outflow, and citizens outflow* (Greenwood and Sweetland, 1972; Winters, 2011). *Population* measures the population registered in the city yearly, *student* and *citizens* outflow are two variables derived from the mobility mapping used to construct the dependent variable and aim to capture the outmigration of each city. *Student outflow* quantifies residents relocating to other cities for university enrollment, while *Citizen Outflow* the number of residents moving out of their current city and registered in the ANPR of the destination city. For the economic-specific control, the model includes Gross Domestic Product (*GDP*), *public R&D investment, private R&D investment*, *total companies,* and e*mployment rate* (Black and Henderson, 1999; Holmes et al., 2000). As economic development acts as a catalyst for attracting human capital and knowledge, these controls are crucial in evaluating urban attractiveness and preventing possible biases in the model. Finally, urban-specific differences include *airport* and *museums and events. Museums and events* consider the number of museums, temporary exhibitions, and art galleries annually that affect the tourism and visitors' inflow in the city. The variable is based primarily on ISTAT data, and supplemented by Booking.com, which was used to identify and verify *museum and events* available in each city. Using Booking.com's "*Attractions*" section, we retrospectively collected event-related data from January 1st to December 31st of each year in the city using WayBack Machine. Finally, *airport* variable considers airport (s) located in the city in the neighboring (50 Km) area. This variable, according to Florida (2004) and Gambardella et al. (2009), serves as a proxy for urban openness and reflects structural conditions that facilitate the inflow of newcomers. This control allows us to account for differences in cities' baseline attractiveness related to their openness orientation.

Table 1 presents a detailed description of each variable concern, and Table 2 presents the descriptive statistics and correlations among our variables. While most correlations remain below conventional thresholds (0.700), we note three relatively high values: *public R&D investment* and *DTI* (0.704), *Social Media* and *DTI* (0.677), and *public R&D investment* and *Social Media* (0.612). We performed Harman's single-factor test, which confirmed that no single factor accounted for the majority of the variance, further mitigating concerns about common method bias or collinearity. However, in line with best practices for addressing common method bias (Podsakoff et al., 2003), we acknowledge that Harman's single-factor test is only diagnostic and does not fully exclude the risk. For this reason, we combined multiple strategies. First, we complemented the test with VIF calculations (all <4), which indicate that multicollinearity is not a concern. Second, we re-estimated the models by excluding potentially correlated variables as highlighted before, finding stable signs and significance across specifications. Together,

Table 1
Variables construction.

Model	Variable	Source	Description	Operationalization
DV - DVa	Regional Citizens Incoming	ANPR	Number of new residents from other cities within the same region registered annually at the city's ANPR.	This variable is operationalized based on the city's yearly population.
DV - DVa	National Citizens Incoming	ANPR	Number of new residents from other regions registered annually at the city's ANPR.	This variable is operationalized based on the city's yearly population.
DV - DVb	International Citizens Incoming	ANPR	Number of new residents from other countries registered annually at the city's ANPR.	This variable is operationalized based on the city's yearly population.
DV - DVa	Regional Students Incoming	MIUR - NSC	Total number of university students moving into the city from other cities within the same region annually.	This variable is operationalized based on the total number of students in the city yearly.
DV - DVa	National Students Incoming	MIUR - NSC	Total number of university students moving into the city from other regions annually.	This variable is operationalized based on the total number of students in the city yearly.
DV - DVb	International Students Incoming	MIUR- NSC	Total number of university students moving to the city from other countries annually.	This variable is operationalized based on the total number of students in the city yearly.
DV - DVa	National Tourism Incoming	ISTAT	Total number of tourists from the same county (domestic tourism) annually.	This variable is operationalized based on the total number of tourists in the country yearly.
DV - DVb	International Tourism Incoming	ISTAT	Total number of tourists from other countries (International tourism) annually.	This variable is operationalized based on the total number of tourists in the country yearly.
IV -(Index)	Online services	ISTAT	Total number of online services proposed by the city on the municipal website per year	Natural logarithm of the variable.
IV -(Index)	Broadband access	AGCOM	Percentage of families who have access to ADSL	Natural logarithm of the variable operationalized over the population in the city per year.
IV -(Index)	Municipal App	ISTAT	Municipal App download number per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	Home-banking diffusion	ISTAT	Number of users who utilize home banking in the city per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	Digital transparency	ANAC	Number of public data concerning the investments of the city per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	Digital Openness	FPA	Total number of public access databases in the city per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	Social public administration	FPA	Variable based on engagement, productivity, and use of public online services in the city per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	Public Wi-Fi	ISTAT Wifi-italia.it	Variable based on the number of access points, quality of service, and communication in the city per year.	Natural logarithm of the variable over the population in the city.
IV -(Index)	IoT development	ISTAT	Total amount of investments in IoT and ICTs in the city per year.	Natural logarithm of the variable over the population in the city.
IV - HHI	Social Media	Website	Official Social networks adopted by the city yearly to provide official information through Social Media.	Herfindal-Hirschman Index (HHI) based on the number of social networks implemented by the city.
CV	GDP	EUROSTAT - OECD	Gross Domestic Product produced in each city yearly.	This variable is operationalized based on the city's yearly population.
CV	Population	ANPR	Descriptive number of the total population in the city yearly.	This variable is operationalized based on the country's yearly population.
CV	Students outflow	MIUR - NSC	Number of students moving out of their current city to enroll in university courses in other cities annually.	This variable is operationalized based on the total number of students in the city yearly.
CV	Citizens Outflow	ANPR	Number of residents moving out of their current city and registered in the ANPR of the destination city.	This variable is operationalized based on the city's yearly population.
CV	Public R&D Investment	ISTAT	The total amount of public sector investments in R&D in the city yearly.	This variable is operationalized based on the city's yearly population.
CV	Privare R&D Investment	ISTAT	The total amount of private sector investments in R&D in the city yearly.	This variable is operationalized based on the city's yearly population.
CV	Total Companies	IBS	Total number of companies active in the city, based on registration on the Chamber of Commerce.	This variable is operationalized based on the city's yearly population.
CV	Employment	ISTAT	Percentage rate of employment in the city (over 30 years).	This variable is operationalized based on the city's yearly population.
CV	Airports	Assoaeroporti	Total number of airports in cities and nearby areas (50Km)	This variable is operationalized based on the city's yearly population
CV	Museum and Events	ISTAT Booking.it	Total number of museums, temporary exhibitions, and art galleries in the city.	This variable is operationalized based on the city's yearly population.

Sources: ANPR: *(Anagrafe Nazionale della Popolazione Residente)*; AGCOM: (*Autorità per le Garanzie nelle Comunicazioni*); IBS *(Italian National Business Register)*; NSC (*National Students Clearinghouse)*; IBS (*Italian Business Register*); ISTAT (*Italian National Institute of Statistics*); MIUR *(Ministry for Education, University and Research)*; FPA *(European Financial Planning Association*); Assoaeroporti.it, Booking.com, wifi-italia.it, EUROSTAT: (*Statistical office of the European Union*).

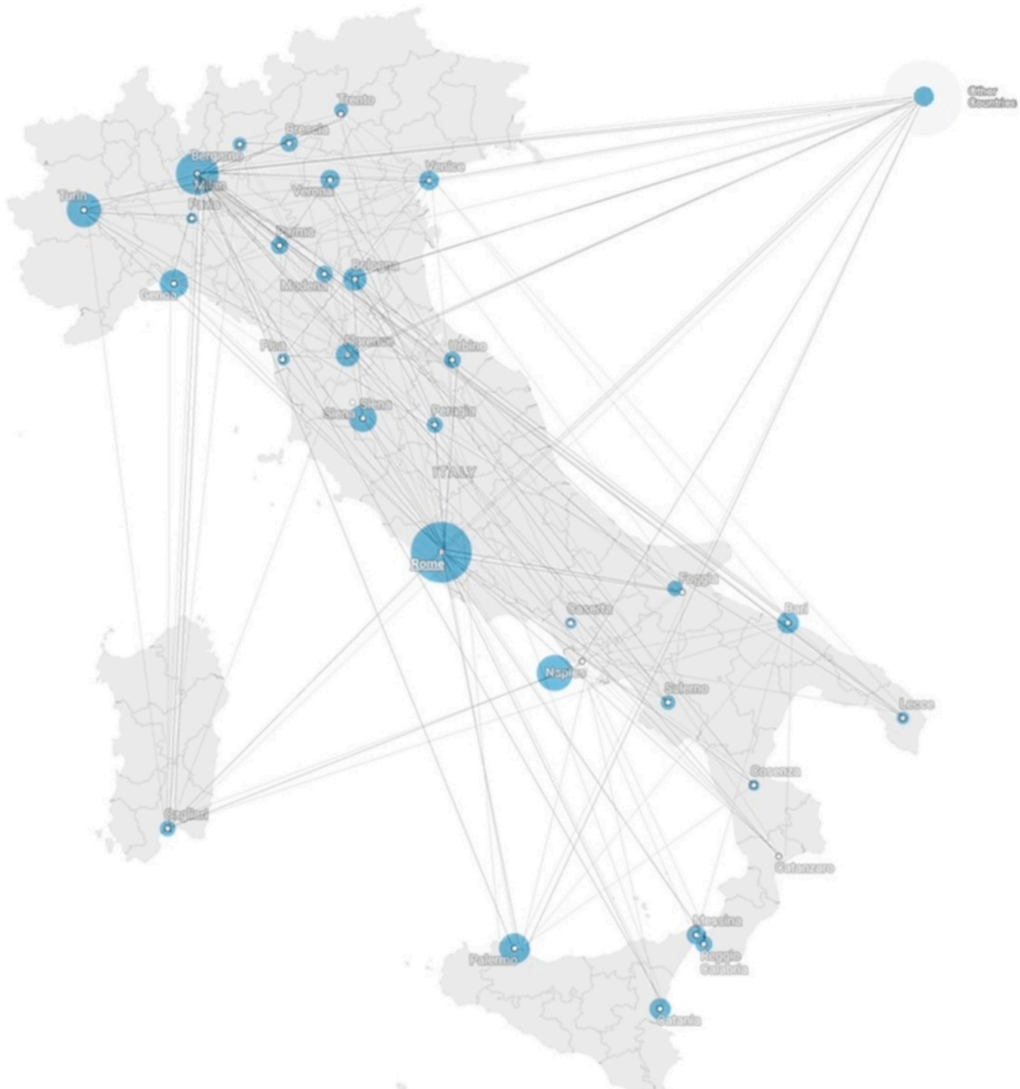

Fig. 2. Sample distribution and mapping mobility.

these checks strengthen the robustness of our results and mitigate concerns about overlap between constructs.

4. Results

Tables 3 and 4 present the results from the GMM approach. To estimate the empirical model, we used a robust stepwise regression, we progressively adding main effects, controls, and interactions. Model I includes only the lagged dependent variable and independent variables. Model II adds the control variables to the baseline specification. Model III incorporates Digital Technology Implementation (DTI) and its squared term (DTI^2) to test the main and curvilinear effects (H1). Model IV extends the estimation by adding the interaction terms (Social Media × DTI and Social Media × DTI^2) to test the moderating effect (H2). Finally, Table 4 distinguishes national and international newcomers. Models V–VI test H1a/H1b, while Models VII–VIII test H2a/H2b by introducing the interaction with Social Media at the group level. In following this process, no significant incongruence was found regarding relationship signs and strength in both estimation models (Tables 3 and 4). Moreover, to facilitate the interpretation of effect sizes and significance levels, standardized coefficients (β) and exact *p*-values for the main models are reported in Appendix Table A1 and Table A2.

In testing the hypotheses, we first examine test H1, considering the overall relationship to assess the interaction between *DTI* and *urban attractiveness*. Model III in Table 3 shows that the parameter for *DTI* is positive and significant for explaining *urban attractiveness* ($\beta = 0.411$; $p = 0.002$), showing that digital technologies implementation in cities contributes to urban attractiveness in the city by offering an advanced and customized environment (J. Lee and Lee, 2014). Also, *DTI* ^{2} is statistically significant but highlights a negative effect ($\beta = -0.169$; $p = 0.036$), showing that the perception of incoming users increases for a proper level of *DTI* in the city up to a certain point, after which the level of digital technologies implementation becomes too high. Passing this point, digital technologies implementation loses its effect on incoming users, becoming a mere technological advancement, and, consequently, the effect on urban attractiveness diminishes. Fig. 3 displays the effect estimations presented in Model III. Specifically, it shows that the point where digital technologies implementation in cities has negative consequences for urban attractiveness is at 0.618 (tipping point) on the *DTI* scale (maximum score is 0.921).

Based on the previous results, we proceeded to hypothesis testing. Specifically, the results diverge considering H1a and H1b, showing interesting and opposite results.

While the effect of *DTI* on both *national* ($\beta = 0.371$; $p = 0.001$) and *international urban attractiveness* ($\beta = 0.237$; $p = 0.001$) is positive and statistically significant (Model V and VI in Table 4), the parameter for

Table 2
Descriptive statistics and correlations.

	Variables	Vif	Mean	S.D	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]
[1]	Urban Attractiveness (UA)	–	0.221	0.443	1														
[2]	UA - National	–	0.198	0.309	–	1													
[3]	UA - International	–	0.052	0.254	–	–	1												
[4]	DTI	1.96	0.664	0.329	0.263	0.251	0.289	1											
[5]	Social Media	1.96	0.253	0.452	0.155	0.173	0.218	0.688	1										
[6]	GDP	4.19	3.765	0.886	0.341	0.402	0.267	0.359	0.433	1									
[7]	Population	3.21	2.639	0.775	0.112	0.165	0.098	0.298	0.361	0.677	1								
[8]	Students outflow	3.01	0.098	0.198	0.098	0.056	0.012	0.117	0.329	0.231	0.326	1							
[9]	Citizens Outflow	2.23	0.216	0.153	0.388	0.401	0.194	0.155	0.294	0.255	0.406	0.088	1						
[10]	Public R&D Investment	2.88	0.778	0.451	0.375	0.298	0.403	0.704	0.612	0.221	0.254	0.115	0.124	1					
[11]	Privare R&D Investment	3.32	0.542	0.303	0.128	0.127	0.135	0.402	0.212	0.187	0.134	0.084	0.097	0.144	1				
[12]	Total Companies	4.11	1.753	0.179	0.233	0.359	0.144	0.232	0.105	0.542	0.327	0.116	0.226	0.246	0.622	1			
[13]	Employment	3.23	0.233	0.155	0.195	0.245	0.098	0.125	0.067	0.412	0.278	0.057	0.301	0.118	0.231	0.532	1		
[14]	Airports	2.21	0.176	0.642	0.093	0.085	0.112	0.092	0.045	0.154	0.077	0.105	0.154	0.119	0.108	0.112	0.093	1	
[15]	Museums and Events	2.68	0.268	0.388	0.122	0.093	0.157	0.054	0.148	0.221	0.252	0.199	0.142	0.092	0.141	0.142	0.143	0.412	1

DTI^2 assumes different effects, providing interesting findings. While *DTI^2* confirms the negative effect on *national urban attractiveness,* showing a negative and statistically significant parameter (β =0.203; p = 0.013), supporting our hypothesis *H1a* (Model V). Instead, a reverse curvilinear effect for *international urban attractiveness* is not supported in Model VI, highlighting that international newcomer incoming increases with digital technology implementation in the city, and the effect of an excessive digital technology implementation does not diminish this interaction. This result is in line with the current debate about digital technologies implementation in cities (Caragliu and Del Bo, 2019; J. H. Lee et al., 2013; Vanolo, 2014) but also contributes to the critical perspective of smart city cities concerning being digital- rather than user-centric (Datta and Odendaal, 2019; Hollands, 2008; Kummitha, 2018, 2020).

In testing our hypotheses H2, we refer to Table 3 for the overall evaluation considering urban attractiveness for both national and international newcomers. The results highlight that considering the interaction effect of *Social Media*, the tipping point translates up to the previous level, increasing the relationship between *DTI* and *urban attractiveness* (model IV). This evidence supports the H2 since introducing the interaction effects (*Social Media*DTI* and *Social Media* DTI^2*), the parameter for *Social Media* DTI* is positive and statistically significant for urban attractiveness (β =0.168; p = 0.004), and the parameter *for Social Media*DTI^2* is negative and statistically significant (β =0.114; p = 0.024), providing support for the existence of complementarity effect of the cities' adoption of social media platforms in this relationship. Specifically, digital technology implementation affects urban attractiveness up to a certain point, after which it loses its effects. However, the city's adoption of emerging social media trends can extend this relationship, shifting the point of decline while amplifying the effect of digital technologies implementation, driving the tipping point from 0.618 to 0.763.

Interestingly, the effect of social media diverges for *national* and *international urban attractiveness.* Specifically, introducing the interaction effects for both national (*H2a*) and *international* (*H2b*) levels of newcomers, the results differ, leading to a double interpretation. Model VI shows that the parameter for *Social Media*DTI* is positive and statistically significant for *national urban attractiveness* (β =0.358; p = 0.001), highlighting how social media amplifies the effect of *DTI* on *national urban attractiveness,* increasing user perception. Moreover, since the parameter for *Social Media* DTI^2* is still negative and statistically significant (β =0.176; p = 0.022), confirming the positive effect of social media adoption in the city amplifies the effect of the previous relationship (confirming a decrease of the curvilinear effect but extending the tipping point). Fig. 4 presents the graphical representation of the effect of the *social media variable* in the relationship, showing that it contributes to advancing the strength of the interaction and extending the tipping point in the *DTI* scale (the graph is based on the estimations in Model VII). Contrary, Model VIII does not support *H2b* as the effects of *social media* on the interaction between *DTI* and *international urban attractiveness* are null or minimal in contributing to extending the effect of digital technologies implementation on international users. The graph in Fig. 5 displays the effect of *social media* on the interception between *DTI* and *international urban attractiveness,* showing that social media diminishes the amplitude effect with respect to the national user. As for *H1b*, no statistical significance emerges for a curvilinear relationship, including this effect, in line with the previous results. Taken together, these findings suggest that the effect of cities' adoption of social media platforms provides generalized positive outcomes considering different levels of users in line with the current literature (Mariani et al., 2016; Molinillo et al., 2019; Yuan et al., 2020). However, this finding also reveals a lack of connection with international, highlighting a null or marginal effect contributing to the debate on the generalized effect of social media on city policies (Engelbert et al., 2019; Karimikia et al., 2022; Reddick et al., 2017).

Table 3
GMM results - urban attractiveness as a DV.

	Model I		Model II		Model III		Model IV	
	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e
Urban Attractiveness (n-1)	1.519***	[0.061]	1.766***	[0.036]	1.498***	[0.064]	1.361***	[0.058]
DTI	0.872***	[0.378]			0.766**	[0.316]	0.712**	[0.321]
DTI ^{2}	−0.332**	[0.176]			−0.253***	[0.098]	−0.246**	[0.106]
Social Media	0.258***	[0.231]			0.244***	[0.016]	0.235***	[0.197]
Social Media* DTI	0.175**	[0.269]					0.168**	[0.244]
Social Media* DTI ^{2}	0.108**	[0.286]					0.113*	[0.234]
GDP			1.332***	[0.134]	1.165***	[0.131]	1.099***	[0.136]
Population			0.778**	[0.426]	0.756**	[0.434]	0.741***	[0.451]
Students outflow			0.184*	[0.301]	0.177	[0.312]	0.168*	[0.309]
Citizens Outflow			0.451**	[0.358]	0.402**	[0.360]	0.399**	[0.364]
Public R&D Investment			0.183***	[0.317]	0.165***	[0.321]	0.164***	[0.316]
Privare R&D Investment			0.125**	[0.113]	0.118*	[0.119]	0.120**	[0.114]
Total Companies			0.884*	[0.269]	0.792	[0.273]	0.788*	[0.281]
Employment			0.305*	[0.538]	0.288*	[0.544]	0.281*	[0.547]
Airports			0.108**	[0.192]	0.098**	[0.186]	0.093**	[0.188]
Museum and Events			0.269*	[0.196]	0.214*	[0.191]	0.206**	[0.187]
Year Effects	*Included*		*Included*		*Included*		*Included*	
City Effects	*Included*		*Included*		*Included*		*Included*	
Adjusted R^2	0.051		0.068		0.073		0.074	
AR(2)	1.69		1.73		1.75		1.80	
P-value	0.109		0.110		0.129		0.142	
Sargan Test	44.68		47.12		51.76		55.08	
P-value	0.662		0.735		0.791		0.731	
N° Observation	330		330		330		330	
N* City	30		30		30		30	

*Urban attractiveness as a DV. Digital Technology Implementation (DTI) as a IV. Significance level: *p < 0.05; **p < 0.01; ***p < 0.001. Robust standard errors in brackets. VIF (variance inflation factor) < 4. Arellano–Bond AR (2) is used to look for possible autocorrelation issues. Sargan test is used to look for possible over-identification restrictions in the model. The number of observations is reduced for the leg effect (−1).*

4.1. Endogeneity

To assess the results emerging from the GMM estimation, a set of controls and tests are included as proxies to guarantee the robustness of the results. First, the dynamic panel data approach with a two-step system GMM and timing control for the dependent variable reduces the influence of possible unobserved heterogeneity and endogeneity issues (Roodman, 2009; Windmeijer, 2005). Then, both Sargan and Arellano-Bond (2) tests are performed to control autocorrelation and over-identification issues (Bond and Arellano, 2012; Sargan, 1958). The Sargan test shows that all models in Tables 3 and 4 are unaffected by autocorrelation since the results meet the 95 % significance level. Next, we considered Arellano-Bond to control for autocorrelation in the idiosyncratic disturbance term. The control revealed that the range GMM estimation for *urban attractiveness* (AR(2) between 1.68 and 1.90) and *national* and *international* urban attractiveness (1.38 to 1.87) are not affected by autocorrelation (Bond and Arellano, 2012; Magazzini and Calzolari, 2020; Windmeijer, 2005). These results are consistent with the GMM estimations, confirming that our results do not appear to be driven by data disturbance and model estimation issues (Roodman, 2009).

5. Discussion

Our study demonstrates that digital technology implementation in smart cities enhances urban attractiveness for both national and international newcomers, though with curvilinear limits. While benefits for national newcomers peak beyond a certain threshold, international newcomers continue to gain from advanced digitalization. Social media amplifies these effects, particularly for national newcomers, by extending the tipping point of digital technologies' positive impact. These results challenge the "*more is better*" assumption in smart city research and highlight the need for differentiated, user-centric strategies. In doing so, our work advances the smart cities discourse and practice by showing how technology and communication tools interact to shape urban appeal across newcomer types. We now discuss some implications of these findings for research and practice.

To the best of our knowledge, our study is the first to provide strong empirical evidence that supports the widely held assumption and expectation that there is value in investing in smart city initiatives (e.g., Buhalis, 2020; Caragliu et al., 2011; Marchesani et al., 2023; Romão et al., 2018). Theoretically, this is important as it suggests extending and connecting the scope of research on smart cities from focusing on service efficiency outcomes to the resulting urban attractiveness. In other words, our findings suggest theoretically reframing the value proposition of smart city technology from being predominantly about infrastructure and systems optimization to also being about strategic positioning in the competition for mobile talent and population growth. For leaders of smart city initiatives, reframing aligns with the need to justify the substantial initiative investment. For instance, it is estimated that 100 European cities with an average population of 100,000 would need to invest €96 billion in digital technology to help achieve climate neutrality by 2030.[4] Thus, if this investment enhances urban attractiveness for both national and international newcomers, it will be due to a range of quality-of-life benefits, amenities, and infrastructures tailored to these users. Such effects are worthy of future research investigations. For example, how do different types of newcomers perceive increased urban attractiveness? Studies could examine potential causes, such as personalized digital experiences and the strategic use of data analytics to understand and anticipate newcomer needs. These approaches enable cities to offer tailored services and experiences, thereby increasing their attractiveness to various national and international newcomers.

A second major implication from our findings the limited impact of smart digital technology on urban attractiveness obliges smart city scholars to refine their theoretical assumptions about the role of digital technology. By identifying curvilinear relationships (i.e., null or even diminishing returns at high levels of digital technology

[4] Source: European Court of Auditors. (2023/24). Smart City Report 2023/24. Commissioned by the European Union, p. 36. Retrieved from https://www.eca.europa.eu/ECAPublications/SR-2023-24/SR-2023-24_EN.pdf.

Table 4
GMM results - national and international urban attractiveness as a DV.

	Model I		Model II		Model III		Model IV		Model V		Model VI		Model VII		Model VIII	
	National UA		International UA		National UA		International UA		National US		International UA		National AU		International UA	
	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e	Coeff.	s.e
National UA (n-1)	1.212***	[0.106]			1.206***	[0.036]			1.188***	[0.106]			1.088***	[0.055]		
International UA (n-1)			0.358***	[0.052]			0.326***	[0.036]			0.321***	[0.052]			0.312***	[0.058]
Digital DTI	0.775**	[0.331]	0.512**	[0.244]					0.687***	[0.291]	0.488***	[0.237]	0.599***	[0.230]	0.421***	[0.321]
Digital DTI ^{2}	−0.265***	[0.125]	−0.169	[0.138]					−0.185**	[0.121]	−0.155	[0.131]	−0.176**	[0.124]	−0.146	[0.106]
Social Media	0.204**	[0.268]	0.288***	[0.199]					0.218***	[0.256]	0.269*	[0.201]	0.244***	[0.199]	0.251*	[0.197]
Social Media* DTI	0.139***	[0.201]	0.151*	[0.206]									0.127***	[0.174]	0.109*	[0.206]
Social Media* DTI ^{2}	0.115**	[0.243]	0.098	[0.257]									0.112*	[0.253]	0.063	[0.257]
GDP					1.269***	[0.152]	1.113***	[0.268]	1.215***	[0.160]	1.008***	[0.231]	1.096***	[0.155]	1.029***	[0.236]
Population					0.632**	[0.486]	0.404**	[0.375]	0.611**	[0.477]	0.396**	[0.334]	0.737***	[0.435]	0.721***	[0.241
Students outflow					0.155*	[0.362]	0.139*	[0.255]	0.184*	[0.371]	0.127*	[0.267]	0.171*	[0.296]	0.119*	[0.269]
Citizens Outflow					0.427**	[0.318]	0.421**	[0.601]	0.418**	[0.321]	0.412**	[0.581]	0.381**	[0.333]	0.387**	[0.562]
Public R&D Investment					0.204***	[0.296]	0.196***	[0.436]	0.199***	[0.217]	0.184***	[0.436]	0.151***	[0.321]	0.173***	[0.412]
Privare R&D Investment					0.116**	[0.134]	0.212**	[0.231]	0.108**	[0.124]	0.203*	[0.216]	0.111**	[0.098]	0.201**	[0.230]
Total Companies					0.895*	[0.288]	0.443*	[0.266]	0.876*	[0.291]	0.398	[0.270]	0.753*	[0.248]	0.385*	[0.255]
Employment					0.323*	[0.546]	0.132*	[0.413]	0.316*	[0.530]	0.117*	[0.488]	0.265*	[0.531]	0.181*	[0.476]
Airports					0.129**	[0.216]	0.443**	[0.532]	0.110**	[0.206]	0.412**	[0.496]	0.103**	[0.212]	0.393**	[0.462]
Museum and Events					0.274*	[0.204]	0.451*	[0.277]	0.259*	[0.198]	0.439*	[0.282]	0.197**	[0.163]	0.279**	[0.271]
Year Effects	*Included*		*Included*		*Included*		*Included*		*Included*		*Included*		*Included*		*Included*	
City Effects	*Included*		*Included*		*Included*		*Included*		*Included*		*Included*		*Included*		*Included*	
Adjusted R^2	0.063		0.039		0.068		0.041		0.074		0.045		0.077		0.049	
AR(2)	1.38		1.71		1.47		1.73		1.52		1.78		1.60		1.87	
P-value	0.106		0.129		0.111		0.136		0.114		0.137		0.120		0.143	
Sargan Test	50.89		63.23		52.16		65.63		55.98		67.55		58.47		69.23	
P-value	0.612		0.553		0.620		0.563		0.648		0.577		0.689		0.584	
N° Observation	330		330		330		330		330		330		330		330	
N* City	30		30		30		30		30		30		30		30	

*National and International Urban Attractiveness (UA) as a DV. Digital Technology Implementation (DTI) as a IV. Significance level: *p < 0.05; **p < 0.01; ***p < 0.001. Robust standard errors in brackets. VIF (variance inflation factor) < 4. Arellano–Bond AR (2) is used to look for possible autocorrelation issues. Sargan test is used to look for possible over-identification restrictions in the model. The number of observations is reduced for the leg effect (−1).*

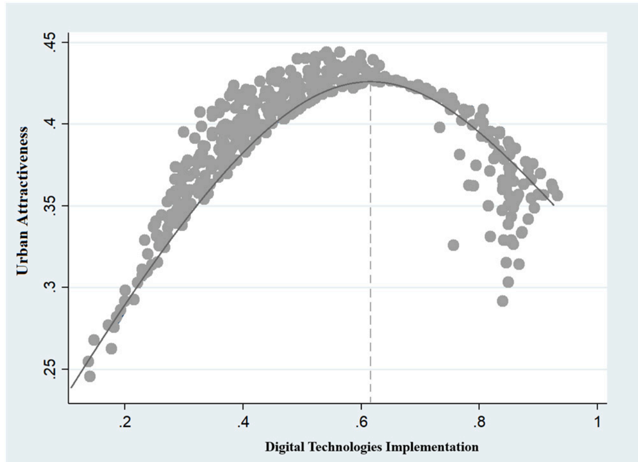

Fig. 3. The inverted U-shaped relationship between DTI and UA.

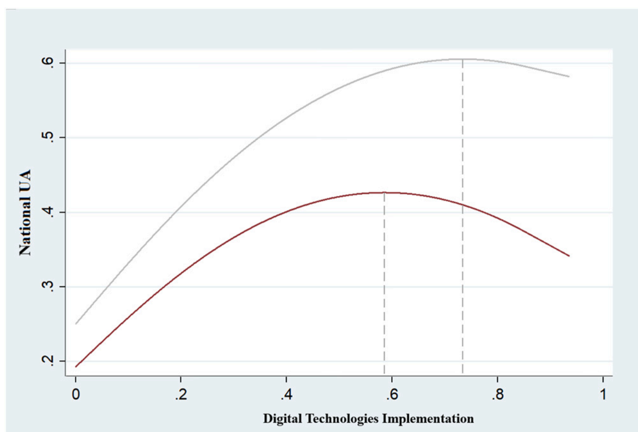

Fig. 4. Interaction effect of social media in the relationship between DTI and National UA.

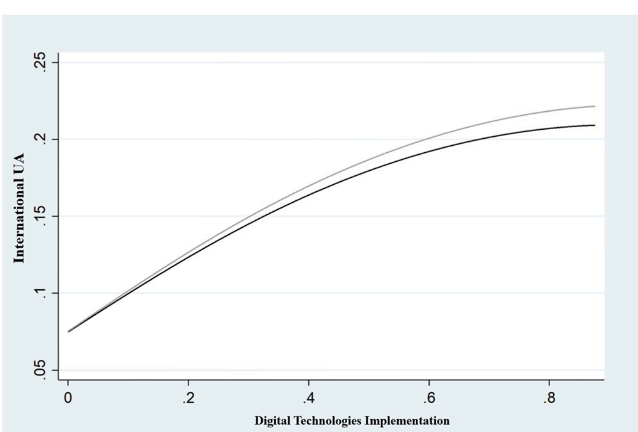

Fig. 5. Interaction effect of Social Media in the relationship between DTI and International UA.

implementation), our study challenges the linear-progress narrative often implicit in smart city research — that more technology is always better. Furthermore, the threshold level for the relationship varies with the newcomer type, with it being higher for international newcomers. This finding is consistent with the view that, at some point, technology investments driven by national and European policies for smart cities may become misaligned with newcomer needs, nullifying their positive effect on the urban environment (Datta and Odendaal, 2019; Kummitha, 2018; Vanolo, 2014). This misalignment might arise more likely with national newcomers encompassing all age groups, including those less technologically adept. In contrast, international newcomers (especially students and tourists) might have higher technological readiness or different expectations, making them more receptive to more advanced digital technologies implementations.

Future studies could investigate potential solutions to help this alignment, which represents a significant source of funding dispersion. The potential for a stronger positive effect on international urban attractiveness signals the need for strategies that better align smart city initiatives with the expectations of diverse newcomer types. Additionally, the limits of the attractiveness curve for national newcomers warn of potential repercussions in urban dynamics. Therefore, future research could explore how aligning urban development with the needs of both national and international newcomers, and balancing technological investments with user-centric strategies, can mitigate negative impacts and further enhance urban livability and attractiveness. Also, future research could theorize and study the possibility that international newcomers, relative to national newcomers, have a greater tolerance for the risks of digital services, as the benefits to them are greater. In other words, our results about different newcomer types encourage contingency-based theorizing rather than one-size-fits-all technological determinism.

A third major implication is that our results extend the emerging literature on social media and smart cities (Karimikia et al., 2022; Molinillo et al., 2019; Yuan et al., 2020) by showing that social media's impact goes beyond institutional contexts and is significantly influenced by the distinction between national and international newcomers. Social media has this impact by broadcasting, curating, and accelerating the availability and benefits of digital technology implementation for newcomers, but more significantly for national newcomers than for international ones. One explanation for this result is that city social media and national newcomers share language, culture, and social networks. This finding has significant implications for leaders of smart cities, who should consider cross-national differences by implementing tailored strategies that address the distinct needs of various newcomer types. Moreover, social media should be viewed as a complementary strategic tool for promoting smart city practices due to its potential to engage a broad and diverse audience (Yuan et al., 2020; Zhou and Wang, 2014). In fact, in January 2023, the European Commission, through the PNRR (National Recovery and Resilience Plan),[5] included social media platforms and cities' communication in the policymakers and municipalities' activities, which must be (for the first time) included in the reporting budget. For researchers, this highlights the importance of exploring the cultural dimensions in smart city strategies, particularly in the context of social media engagement. Practitioners, on the other hand, are encouraged to tailor their social media strategies to address these cultural variances, ensuring that their initiatives are inclusive and effectively resonate with both national and international audiences.

Together, these implications from our results highlight the necessity of shifting from policy- and technology-driven approaches to a more business-oriented strategy, characteristic of an entrepreneurial vision (Krivý, 2018; Kummitha, 2018; Mora et al., 2023; Wiig, 2016). In practical terms, this approach underscores the need for city administrators and public managers to adopt strategies that not only consider digital and social media implementation but also integrate cultural nuances and digital engagement preferences of both national and international newcomers. By doing so, cities can enhance their attractiveness and efficacy as *urban enterprises*, effectively balancing the dual goals of economic development and inclusive, culturally sensitive urban management. These findings carry significant implications for practitioners since they emphasize the necessity of designing initiatives that are inclusive and responsive to the varying needs of different newcomer types, thereby elevating their impact in urban dynamics.

This study has some limitations that are also worthy of future research. First, our analysis focuses only on Italy. Even though the Italian empirical context is both appropriate and important for generalizing insights to the European Union and to North America (Christofi et al., 2021; Vanolo, 2014), future research could benefit from considering a sample of different countries to generalize the findings in different geographical areas and a smart city approach (Guo and Zhong, 2022; Irazábal and Jirón, 2021).

Second, like many empirical studies, the variables are reasonable but indirect proxies for complex constructs such as digital technologies implementation and urban attractiveness. While our composite index captures relevant infrastructural and service dimensions, it may not fully reflect qualitative aspects such as usability, inclusivity, or actual user adoption. Future research could improve construct validity by incorporating user-level data, survey-based measures, or behavioral indicators to assess both policy responsiveness and user responsiveness more directly.

Third, the measurement of urban attractiveness relies on inflows of students, tourists, and new residents, which may also reflect broader mobility dynamics not necessarily driven by smart city technologies. While this approach aligns with our theoretical framing of attractiveness as the capacity to generate new inflows, future research could use primary data (e.g., interviews or surveys) to investigate users' motivations and perceptions, thereby disentangling digital-driven attractiveness from general movement patterns.

Fourth, the study focuses on newcomers (students, tourists, and citizens) as the primary users affected by digital technologies implementation. Although this focus is consistent with our definition of urban attractiveness as the ability to attract external users, it excludes long-term residents whose evaluation of the city may be shaped by accumulated experiences and retention factors. Future work could investigate how digital services influence resident satisfaction, loyalty, and long-term engagement to provide a more holistic view of urban attractiveness.

Fifth, while our analysis defines urban attractiveness as the city's capacity to attract newcomers, it does not directly account for levels of engagement or participation once these users are integrated into the urban environment. Although attractiveness and engagement are conceptually distinct (one capturing inflow, the other interaction), future research could explore how digital technologies not only attract but also sustain participation and civic involvement over time, especially among different user groups. This would help clarify the continuum between attraction and long-term urban integration.

Sixth, an important limitation of this study concerns the operationalization of social media. While our measure based on the Herfindahl-Hirschman Index (HHI) captures institutional adoption and diversification of platforms, it does not fully capture the three functional mechanisms theorized such as curating, broadcasting, and accelerating. Future research could advance this line of inquiry by differentiating platforms according to their dominant functions (e.g., Instagram for broadcasting, LinkedIn for curating, Twitter/X for accelerating) and by incorporating indicators of user engagement, content type, and sentiment. Such an approach would allow a closer alignment between the theoretical model and the measurement of social media dynamics in smart cities.

Moreover, in line with the previous point, our operationalization considers platform presence rather than the level of actual user engagement or content interaction. Therefore, future research could more directly investigate this relationship, focusing on the use of social media as a strategic tool for cities to gain a competitive advantage in the smart city competition worldwide, contributing to the discussion about the entrepreneurial urbanism place in contemporary cities (Karimikia et al., 2022; Kummitha, 2018; Molinillo et al., 2019; Wiig, 2016).

Finally, the adoption of artificial intelligence (AI) technologies in smart cities offers fertile ground for academic inquiry into their effects on urban attractiveness. For example, how might the prediction capabilities of AI technology produce hyper-segmented and hyper-personalized communication and digital strategies that enhance visibility, engagement and interaction (Marchesani and Testa, 2026). Also, the risks that come with AI warrant research attention for their impact on urban attractiveness. For example, how might inappropriate algorithmic bias (Kordzadeh and Ghasemaghaei, 2021) and '*botshit*' (Hannigan et al., 2024), result in AI enabled smart city information that lacks integrity, that then adversely impacts urban attractiveness. Building on our work, future studies could theorize and empirically examine how such digital technological risks undermine trust in smart

[5] Source:https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility/country-pages/italys-recovery-and-resilience-plan_en.

city initiatives.

6. Conclusion

This study questions the prevailing "*more is better*" assumption regarding digital technology implementation in smart city research by revealing that its impact on urban attractiveness follows a curvilinear pattern: while international newcomers continue to respond positively to advanced digitalization, national newcomers experience null or diminishing returns. This divergence underscores the risk of over-investment when policies are not aligned with newcomers' needs. Additionally, while social media further amplifies the benefits of digital technology, its moderating effect is notably stronger for national newcomers who share language and cultural context with the smart city. These findings underscore the need for differentiated, user-centered approaches in smart city planning, balancing technological advancement with attention to diverse user profiles. Smart city leaders and researchers are encouraged to understand how digital and social media initiatives should be tailored to maximize urban appeal to different newcomer types.

Novelty statement

This study pioneers the exploration of how digital technology implementation and social media adoption in smart cities influence urban attractiveness for both national and international user groups. While the existing literature extols the potential benefits of smart city initiatives, this research addresses critical gaps by empirically investigating the nuanced, curvilinear relationship between digital implementation and urban attractiveness. Furthermore, it examines the moderating role of social media platforms, shedding light on their capacity to curate, broadcast, and accelerate the impact of smart technologies.

The originality of this study lies in its novel data and multilevel investigation, which aim to empirically corroborate and question existing discourses about the contemporary role of social media and digital technologies in shaping urban migration patterns. It provides fresh insights into the differential impacts of digital and social media strategies on urban attractiveness for national versus international users, emphasizing the importance of user-centric approaches in technology-driven urban planning. This research contributes to advancing the discourse on smart city development, offering actionable implications for policymakers, urban planners, and practitioners. It also underscores the need to balance technological advancements with inclusivity to sustain urban livability and competitiveness in an increasingly digitalized world.

CRediT authorship contribution statement

Filippo Marchesani: Writing – original draft, Visualization, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Federica Ceci:** Writing – original draft, Validation, Supervision, Conceptualization. **Ian P. McCarthy:** Writing – original draft, Visualization, Supervision, Conceptualization.

Declaration of competing interest

None.

Data availability

Data will be made available on request.

Appendix A. Appendix A

Table A1
Supplementary model estimates for result interpretation of Table 3.

Variable	Model III - Table 3			
	Coeff.	s.e.	β Standardized	P-value
Urban attractiveness (n-1)	1.498	0.064	0.219	0.001
DTI	0.766	0.316	0.411	0.012
DTI^2	−0.253	0.098	−0.169	0.001
Social Media	0.244	0.016	0.065	0.001
Control Variable	Yes	Yes	Yes	Yes
Year Effects	Yes	Yes	Yes	Yes
City Effects	Yes	Yes	Yes	Yes

Standardized coefficients (β) are reported alongside unstandardized coefficients and standard errors to facilitate cross-variable comparison and interpretation. *P*-values are included for each coefficient, with significance levels indicated as follows:: $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Table A2
Supplementary model estimates for result interpretation of Table 4.

Variable	Model V				Model VI				Model VII				Model VIII			
	Coeff.	s.e.	β Standardized	P-value	Coeff.	s.e.	β Standardized	P-value	Coeff.	s.e.	β Standardized	P-value	Coeff.	s.e.	β Standardized	P-value
National UA (n-1)	1.188	0.106	0.215	0.001					1.088	0.055	0.221	0.001				
International UA (n-1)					0.321	0.052	0.236	0.001					0.312	0.058	0.209	0.001
DTI	0.687	0.291	0.371	0.001	0.488	0.237	0.237	0.001	0.599	0.230	0.341	0.001	0.421	0.321	0.281	0.001
DTI^2	−0.185	0.121	−0.203	0.013	−0.155	0.131	0.027	0.618	−0.176	0.124	−0.176	0.019	−0.146	0.106	−0.146	0.116
Social Media	0.218	0.256	0.079	0.002	0.269	0.201	0.031	0.096	0.244	0.199	0.065	0.003	0.251	0.197	0.071	0.047
Social Media*DTI									0.127	0.174	0.359	0.001	0.109	0.206	0.062	0.045
Social Media*DTI^2									−0.112	0.253	0.022	0.037	0.063	0.257	−0.019	0.001
Control Variable	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
Year Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*
City Effects	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*

Standardized coefficients (β) are reported alongside unstandardized coefficients and standard errors to facilitate cross-variable comparison and interpretation. P-values are included for each coefficient, with significance levels indicated as follows:: *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

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