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Smart city as a hub for talent and innovative companies: Exploring the (dis) advantages of digital technology implementation in cities

Filippo Marchesani [a,b,*], Francesca Masciarelli [a], Andrea Bikfalvi [b]

[a] Department of Management and Business Administration, University of Chieti-Pescara, Italy
[b] Department of Business Administration and Product Design, University of Girona, Spain

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ABSTRACT

The number of smart city initiatives is growing worldwide at an incredible pace. Their ambition is to add to the competitiveness of local communities through innovation while increasing and attracting users, financial capital and talent by offering an environment suited to current needs. Digital implementation plays a key role in this evolution, facilitating cities' ability to offer and advanced urban environment tailored for its users and stakeholders. In this paper, we examine how digital technology implementation affects the attractiveness of cities in terms of intra- and international talent flows and the creation of innovative companies. Our analysis is based on a dataset of 20 Italian cities over an 11-year period. We use the GLS (Generalized Least Square) panel data estimation method, considering both direct and u-shaped effects to evidence the relationship between digital technology implementation and the attractiveness of cities for intra- and international talents, and to explore an advancing urban environment conducive to innovation and entrepreneurship. Based on empirical outcomes, this study offers valuable insights for both academics and policymakers in understanding and balancing the current interplay between digital implementation, innovative companies, and talents in contemporary cities.

1. Introduction

Cities have now assumed a central role in social and economic geography as a vanguard in urban innovation, catalysing human development, knowledge transfer and the creation of companies. In the digital era, cities are changing their trajectories following the "smart" revolution, which aims to manage, offer, support and guarantee suitable planning for cities and stakeholders (Camboim et al., 2019).

Technology has taken on a pivotal role as a driver and instrument in the transition from cities to smart cities, orchestrating a pool of actors, needs, structures, policies and strategies, and contributing to generating and advancing local ecosystems (Kummitha and Crutzen, 2017; Kummitha, 2019; Pittaway and Montazemi, 2020; Mouton and Burns, 2021; Sharifi et al., 2021). Although the smart city concept has been widely used for different purposes and from varying perspectives, the literature as yet provides no unequivocal definition of it (Albino et al., 2015). Most of the existing definitions do, however, focus on cities' and stakeholders' digital advancement and the implementation of urban technology. To this effect, one of the most reliable definitions leaves it clear that smart city initiatives aim to "*improve urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration among different economic actors, and to encourage innovative business models in both the private and public sectors*" (Marsal-Llacuna et al., 2015, p. 618).

With digital technology implementation, cities want to facilitate interaction among citizens, governments and other actors to enrich the established relationship between the local and economic environments (Shelton et al., 2015; Batabyal and Nijkamp, 2019; Camboim et al., 2019; Christofi et al., 2021), moving towards a more comprehensive concept of a smart city that is interrelated with innovation, knowledge, entrepreneurship and stakeholders (Vanolo, 2014; Albino et al., 2015; Camboim et al., 2019; Kummitha and Crutzen, 2019; Hollands, 2020; Abid et al., 2022). Researchers have long debated the historical influence that cities' digital and technological advancement has had on attracting and harnessing talent, and on creating an environment suitable for innovative companies (Nieto and Quevedo, 2005; Florida et al., 2017; Kummitha and Crutzen, 2019, p. 51). In this regard, digital advancement in the city provides an innovation-oriented environment and ecosystem for companies to build on, stimulating the creation of new and innovative businesses (Adler et al., 2019; Adler and Florida, 2021; Marchesani et al., 2022). The functional relationship between

* Corresponding author at: Department of Management and Business Administration, University of Chieti-Pescara, Italy.
E-mail addresses: filippo.marchesani@unich.it (F. Marchesani), francesca.masciarelli@unich.it (F. Masciarelli), andrea.bikfalvi@udg.edu (A. Bikfalvi).

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digital technology implementation, talent inflow and innovative companies is likewise under discussion although currently under-evaluated, meaning that we have limited available knowledge about the policies applied and their outcomes. The connection between city users and the technologies being developed and implemented in the cities remains a major research gap in terms of smart cities (Kummitha, 2020, p. 5).

This research gap is intrinsic to current cities' trajectories, highlighting the need to investigate the development of and the relationship between digital technology implementation and innovative ecosystems in attracting innovative companies and talent to them (Tsvetkova, 2015; Kummitha and Crutzen, 2019; Marchesani et al., 2022). Furthermore, recent research on smart cities has highlighted the importance of shifting from a technology city to a social city where technology is created and used by human agents, rather than promoting the technologies above human propensity (Hollands, 2015, p. 74; Kummitha, 2018, p. 337; Appio et al., 2019, p. 12). Moreover, from a comprehensive ecosystem point of view, cities are not just the containers where knowledge, innovation and entrepreneurship happen but they are also the key mechanisms that enable their development (Florida et al., 2017, p. 93). The discrepancy between expected and actual results leads us to focus on the critical debate in the relationship between cities and technologies and the current benefits of smart city implementation (Hollands, 2008, 2020; Datta, 2015; Kummitha and Crutzen, 2017; Kummitha, 2020). The gaps become even more clear if we consider that the literature on innovation ecosystems has widely reported that knowledge and talent attractiveness and development are pivotal entities in terms of the competitiveness of knowledge-based innovation systems such as smart city projects (Ardito et al., 2019, p. 313).

Building on this state-of-the-art (Adler and Florida, 2021; Ardito et al., 2019; Florida et al., 2017; Hollands, 2008; Kummitha, 2018; Kummitha and Crutzen, 2019; Marchesani, 2022), we focus on the intersection between digital technology implementation in the city for intra- and international talent inflows and innovative companies to produce an in-depth analyses of the often neglected contributions potentially made by digital advancement in smart city trajectories to city attractiveness. Acquiring talent and attracting and promoting innovative companies that can simultaneously foster urban innovation and boost cities' competitiveness are vital in the current smart cities ecosystem (Liu et al., 2009; Adler and Florida, 2021; Marchesani et al., 2022). We approach the present research from a dual perspective. First, in relation to incoming talent flows, evaluated through intra- and international student flows as an *input* of innovation. And second, we analyse innovative companies in urban settings as an *output* of innovation. In the interaction between smart cities and talent flow, digital technology implementation in cities affects the outcomes in terms of attracting and generating new talent and knowledge given that the city provides the conditions, necessary tools and structures to meet current users' needs (Florida, 2002; Knudsen et al., 2007; Taylor Buck and While, 2017; Marchesani et al., 2022).

Our research focuses on Italy, contributing to the emerging smart cities debate related to cities' attractiveness and digital advancement in their transitions (Vanolo, 2014; Grossi and Pianezzi, 2017; Abid et al., 2022). Recent years have seen a growth in competitive-oriented smart city projects, mainly in North America and Europe, confirming the vitality and efforts of developed regions in the smart city transition (Christofi et al., 2021, p. 961). Following this research trend, we focus on the Italian context as a prominent country in the smart city debate on the strengths and weaknesses of this transformation. In this regard, Vanolo (2014, p. 894) points out that while the lively and celebratory images promoting the smart city strategy in the Italian media contribute to the rhetoric of smartness, they also risk building an a priori non-critical consensus. Together with the scant empirical evidence of the risk of the overdevelopment of smart cities, this lack of consensus contributes to the current debate about the transition of smart cities.

The present study aims to fill the research gap in the relationship between digital technology implementation, the attraction of talent and the development of innovative companies, controlling both the direct effect and the criticalities and loss of effectiveness of an excessive digital technology implementation. From this perspective, we aim to investigate and hypothesise the presence of a threshold point in the relationship between digital technology implementation, talent and innovative companies, and to see whether beyond this point the level of digital and technological implementation becomes too high and the expected outcomes diminish.

The article is structured as follows. The introduction (Section 1) is followed by a literature review in Section 2 of the existing research on technological progress and its associations with cities, the resulting smart city in the light of the digital era, its attractiveness for new talent and urban development for innovative companies. The methods are described in Section 3, with special emphasis on the quantitative approach and a description of the variables and methods for modelling and testing the hypotheses. The results are presented in Section 4, using the computed models. Section 5 discusses and concludes the research, summarising the main findings and formulating implications for policy, practitioners and research.

2. Literature review

2.1. Digital technology implementation in cities

A city's digital and technological implementation affects its perceived value among users and stakeholders and is increasingly at the centre of the development of smart cities (Pittaway and Montazemi, 2020; Nikki Han and Kim, 2021). In fact, digital and technological advancement can be considered the main drivers of this value through the increasing use of information technologies (ITs) and the IoT to improve services, products and efficiency via real-time control systems. This advancement also reduces the distance between citizens and policymakers in the smart city context (Goodspeed, 2015; Allam and Dhunny, 2019). In parallel, digital technology implementation can also be considered the main problem of cities given the need for technological development and the corresponding investments suited to the urban area that must be adopted by users, including citizens, companies and entrepreneurs. One aspect of this problem is how smart city technologies are implemented and the idea that they are largely a strategic vision rather than a reality on the ground (Ibrahim et al., 2018). Indeed, smart cities' development has mostly focused on technology, and for years this perspective has resulted in a loss of relationships with users and stakeholders (Linders, 2012; Neumann et al., 2019).

The existing implementation of technologies in cities creates greater engagement between citizens and the city and influences cities' strategic development by generating ongoing stakeholder relationships (Gagliardi et al., 2017). To this effect, we consider digital and technological implementation in cities a driving factor of the "smart" cities' trajectories, and we assume that the advancement of these practices in cities impacts on the attractiveness of the city in terms of new talent and innovative companies.

Technological implementation is a very broad concept and when referring to a city environment covers different areas and tools used as measurement indicators. In this regard, the public sector's online services and ICT applications such as municipal apps and social media channels are often underutilised or do not effectively meet the needs of users and citizens (Gagliardi et al., 2017; Alruwaie et al., 2020; Pittaway and Montazemi, 2020). The growing need among citizens for greater engagement in city activities and its advances and investments in ICT, and an improved relationship between government and citizens, are all connected to technological implementation and impact on city strategies (Pereira et al., 2018). Digital implementation and the adoption of these technologies by city governance, users and stakeholders are therefore becoming key factors in smart city development. For example, the IoT offers a unique opportunity for citizen empowerment, improving the engagement of societies with cities at both micro and macro levels

(El-Haddadeh et al., 2019). The combination of Artificial Intelligence (AI) and IoT information systems is now assumed to be an essential precondition for the success of information systems and the increased use of smart services by citizens. This issue has gained prominence in light of recent improvements in the quality and implementation of cities' technological services and systems. In the light of the growing importance of the IoT and ICT in the development of smart cities (Ullah et al., 2021), we examine technological implementation from the broader perspective of the technological advances of the city's products and services. As is widely documented in the literature, city governance and strategies impact technology (Gagliardi et al., 2017; Silva et al., 2018; Valdez et al., 2018) and its implementation in the dynamics of cities creates value for city users. Against this backdrop, our study aims to investigate the effect of digital technology implementation on cities' attractiveness since this is a central element and potential driver of city advancement and current smart city trajectories.

2.2. Smart cities' attractiveness in the digital era

Our analysis also examines the ability of cities to generate value for stakeholders and trigger new competition at local and international levels, whereby the more developed cities attract and sustain wealth. In this direction, a key element is the use of the IoT and ICT, which has completely changed the urban dynamics previously anchored in local development (Vanolo, 2014). This shift has implications for global competition in different areas such as tourism (Romão et al., 2018), retail (Burnes and Towers, 2016), financial capital (Chatterjee and Kar, 2015) and human capital in terms of both citizens and knowledge (Lee et al., 2010; Neirotti et al., 2014), and extends global competition worldwide. In the digital era, a key element of the smart city is a city's ability to promote itself and compete worldwide. As pointed out by IBM in their marketing literature about competitive smart cities, *in the 21st century cities compete globally to attract both citizens and businesses. A city's attractiveness is directly related to its ability to offer the basic services that support growth opportunities, build economic value and create competitive differentiation. Potential inhabitants, of both the commercial and the residential variety, are a discriminating lot, and they are looking for cities that operate efficiently and purposefully. They are looking for smarter cities* (IBM Smarter Cities, 2012). Regarding the attractiveness of cities, a high digital technology implementation, a high level of services and the competitive development of smart cities elevate them to a dominant position on the national and international stages (Kumar et al., 2016). Digital technology implementation not only affects relations with stakeholders but also enables the city to enhance its position in the local and international panoramas, and to become centres of innovation and entrepreneurship because the technologies smart cities adopt generate data which then helps businesses to explore new opportunities (Kummitha, 2019, p. 1). Furthermore, this implementation has a dual effect in the local environment in relation to talent attractiveness because it (i) affects the intra- and international talent migration to cities (Florida, 2002; Adler and Florida, 2021; Marchesani et al., 2022), and (ii) it contributes to the role that cities have historically played in attracting and harnessing talent to create and advance new enterprises (Kummitha and Crutzen, 2019, p. 51).

In relation to the above, our study focuses on digital technology implementation in cities as an engine of development and attractiveness in terms of new talent flows and innovative companies. We analyse the interaction between digital technology implementation and smart cities by focusing on two variables that are closely related to the concept of smart cities, knowledge and innovation.

2.3. Talent attraction and smart city development

In the absence of a common template to define a smart city and its features, most of the proposed definitions include the potential of smart cities to address several innovative socio-technical and socio-economic aspects of growth (Albino et al., 2015, p. 11; Kummitha and Crutzen, 2019, p. 46). The smart city must therefore be considered a city of technology and knowledge because of its ability to drive innovation based on knowledgeable and creative human capital (Zygiaris, 2013). This ability to attract and generate knowledge and talent likewise elevates cities to a dominant position, fostering innovation and economic and social development, thereby becoming centres of innovation, entrepreneurship and economic growth processes (Florida et al., 2017). The smart city brings together skills, knowledge and capital and provides an innovation-based technology structure that allows stakeholders to be recombined in new productive forms (Tachizawa et al., 2015; Paskaleva and Cooper, 2018). These factors together create a new urban view of growth that impacts both locally and internationally.

Technological implementation and the promotion and attraction of knowledge and innovation are fundamental to a city's development policies and growth (Yigitcanlar et al., 2020). One of the first but still topical research studies was carried out by Jacobs (1969), who affirmed that capacity to innovate is a product of a local environment that attracts talented people and is open and creative. In the context of smart cities, knowledge is still seen as a driver of economic growth to sustain the production and generation of talent (Bakici et al., 2013). From this perspective, the role of knowledge is fundamental to the smart city concept, different forms of which along with high-skilled human capital are key in the relationship between technological development and smart cities (Valdez et al., 2018), and in developing innovative companies (Adler et al., 2019). The development of a social context based on technology capable of attracting and generating new talent and knowledge enables the city to form part of the smart city concept in the short and long terms (Kar et al., 2019). Consequently, cities have become a competitive landscape for the technology companies, innovative hubs and knowledge flows that generally characterise places capable of ensuring development conditions, and that provide the necessary tools and structures for these conditions (Taylor Buck and While, 2017). The city's ability to attract and retain talent and knowledge has become fundamental to the smart city concept, with technological development playing a key role in this relationship as one of the main drivers (Yigitcanlar et al., 2020; Valdez et al., 2018).

2.4. Urban development and innovative companies in smart cities

A smart city aims to increase its competitiveness through innovation while improving the quality of life of its citizens and offering a technologically advanced context for users and stakeholders. Consequently, it also enables its stakeholder companies and entrepreneurs to exploit the services and tools it offers to improve its competitiveness and strategies (Kumar et al., 2016). The relationship between smart cities and innovative and technological development has been extensively studied by analysing the impacts of these developments on citizens (Neirotti et al., 2014; Gagliardi et al., 2017) and on the economic and social evolution of the city (Allam and Dhunny, 2019; Yigitcanlar et al., 2020). Companies interact in an innovative and technological context with ample room for manoeuvre and growth and with tools for their growth strategies (Neumann et al., 2019). To help companies reach their goals, the smart city concept encompasses factors that include ICT and IoT elements such as fibre optic networks, sensors and connected devices and open data analytics (Albino et al., 2015). In addition to these factors, smart cities must also consider the concept of innovative environment and the relationship between business and urban development (Florida et al., 2017; Leitheiser and Follmann, 2020).

Smart cities leverage a combination of skills, knowledge, and capital to foster an urban ecosystem that facilitates and propels interactions among diverse stakeholders, promoting an innovative and dynamic urban dimension (Tachizawa et al., 2015; Paskaleva and Cooper, 2018). The current concept of smart cities includes the expectation to facilitate information gathering among citizens, entrepreneurs and companies, which enables them to provide public services and a new competitive edge for stakeholders more efficiently and sustainably (Ooms et al., 2020) and a new urban vision of growth with local and international implications.

Urban innovation is also closely related to the urban context as a whole. Typical smart city projects involve not only large multinationals and local authorities but also local companies and startups, who transfer general technological solutions and produce innovation (Caragliu and Del Bo, 2019).

The relationship between innovation and cities also features in the studies by Adler et al. (2019), who considers cities as the centre of innovation and entrepreneurship processes. He evidences the reflections of Jane Jacobs in her recent urban research on the role of the city, and those of Joseph Schumpeter on innovation and entrepreneurship. From this perspective, smart cities are perceived as collaborative ecosystems that facilitate innovation by connecting citizens, governments, businesses and educational institutions. These innovative clusters foster the development of high added-value activities and innovative companies (Appio et al., 2019). Consequently, this relationship impacts the management and development of local companies that can manage the services offered by the city, which is becoming more and more user centric (Lee and Lee, 2014). The acquisition and perception of these services improve the development and growth opportunities of innovative companies, which consequently impacts the entire economic and social environment of the city. With entrepreneurship based on local knowledge and supported by the local ecosystem, the role of local companies and knowledge in the smart city transition is firmly at the centre of the debate (Datta, 2015; Kummitha, 2018, 2020; Kummitha and Crutzen, 2019). This debate helps to strengthen our hypothesis of the extent to which digital technology implementation in cities influences the creation of innovative firms, and the point at which this implementation becomes mere digital advancement. More specifically, building on the criticism of the relationship between smart cities and entrepreneurship (Kummitha, 2018) and firms' contributions to the local environment (Hollands, 2008; Datta, 2015; Kummitha and Crutzen, 2017), we assume that there is still much to investigate on the bilateral relationship between digital technology implementation and economic environment in the contemporary city. In particular, the current role of technology and digital advancement in society calls for a more comprehensive understanding of the relationship between smart cities and the innovative economic environment (Hollands, 2008, 2020; Kummitha and Crutzen, 2017). However, the current perspective remains in line with that of the early critics of smart cities, who point out that urban visioning is being increasingly reduced to a single technology-centric vision of the city of the future (Vanolo, 2014, p. 894), losing sight of the connection with companies, entrepreneurs and the local environment. In this transition, it therefore becomes fundamental to orchestrate digital technology implementation according to the economic and entrepreneurial environment. Digital technology implementation in cities contributes to the desirable outcome of generating a bilateral connection where companies support cities' digital and technological advancement, and digital technology implementation in cities drives companies to innovate (Christofi et al., 2021, p. 969). However, in this regard, as a primary objective smart cities should focus on considering digital technology implementation as an engine for the economic environment and on ensuring that it does not become mere digital implementation (Berrone et al., 2016; Chatterjee et al., 2018; Marchesani, 2022).

2.5. Conceptual framework

This paper aims to analyse the interaction between digital technology implementation in cities and city attractiveness, assessed in terms of talent flow and innovative companies. Understanding the effect of the advancement of digital and technology implementation in society on different players such as innovative firms, startups and small and medium-sized enterprises, and of knowledge flow in the local context, are considered essential elements to customise and tailor cities to their current and future needs.

To investigate these interactions, we proceeded according to the structure presented in Fig. 1, which synthesises the conceptual and theoretical framework of the study. Digital technology implementation in cities is explained and measured using nine indicators, which broadly cover the main characteristics of digital and technological development in cities, allowing us to quantitatively assess the range of digital technology implementation within our sample. To this end, we measured the digital and technological services implemented by the city for users (i.e., Public wi-fi, Online Services and Municipal Apps), the digital implementation in cities' trajectories (i.e., Digital Transparency, Digital Openness, Social Public Administration and IoT Development) and the digital advancement in the urban area (Broadband access and Home Banking Diffusion). Table 1 shows the variable type, source, measurement, operationalisation and description of the variables.

Based on this structure, we hypothesised a direct effect of digital technology implementation in the city on the intra-national (H1) and international (H2) talent inflow variables, and we analysed whether this relationship influences each flow through a u-shaped effect (H1a and H2a). Moreover, we evaluated the relationship between the innovative companies in cities and digital implementation (H3) and their relative influence over the years, also through a u-shaped effect (H3a). The purpose of these analyses was to enable us to evaluate and measure the various (and potentially related) factors that determine the attractiveness of cities based on talent flow. Furthermore, we assessed the creation of an innovative context for companies and startups.

Given that the effective value and outcomes of digital technology implementation in smart city trajectories remain the subject of academic and policy debates (Vanolo, 2014; Datta, 2015; Kummitha, 2018, 2020; Kummitha and Crutzen, 2019), and that this lack of knowledge is accentuated in the relationship between talent inflow and innovative companies (Kummitha and Crutzen, 2019; Adler and Florida, 2021; Marchesani et al., 2022), this study proposes the following hypotheses:

H1. : The higher the level of digital technology implementation in the city, the higher the attraction of intra-national talent.

H1a. : The digital technology implementation in cities is curvilinearly (inverted u-shape) related to the attraction of intra-national talent in the city.

H2. : The higher the level of digital technology implementation in the city, the higher the attraction of international talent.

H2a. : The digital implementation in cities is curvilinearly (inverted u-shape) related to the attraction of international talent in the city.

H3. : The higher the level of digital technology implementation in the city, the higher the number of innovative companies.

H3a. : The digital technology implementation in cities is curvilinearly (inverted u-shape) related to the number of innovative companies in the city.

3. Methodology

The development of smart cities has a direct impact on a city's internal development and attractiveness at local and international levels. A recent line of research examines the role played by cities' strategies in the implementation and development of urban policies (Pittaway and Montazemi, 2020; Xiahou et al., 2020). Italy, Spain, the US and the UK stand out in terms of academic research on smart cities, with a focus on the internal perspective and the global landscape (Christofi et al., 2021, p. 961).

Italy is an interesting context because it has a high commitment to smart urban policies (Vanolo, 2014), and smart strategies and actions can be found in the largest Italian metropolises and smaller towns alike (Dameri et al., 2019). We focus on 20 Italian cities selected on an equal

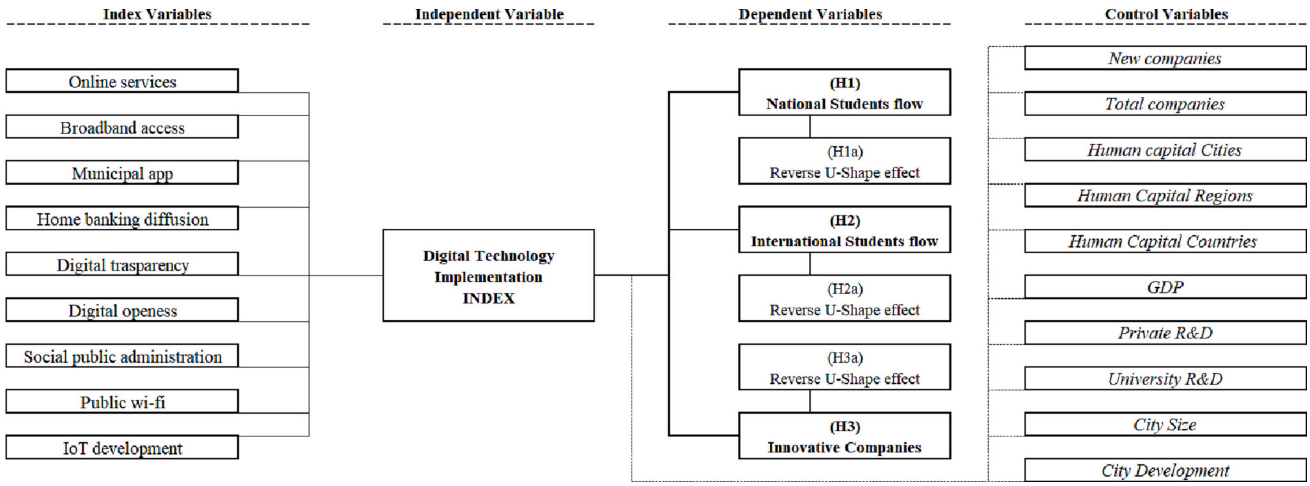

Fig. 1. Research framework.

basis, covering medium and large cities from north to south (see Fig. 2), and we use the probability-proportional-to-size sampling in each stratum of medium and large, and less- and well-developed cities (Levy and Lemeshow, 2011). The sample obtained shows good heterogeneity in terms of size and economic development, although this heterogeneity was higher in the northern part than in the southern part of the country. All the cities selected are classified as smart cities in the EU's latest available report on mapping smart cities (European Parliament, 2014).

The sample allowed us to assess the correlation between the perceived technological progress of the city and its attractiveness for new talent and innovation. To do so, we used a panel dataset that considered an 11-year period (2010–2020) and the twenty cities considered in the sample: Milan, Verona, Turin, Bergamo, Genoa, Bologna and Brescia in Northern Italy, Rome and Florence in central Italy, and Naples, Palermo, Foggia, Salerno, Bari, Catania, Caserta, Reggio Calabria, Messina, Lecce, and Cosenza in Southern Italy. We developed this work based on the information contained in different databases of the Italian National Institute of Statistics (ISTAT), the Authority for Communications Guarantees (AGCOM) and Forum Public Administration ()FPA, and on municipal open data, aiming to evaluate the technological development of the city and create an index for evaluating this development in terms of services and users. The Italian Ministry of Education (MIUR) website provided a quantitative evaluation of student mobility flows, and information from the National Students Clearinghouse (NSC) meant we could identify the movements of students in Italy and verify inflows from other cities and countries. In this regard, we detected more than 418,000 students moving from one city to another and around 44,000 students moving from another country to the cities included in the sample. Last, as regards the formation of innovative companies, we used the data from two different databases, ISTAT and the company registry of each region, allowing us to identify the technology-intensive companies born in the cities for each of the 11 years considered.

3.1. Operationalisation of the variable

3.1.1. Dependent variables

Our model included 3 dependent variables (the number of students from other regions, i.e., *national student flows*; the number of students from other countries, i.e., *international students flows*; and the number of innovative companies over the period considered, i.e., *innovative companies*). Our first dependent variable, *national student inflows* into the city, was the number of students arriving in the study period from regions other than those where the cities are found. This allowed us to systematically evaluate the incoming flows for each city in relation to its size and development. Our second dependent variable was *international student flows,* which was the flow of students from another country into the sample cities. Both variables were operationalised on the total number of students in the city to have a uniform assessment of the development of the city and the flows of incoming students. Last, as a third dependent variable (*innovative companies*), we considered the companies founded each year during the 11-year period in the city that developed, produced and marketed innovative products or services based on high technological features. This variable was weighted on the total number of companies located in the city. To this effect, we could perceive the development of innovative companies in each city in relation to their economic and geographical context of reference.

3.1.2. Independent variable

Digital technology implementation in cities was our independent variable, given that it is strongly linked to the overall concept of smart cities and the IoT, and includes technology and urban service practices. To assess this variable, we proposed an index based on different indicators that contained a set of variables including digital openness, public Wi-Fi, home banking diffusion, digital transparency, digital openness and the use of municipal apps (see Table 1). It was an all-encompassing category that considered not only the technological development of cities, but also the perception and adoption of these practices by the various users and stakeholders (Lee and Lee, 2014; Li and Liao, 2018; Abid et al., 2022; Marchesani, 2022).

We decided to create the digital technology implementation index to weigh the variables of city characteristics such as size, population and economic development, focusing on the users of the respective services considered within the individual variables. We indexed the variables not at a single level but for the entire sample of cities. To assess this index, we considered nine indicators that allowed us to represent the digital technology implementation in the city, starting with the more developed cities (e.g., Milan, Rome, and Bologna) and going down to the as yet underdeveloped ones (e.g., Reggio Calabria, Foggia and Cosenza). The final value ranged from 0 to 1, representing the various degrees of digital technology implementation in the cities, and enabling us to quantitatively assess the digital and technological advancement of the city, which has a central role in the smart city concept (Orlowski and Romanowska, 2019; Francini et al., 2021).

3.1.3. Control variables

In our models, we included a different set of time and control variables. Regarding the control variables, we considered the main city characteristics useful for assessing and empirically evaluating the city's incoming flows according to the urban literature (Freeman, 2010;

Table 1
Description of the variables included in the model.

Variable	Measurement	Source	Description	Operationalization
Digital technology implementation index				
Online services	Constant	ISTAT	Number of online services available in the city	Natural logarithm of the variable over the population in the city
Broadband access	Percentage	AGCOM	Percentage of families who have access to ADSL	Natural logarithm of the variable over the population in the city
Municipal App	Constant	ISTAT	Municipal App download number	Natural logarithm of the variable over the population in the city
Home-banking diffusion	Percentage	ISTAT	Number of users and citizens who utilize home banking	Natural logarithm of the variable over the population in the city
Digital transparency	Constant	ANAC	Number of public data concerning the investments of the city	Natural logarithm of the variable over the R&D investment in the city
Digital openness	Constant	FPA	Total number of public access databases in the city	Natural logarithm of the variable over the population in the city
Social public administration	Construpt	FPA	Total use of public online services, engagement and productivity	Natural logarithm of the variable over the population in the city
Public Wi-Fi	Construpt	ISTAT	Number of access points, quality of service and communication	Natural logarithm of the variable over the population in the city
IoT development	Percentage	ISTAT	Investments in IoT and ICTs in cities	Natural logarithm of the variable over the total investment in R&D in the city
Dependent variables				
Innovative companies	Constant	ISTAT	Number of innovative companies registered in the "Chamber of Commerce" of each city per year	Natural logarithm of the variable over the total number of active companies in the city
National flow incoming	Constant	NSC	New students arriving annually from other cities of the same country in the city	Natural logarithm of the variable over the total students in city
International flow incoming	Constant	NSC	New students arriving annually from other countries in the city	Natural logarithm of the variable over the total students in city
Control variables				
New companies	Constant	IBS	Number of companies registered in the "Chamber of Commerce" of each city per year	Natural logarithm of the variable over the population in the city
Total companies	Constant	IBS	Total number of companies active in the city, based on registration on the Chamber of Commerce	Natural logarithm of the variable over the population in the city
HC Cities	Constant	ANPR	New residents arriving annually from other cities of the same regions based on registration in the cities' register (ANPR)	Natural logarithm of the variable over the population in the city
HC Regions	Constant	ANPR	New residents arriving annually from other regions of the same country based on registration in the cities' register (ANPR)	Natural logarithm of the variable over the population in the city
HC Countries	Constant	ANPR	New annual residents arriving from other countries based on the registration in the cities' register (ANPR)	Natural logarithm of the variable over the population in the city
City GDP	Constant	EUROSTAT - OECD	Gross Domestic Product produced in each city in the year n considered	Natural logarithm of the variable over the population in the city
Private R&D	Constant	ISTAT	Total amount of private sector investments in R&D in year "n"	Natural logarithm of the variable over the population in the city
R&D Public	Constant	ISTAT	Total amount of public sector investments in R&D in year "n"	Natural logarithm of the variable over the population in the city
City Development	Dummy	ISTAT	Economic development of the city according to the division proposed by the European community.	We constructed a dummy variable that considered cities in the most developed urban areas (1) and cities in transition areas (0)
City Size	Dummy	ISTAT	Size of the city considering that 300,000 is the threshold between medium and large cities.	We constructed a dummy variable considering (1) cities with a population greater than 300,000 and (0) cities with lower population numbers

Database: ANPR: Anagrafe Nazionale della Popolazione Residente, ISTA; Italian National Institute of Statistics; OECD - Organisation for Economic Co-operation and Developme; FPA: European Financial Planning Association; AGCOM: Autorità per le Garanzie nelle Comunicazioni; ANAC: National Anti-Corruption Authority; IBS: Italian Business Register; EUROSTAT: Statistical office of the European Union; NSC: National Student Clearinghouse.

Sinkienė and Kromalcas, 2010; Romão et al., 2018; Qian, 2018). We examined three variables to assess human capital flows, which were the flow of human capital from other cities in the same regions (*HC City*), other regions (*HC Regions*) and other countries *(HC Country*) (Fratesi and Percoco, 2014). We also considered the technological investment in the cities in relation to both the companies and universities located there by means of their investments in R&D (*Private R&D* and *University R&D,* respectively) (Laursen et al., 2012; Capuano and Grassi, 2019). The economic development of the city was measured using three variables, including *GDP*, an economic measure commonly used to assess the economic development of an urban area. Regarding *city size*, we constructed a dummy variable that assigned the value of 0 if the city had a population of less than 300,000 inhabitants and 1 if the population was over 300,000. We also controlled for the development of the city by constructing a dummy variable following the categorisation of the most developed regions (1) and those in transition (0) proposed by the European Community. Last, we considered the development of the local entrepreneurial context by taking the total number of companies operating in the city (*total companies*) and the number of companies founded annually (*new companies*).

3.2. Research strategy and modelling

To examine our hypothesis, we used the GLS (General Least Square) method to quantitatively evaluate the sample over the period considered. We decided on this method because cities, our units of analysis, differ in many significant ways (e.g., the size and economic evolution measured by the GDP). Differing GDPs is a common source of heteroscedasticity, which is a sound basis for evaluating the heterogeneity of the sample and helps to detect problems such as how to manage an observation unit that has an important spatial component (De Matteis et al., 2021). While we could have used the OLS (Ordinary Least Squares) method or the Spatial-Panel data methods (Elhorst, 2010; Debarsy, 2012) to estimate our model, we decided to use the GLS

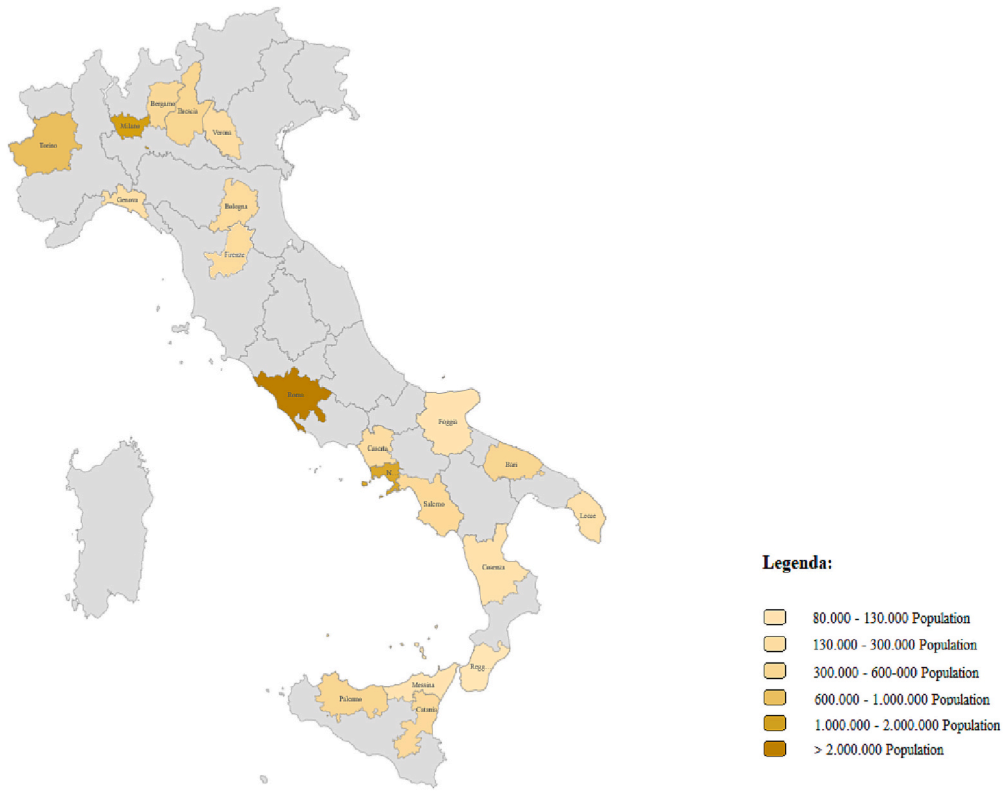

Fig. 2. Sample of analysis.

method because we also took into consideration a random effect on the sample. Furthermore, we discounted the spatial panel data methodology used in other urban level research. In our variables, we considered the inflows from different regions rather than from different cities, thus superimposing a spatial approach on the study (Elhorst, 2003). Furthermore, to confirm the use of the GLS methods and to avoid statistical problems, we applied the Hausman test and controlled for VIF variance inflation factors. First, we checked the fixed and random effects on the OLS model, and then we applied the GLS model to perform the test. We obtained a p-value = 0.889. This result indicated that the decision to use the GLS model was a basic solution for quantitatively evaluating this relationship.

4. Results

This section begins with a descriptive analysis of the data and the correlation between variables, considering the three dependent variables. Table 2 shows the descriptive statistics and Tables 3, 4 and 5 the correlation among variables.

Table 2
Descriptive statistics.

Variables	Obs.	Mean	Standard deviation	Min	Max
National flows	220	0.031	0.040	0.001	0.043
International flows	220	0.024	0.031	0.001	0.032
Inn. companies	220	0.097	0.051	0.008	0.056
Digital technology implementation	220	0.397	0.168	0.152	0.978
New companies	220	0.058	0.004	0.023	0.082
Total companies	220	0.312	0.589	0.066	0.863
HC Cities	220	0.021	0.066	0.067	0.035
HC Regions	220	0.053	0.021	0.009	0.122
HC Countries	220	0.038	0.008	0.017	0.075
GDP	220	0.112	0.075	0.001	0.363
Private R&D	220	0.775	0.864	0.031	1.733
University R&D	220	0.381	0.189	0.012	0.126
City Size	220	0.450	0.498	0.000	1.000
City Development	220	0.500	0.501	0.000	1.000

The first testing began with an examination of the correlation matrix and the presence of multicollinearity. In our models, we expected the coefficient between two variables to be lower than 0.700. When the coefficient exceeded this figure, we proceeded to construct the model also considering the assumed multicollinear variables individually. We used the same process to assess the stability of the sign and the significance of the coefficients, in addition to the influence of standard errors. We computed our model following this preliminary study of the principal variables. As can be seen in Tables 3, 4 and 5, among all the variables used *Private R&D, GDP* and *City Size* had a correlation coefficient higher than 0.700. More specifically, for *Private R&D* and *GDP* the coefficient was between 0.721 and 0.755 (Tables 3, 4 and 5) and for *City Size* and *Private R&D* it was 0.752 (Table 3). Considering the high correlation with the variable we ran the regressions, excluding *Private R&D* and *City Size*. All the results were confirmed.

We also carried out a control test to assess the potential multicollinearity, using the variance inflation factor (VIFs) and Housman test to avoid it and ensure that there were no statistical problems. Both statistics suggested that no multicollinearity was present among our city-level variables because the VIF scores were less than 10 (Salmerón et al., 2018). For each model in Table 6, the mean and maximum VIF were well below the threshold of 5.3. We thereby concluded that multicollinearity was not a threat to the validity of our results.

The results of the GLS models are presented in Table 6. Models I, IV and VII represent our empirical model estimated with all the controls. In Models II, V and VII we highlight the interaction between the dependent variable and the independent variables assessed in the model, and in Models III, VI and IX we consider the interaction between the dependent and independent variables, including a u-shaped effect in the proposed model.

Models II and V provide support for Hypotheses 1 and 2, which

Table 3
Correlation matrix – national student flow.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
1. National flows	1											
2. Digital technology Implementation	0.289	1										
3. New companies	0.263	0.243	1									
4. Total companies	0.389	0.246	0.294	1								
5. HC Cities	0.571	0.391	0.412	0.196	1							
6. HC Regions	0.134	0.111	0.082	0.406	0.391	1						
7. HC Countries	0.072	−0.196	−0.105	0.082	0.078	0.019	1					
8. GDP	0.093	−0.098	0.081	−0.105	0.398	0.0.221	−0.058	1				
9. Private R&D	0.331	−0.156	0.239	0.81	0.531	0.271	0.026	0.721	1			
10. University R&D	0.108	0.398	0.321	0.234	0.255	0.071	0.047	0.354	0.321	1		
11. City Size	0.065	0.125	0.094	0.481	0.431	0.382	0.172	0.260	0.352	0.105	1	
12. City Development	0.392	0.0301	0.292	0.371	0.126	0.102	0.102	0.483	−0.182	0.295	0.121	1

Table 4
Correlation matrix – international student flow.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
1. International flows	1											
2. Digital technology implementation	0.183	1										
3. New companies	0.267	0.084	1									
4. Total companies	0.352	0.348	0.289	1								
5. HC Cities	0.389	0.362	0.247	0.0.192	1							
6. HC Regions	0.341	0.270	0.312	0.304	0.301	1						
7. HC Countries	0.066	0.010	0.111	0.083	0.079	0.018	1					
8. GDP	0.092	0.255	−0.190	−0.105	0.351	0.262	−0.051	1				
9. Private R&D	0.336	0.312	0.098	0.081	0.291	0.271	0.026	0.751	1			
10. University R&D	0.105	0.021	0.153	−0.231	0.231	0.07’	−0.047	0.341	0.331	1		
11. City Size	0.402	0.267	0.203	0.234	0.354	0.318	0.107	0.512	0.753	0.015	1	
12. City Development	0.204	0.261	0.231	0.305	0.298	0.104	0.128	0.361	−0.306	−0.287	0–228	1

Table 5
Correlation matrix – inn. companies.

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]
1. Inn. companies	1											
2. Digital technology implementation	0.281	1										
3. New companies	0.096	0.084	1									
4. Total companies	0.483	0.341	0.346	1								
5. HC Cities	0.291	0.346	0.293	0.286	1							
6. HC Regions	−0.003	0.273	0.312	0.402	0.429	1						
7. HC Countries	0.261	0.001	0.112	0.083	0.079	0.019	1					
8. GDP	0.463	0.252	−0.186	−0.105	0.361	0.263	−0.058	1				
9. Private R&D	0.271	0.487	−0.098	0.081	0.521	0.371	−0.026	0.755	1			
10. University R&D	0.312	0.021	−0.156	0.238	0.346	0.070	−0.047	0.354	0.321	1		
11. City Size	0.319	0.512	0.303	0.312	0.378	0.389	0.107	0.260	0.352	0.105	1	
12. City Development	0.075	0.260	0.331	0.274	0.112	0.108	0.127	−0.356	−0.182	−0.295	0.228	1

propose a direct effect of digital implementation in a city on the flows of incoming students at national and international levels. The parameter for *digital technology implementation* was significant and positive to explain the relationship with national ($\beta = 6523$; $p = 0{,}001$) and international student flows ($\beta = 3983$; $p = 0{,}001$). This result shows how digital technology implementation in cities is perceived by students and impacts on talents flow. To this effect, both types of student are attracted to cities that offer an innovative and social environment capable of satisfying their needs and demands (Pratama and Imawan, 2019; Christofi et al., 2021). Interestingly, this relationship does not yet generate a reciprocal effect on the development of the city, given that our Hypotheses 1a and 2a were not confirmed. Specifically, as we can see in Models III and VI, there is no evidence of the u-shaped relationship between digital technology implementation in cities and student incoming flows either nationally or internationally. Our findings suggest that these two variables currently do not have a reciprocal relationship and the flows of incoming students do not directly impact the digital and technological development of a city. In fact, technological implementation in cities attracts incoming student flows but these students do not influence this development. Even though universities act as knowledge intermediaries, knowledge gatekeepers and knowledge providers (Ardito et al., 2019), the relationship with the development of smart cities is not yet bilateral. However, over the medium and long terms, the impact of incoming talents will be fundamental to the development of smart cities, which by nature are inherently based on knowledge and technology. In this regard, smart cities and universities are an effective context for the exploration and exploitation of new knowledge, and are a conducive environment for generating and attracting talent and new generations.

Regarding Hypothesis 3, the direct hypothesis and the u-shaped effect between these two factors are notably supported. Specifically, the parameter for *digital technology implementation* in cities is significant and positive to explain the relationship with innovative companies ($\beta = 1348$; $p = 0{,}010$). The parameter considered also confirms a direct effect of digital technology implementation on the creation of innovative companies. Interestingly, and contrary to incoming talent flows, we find support for our Hypothesis 3a given the inverted u-shaped effect observed between *Innovative companies* and *digital technology*

Table 6
GLS models.

	National students flow (DV)						International students flow (DV)						Innovative companies (DV)					
	Model I		Model II		Model III		Model IV		Model V		Model VI		Model VII		Model VIII		Model IX	
	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E	Coeff.	S.E
Digital technology implementation	0.033***	0.036	0.225***	[0.045]	0.131	[0.014]	0.005***	0.004	0.259***	[0.006]	0.134	[0.023]	0.094***	0.116	0.119*	[0.052]*	0.207***	[0.048]
Digital technology implementationˆ2	0.001	0.001			0.011	[0.013]	0.001	0.001			0.025	[0.019]	−0.110**	0.053			−0.198***	[0.045]
New companies			−1.114	[1.117]	−1.281	[1.120]			0.095	[1.661]	−0.161	[1.169]			−1.633***	[0.902]	−1.489***	[0.748]
Total companies			0.478**	[0.168]	0.480*	[0.170]			0.457*	[0.228]	0.455*	[0.226]			1.141**	[0.492]	1.195*	[0.481]
HC Cities			0.233	[0.243]	0.240	[0.246]			0.181	[0.336]	0.161	[0.341]			0.812	[0.775]	0.769	[0.747]
HC Regions			0.118	[0.319]	0.125	[0.324]			0.421	[0.456]	−0.406	[0.461]			−3.080**	[1.118]	−3.048**	[1.068]
HC Countries			−0.048	[0.047]	−0.041	[0.048]			0.101	[0.067]	−0.082	[0.069]			−0.195	[0.166]	−0.322*	[0.161]
GDP			−0.231*	[0.092]	−0.221**	[0.092]			0.654***	[0.107]	0.592***	[0.104]			−0.447**	[0.174]	0.660***	[0.179]
Private R&D			0.013**	[0.005]	0.013**	[0.004]			0.047***	[0.005]	0.043***	[0.005]			0.046***	[0.012]	0.065**	[0.012]
University R&D			0.091***	[0.024]	0.009***	[0.002]			0.008	[0.003]	0.006	[0.003]			0.009	[0.007]	0.013	[0.008]
City Size			0.035*	[0.019]	0.036**	[0.012]			0.027	[0.007]	0.029*	[0.016]			0.028	[0.018]	0.018	[0.019]
City Development			0.004	[0.009]	0.011	[0.036]			0.016	[0.004]	−0.009	[0.012]			−0.023	[0.015]	−0.031	[0.017]
City fixed effect	Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes		Yes	
R-Squared	0.594		0.538		0.531		0.621		0.501		0.524		0.347		0.538		0.566	
Chi-squared	189.80		167.31		178.92		109.31		194.34		193.35		65.42		167.31		198.98	
N° Observation	220		220		220		220		220		220		220		220		220	
N* City	20		20		20		20		20		20		20		20		20	

Legend: *0.10; **0.01; ***0.001. Two-tailed tests of significance. Standard errors in [parentheses].

implementation.

The coefficient of *digital technology implementation* and its square in Model IX are positive and negative, respectively (β = 4024; p = 0,001 and β = −4143; p = 0,001), indicating that there is an inverted u-shaped relationship between digital technology implementation and the creation of innovative companies in cities, as shown in Fig. 3. This suggests that perception of digital and technological progress does have a driving role in the promotion and development of innovative contexts, which enables innovative companies to emerge in cities perceived as a technological landscape, in line with the result given in Model VIII.

Smart cities, however, strongly rely on digital and technological implementation as the main driver of city development. The innovative impact of urban areas weakens with the improvement of technology in cities, with the gradual decline of the unicity of the technological urban context. For years, this concept has been at the core of innovative development worldwide, including in Boston, Silicon Valley, Singapore and London, according to the KPMG's latest survey of industry insiders. Meanwhile, the smart city invests in and promotes digital technology implementation in the urban context, the future challenge being to promote an innovative and exclusive context for companies and startup growth through technological progress (Pittaway and Montazemi, 2020). Therefore, long-term digital technology implementation positively affects the creation of innovative companies, although this relationship weakens over time with the promotion of smart city practices at national and international levels.

5. Discussion and conclusions

The smart city vision has been gradually integrated into urban policies worldwide, influencing cities' direct and indirect growth dynamics (Vanolo, 2014). This paper contributes to the urban studies relating to smart city development by empirically analysing the impact of digital technology implementation in cities on the promotion and reshaping of the urban context in terms of talent attraction and innovation. Our findings suggest that the advancement of digital technology in cities affects smart cities' trajectories and serves as a driver for attracting intra- and international talent and to promote the creation of innovative companies. However, this development cannot be detached from the reality of the context and the needs of users and companies. Specifically, we find that talent is less sensitive to an excessive technological and digital development of the city, while innovative companies are only encouraged by a technologically advanced environment that promotes the localisation of innovative companies up to a threshold point, after which the effect of the interaction between digital technology implementation and innovative companies is lost.

Today, the advancement of smart cities worldwide is reshaping the offer of technological and economic services tailored to companies and talent, considered key elements in orchestrating smart city practices (Florida et al., 2017; Kummitha, 2018, 2019; Kummitha and Crutzen, 2019). Standardising this environment benefits smart cities by competitively attracting and promoting innovative companies and providing them with a more advanced environment. The result will be an increasingly competitive environment for the more advanced smart cities both in terms of internal economic development and urban development (Christofi et al., 2021; Taylor Buck and While, 2017). However, despite the advances in research methods and the gradual smart city implementation in society, cities are still a complex issue as a unit of analysis. To this effect, the extrapolation of tools available to carry out competitive and strategic analyses and subsequent policy implementation may not be direct and straightforward.

Last, in the light of the current geopolitical situation, global competition and migration possibilities place cities in a competitive global environment wherein individual talent and innovative companies decide on their location based on the conditions most favourable to their interests. The city's response to the needs of talent and innovative companies is implicit in the development of smart cities which, by

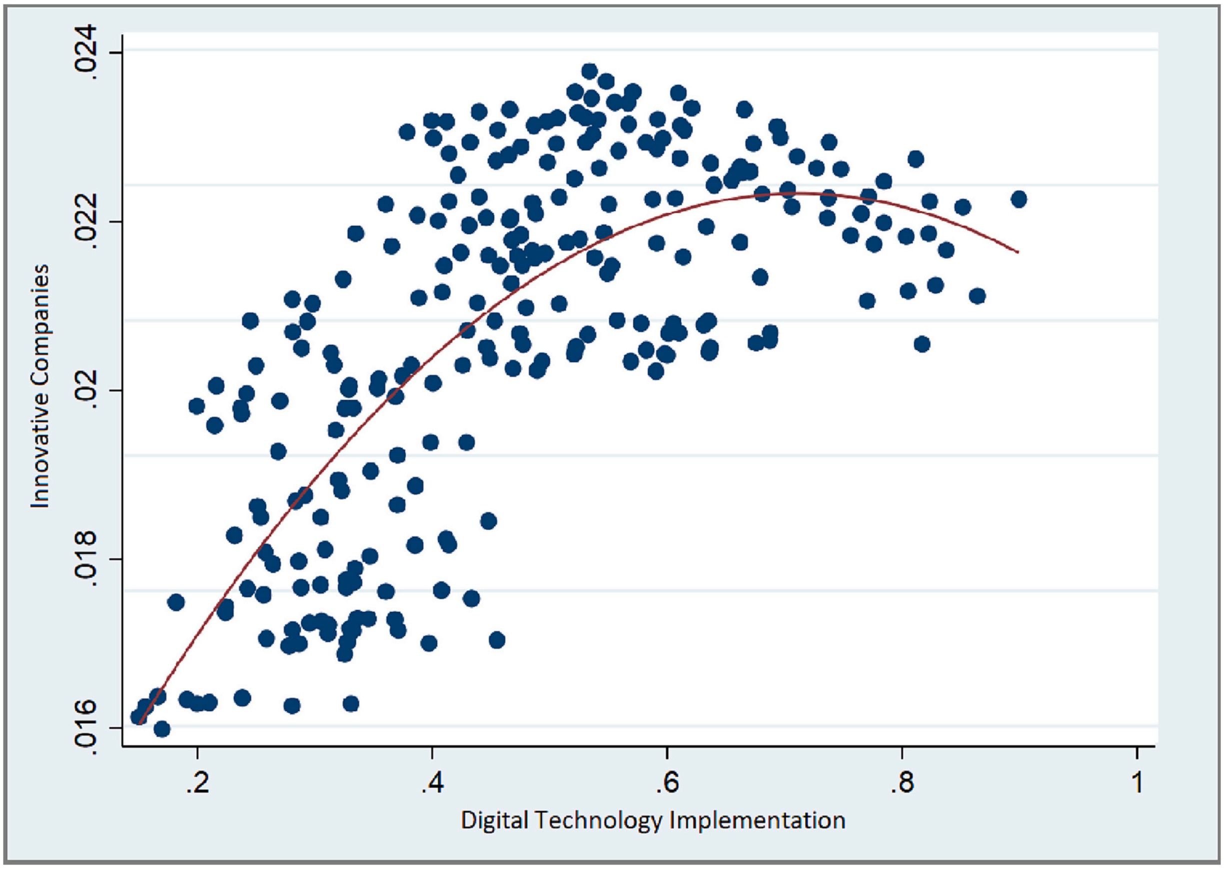

Fig. 3. The inverted U-shaped relationship between digital technology implementation and innovative companies.

offering an optimal environment for them, attracts them to their city, consequently producing a benefit for the city itself. Developing practices tailored to users' and actors' need is therefore vital in the dynamics of smart cities (Adler et al., 2019; Betz et al., 2016; Kummitha and Crutzen, 2019).

5.1. Implications for the literature

By evaluating the effect of digital and technology implementation on contemporary cities, this research provides important insights and adds value to the current literature on both urban innovation (Florida et al., 2017; Adler et al., 2019; Marchesani et al., 2022) and smart cities (Caragliu and Del Bo, 2019; Christofi et al., 2021; Kummitha, 2018, 2019, 2020; Sharifi et al., 2021; Vanolo, 2014).

Beyond the current cities' trajectories and the ideological discussion surrounding them (Hollands, 2008; Albino et al., 2015; Datta, 2015), a smart city approach and solution is a complex, multi-actor and coordinated initiative in which wide ranging stakeholder interests and power and their contribution are vital. This study sheds light on the interaction between digital and technology implementation and smart city dynamics, empirically advancing the smart cities literature by considering the effect of this implementation on cities' national and international talent attractiveness and the promotion of a local environment in driving the creation of innovative companies (Adler and Florida, 2021; Caragliu and Del Bo, 2019; Florida et al., 2017). Our study highlights the importance of orchestrating smart cities' internal dynamics to go beyond mere digital technology advancement to seek effective outcomes to maximise co-alignment and the corresponding potential benefits. These results highlight the importance of advancing and balancing a technological-economic-social environment capable of attracting the talent and skilled human capital considered vital to the current and future smart city dynamics.

Since academic institutions may have difficulty attracting and training the necessary talent (Kummitha and Crutzen, 2017, 2019; Marchesani et al., 2022), smart city dynamics could contribute to cities' ability to attract talent and skilled human capital. Therefore, our research contributes to the nascent literature on the role of "talent in-talent out" in smart cities, most often referred to as the availability (or lack) of suitable talent flowing into (or out) of the city. This talent flow has major implications in terms of recruiting the human resources and highly skilled human capital that is fundamental from a strategic perspective, especially in the early stages when matters of location are being decided in new ventures (Kummitha and Crutzen, 2019). Specifically, we show that digital technology implementation affects talent acquisition nationally and internationally by providing a tailored environment for their needs. Furthermore, we confirm that cities that are progressing towards tailored and customised use-centric development of the local environment are usually more willing to attract and retain talent and innovation (Adler et al., 2019; Florida et al., 2017; Marchesani et al., 2022), potentially contributing to the smart cities trajectories (Kummitha and Crutzen, 2019).

Last, since access to talented and creative people is mandatory to pursue innovative business, we also know that the local environment determines where companies will choose to locate and grow which, in turn, changes the ways cities must compete (Adler and Florida, 2021; Florida et al., 2017; Kummitha, 2020; Kummitha and Crutzen, 2019). Our findings show that smart cities' digital technological implementation contributes to attracting and creating innovative companies. However, we also provide evidence that there is a point at which the smart city's digital technology implementation appears to lose its effectiveness in driving this process. This situation is not necessarily negative. Innovative companies often have abrupt growth trajectories, and depending on their activity and special needs (land and space issues, industrial activity allowance and regulatory frameworks applied in cities), a different location might be optimal (Adler et al., 2019; Caragliu and Del Bo, 2019). To this effect, this paper contributes to the current understanding of how technologies are developed and applied in cities, and of the role of companies and talent in perceiving and being attracted by the digital technological implementation there, while also expanding the current literature that questions the smart trajectories in the contemporary city (Hollands, 2008; Datta, 2015; Kummitha, 2018; Kummitha and Crutzen, 2019).

5.2. Practical implications

We find interesting empirical evidence that offers significant policy implications regarding the success of the IoT and smart city policies that would benefit stakeholders and the urban system by helping to attract new talent and promote an economic and social context that further facilitates the development of an innovative environment. Cities are expected to benefit from digital and technological implementation, especially *if* and *when* the actors are placed at the centre of the project. This construct will allow the actors to take part in the city's digital revolution in a context tailored to their needs (Lee and Lee, 2014; Kummitha and Crutzen, 2019). Consequently, the use of digital implementation will benefit citizens, businesses, entrepreneurs, users and governments in a multitude of ways (Hollands, 2015; Gagliardi et al., 2017). Furthermore, this suggestion is in line with EU recommendations on promoting the development of urban systems more connected to sustainability and technology by providing tools and funds that allow cities to model themselves on current needs (Christofi et al., 2021; Engelbert et al., 2019).

To achieve these objectives, authorities must strengthen the connection between users and smart city practices by developing and implementing technology that challenges the generally accepted idea of 'be technologically advanced - be better' in developing policies, making users (i.e., companies, citizens, talent) and the expected outcomes (i.e., innovations, entrepreneurship and local advancement) key elements in them. This, in turn, could impact cities in terms of their economic development and competitiveness in the global landscape.

Moreover, since this study uncovers that digital technology implementation affects the promotion of innovative companies in the city only up to a certain point, we invite policymakers to not only consider these empirical evidences as an evolution of the existing theoretical perspectives (Hollands, 2008, 2015; Vanolo, 2014; Kummitha and Crutzen, 2017, 2019; Kummitha, 2018; Caragliu and Del Bo, 2019), but also to evaluate carefully the potential drawback when cities' excessive advancement in digital technological implementation causes a loss of connection with their internal and external actors.

5.3. Limitations and future research avenues

This study has some limitations embedded in the empirical nature of the study and the theoretical advancement of the smart cities literature. First, we focused our research sample on 20 cities in a single country. Although Italy and other European countries are considered prominent countries in terms of academic research on smart cities' competitiveness and attractiveness (Christofi et al., 2021, p. 961), this could still be a limitation in terms of the global vision of smart cities. In this regard, future research could test this construct, seeking a connection with other countries on other continents (i.e., Asia, North America and Latin America) and allowing us to examine the link between digital and technological advancement and talent and innovative companies in cities with different policies, cultures and development. A second limitation concerns the construct of digital technology advancement. Due to the lack of well-established and all-inclusive variables to assess this implementation, we referred to the literature to choose the indicators to include in the index. Future research on smart cities could consolidate this variable or consider other indicators inherent to the digital and technological development of the city (policy responsiveness) and its use (user responsiveness). Third, in considering the innovative companies that were active in the cities, we had no information as to whether they were founded in the city or moved to it. Future research could extend this study by examining (i) the ability to promote the creation of innovative firms at the local level; and (ii) the ability to attract innovative companies located in other geographical areas. Fourth, in considering the innovative companies variable, we know the innovative nature of these companies, but we do not know the sector to which they belong. Future research could expand on this aspect by showing which sector is mainly influenced by the development of digital technology implementation in smart cities. Last, different approaches, city (or country) objectives and smart city visions must be considered to shed light on the policies and practices of smart cities designed to effectively influence the outcomes of digital and technological implementation in the urban panorama (Vanolo, 2014; Kummitha, 2018; Caragliu and Del Bo, 2019; Kummitha and Crutzen, 2019; Spicer et al., 2021).

CRediT authorship contribution statement

Category 1: *Conception and design of study*: F. Marchesani; F. Masciarelli; A. Bikfalvi.

Acquisition of data: F. Marchesani.

Analysis and/or interpretation of data: F. Marchesani; F. Masciarelli.

Category 2: *Drafting the manuscript:* F. Marchesani; F. Masciarelli; A. Bikfalvi.

Revising the manuscript critically for important intellectual content: F. Marchesani; F. Masciarelli; A. Bikfalvi.

Category 3: *Approval of the version of the manuscript to be published:* F. Marchesani; F. Masciarelli; A. Bikfalvi.

Data availability

Data will be made available on request.

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Filippo Marchesani is researcher at the Department of Management and Business Administration at the university "G. d'Annunzio" Chieti-Pescara. He holds his PhD in Accounting, Management and Business Economics. He was a visiting researcher at the University of Girona (Spain). His research interests focus on Cities competitiveness, Smart Cities, Smart Tourism, Innovation and Entrepreneurship. He sits on the editorial board of Springer Nature Business & Economics Journal and is a peer-reviewed for several international journals. He has recently published these issues in International Marketing Review, Cities, Journal of Cleaner Production, Current Issues in Tourism and Elsevier books.

Francesca Masciarelli is Associate Professor at the University G. d'Annunzio. She received her Ph.D. from the University of Trento. She was visiting researcher at the Copenhagen Business School and at the University of Sussex. Her research interests include social capital, management of innovation, and entrepreneurship. She has published on these issues on Organization Science, Journal of International Business Studies, Journal of Business Ethics, Regional Studies, Industry and Innovation, International Marketing Review, and Journal of Small Business and Entrepreneurship. She has also published two books with the Edward Elgard Publishing, a book with Emerald Publishing, and a book with Routledge.

Andrea Bikfalvi 'Serra Húnter' Associate Professor, teaching and research staff in the Department of Business Administration and Product Design at the University of Girona (Spain). She holds a PhD in Business Administration. She is currently the deputy director of the Chamber of Commerce Chair of Family Business at the same university. During her trajectory, she conducted several research projects for the regional government of Catalonia, Spain, as well as a series of national and EU projects. Her main research interest is in strategy, entrepreneurship and holistic approaches of innovation in all types of organizations.