Routledge
Taylor & Francis Group

Journal of Urban Technology

ISSN: 1063-0732 (Print) 1466-1853 (Online) Journal homepage: http://www.tandfonline.com/loi/cjut20

Smart Cities in Europe

Andrea Caragliu , Chiara Del Bo & Peter Nijkamp

To cite this article: Andrea Caragliu , Chiara Del Bo & Peter Nijkamp (2011) Smart Cities in Europe, Journal of Urban Technology, 18:2, 65-82, DOI: 10.1080/10630732.2011.601117

To link to this article: http://dx.doi.org/10.1080/10630732.2011.601117

Published online: 10 Aug 2011.

Journal of Urban Technology, Vol. 18, No. 2, April 2011, 65–82

Smart Cities in Europe

Andrea Caragliu, Chiara Del Bo, and Peter Nijkamp

ABSTRACT *Urban performance currently depends not only on a city's endowment of hard infrastructure (physical capital), but also, and increasingly so, on the availability and quality of knowledge communication and social infrastructure (human and social capital). The latter form of capital is decisive for urban competitiveness. Against this background, the concept of the "smart city" has recently been introduced as a strategic device to encompass modern urban production factors in a common framework and, in particular, to highlight the importance of Information and Communication Technologies (ICTs) in the last 20 years for enhancing the competitive profile of a city.*

The present paper aims to shed light on the often elusive definition of the concept of the "smart city." We provide a focused and operational definition of this construct and present consistent evidence on the geography of smart cities in the EU27. Our statistical and graphical analyses exploit in depth, for the first time to our knowledge, the most recent version of the Urban Audit data set in order to analyze the factors determining the performance of smart cities. We find that the presence of a creative class, the quality of and dedicated attention to the urban environment, the level of education, and the accessibility to and use of ICTs for public administration are all positively correlated with urban wealth. This result prompts the formulation of a new strategic agenda for European cities that will allow them to achieve sustainable urban development and a better urban landscape.

Introduction

What is the source of urban growth and of sustainable urban development? This question has received continuous attention from researchers and policy makers for many decades. Cities all over the world are in a state of flux and exhibit complex dynamics. As cities grow, planners devise "complex systems to deal with food supplies on an international scale, water supplies over long distances, and local waste disposal, urban traffic management systems, and so on; (…) and the quality of all such urban inputs defines the quality of life of urban dwellers" (The Science Museum, 2004).

Notwithstanding the enormous formidable challenges and disadvantages associated with urban agglomerations, the world population has been steadily concentrating in cities. Figure 1 shows the percentage of EU citizens living in cities (population living in areas classified as urban according to the country-specific criteria selected by the UN); a massive rise in this percentage took place, from slightly more than 50 percent in 1950 to more than 75 percent of EU

1063-0732 Print/1466-1853 Online.

DOI: 10.1080/10630732.2011.601117

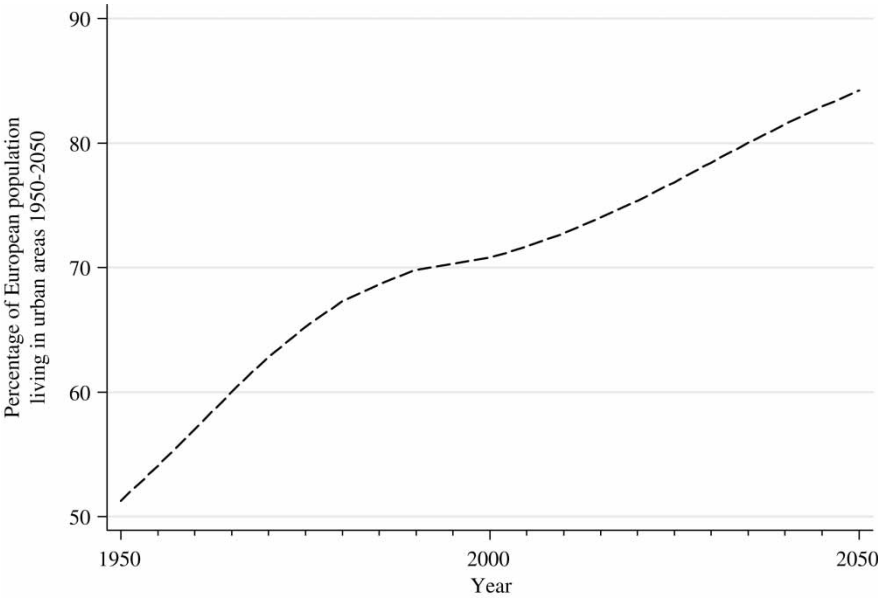

Figure 1. Percentage of EU population living in urban areas, 1950-2050 (forecast)
Source: UN (2009)

population being located in urban areas in the year 2010, and a forecast of about 85 percent within the next 40 years.

In addition, we have also witnessed a substantial increase in the average size of urban areas. This has been made possible by a simultaneous upward shift in the urban technological frontier so that a city can accommodate more inhabitants. Problems associated with urban agglomerations have usually been solved by means of creativity, human capital, cooperation (sometimes bargaining) among relevant stakeholders, and bright scientific ideas: in a nutshell, "smart" solutions. The label "smart city" should, therefore, point to clever solutions allowing modern cities to thrive, through quantitative and qualitative improvements in productivity. However, when googling "smart city definition,"[1] we discovered that included among the very first results were links to a communications provider, a U.S. radio station, an Edinburgh hostel, an initiative of the Amsterdam Innovation Engine, and so on; but no sign of a proper definition.

In the present paper we search for a clear and focused definition of the term "smart city." We next provide qualitative evidence on the correlations between the dimensions of our definition of smart cities and a measure of wealth, i.e., per capita GDP in Purchasing Power Parity (henceforth, PPP).[2] We will start with a brief literature review in the next section.

Literature Review

The concept of the smart city has been quite fashionable in the policy arena in recent years. Its main focus seems to be on the role of ICT infrastructure, although much research has also been carried out on the role of human capital/education, social and relational capital, and environmental interest as important drivers of urban growth.

The European Union, in particular, has devoted constant efforts to devising a strategy for achieving urban growth in a "smart" way for its metropolitan areas. Not only the European Union, but also other international institutions and think tanks believe in a wired, ICT-driven form of development. The Intelligent Community Forum, for example, produces research on the local effects of the ICT revolution, which has now spread worldwide. The OECD and EUROSTAT *Oslo Manual* (2005) stresses the role of innovation in ICT sectors and provides a toolkit to identify consistent indicators, thus shaping a sound framework of analysis for researchers on urban innovation. At a *meso*-regional level, we observe renewed attention to the role of soft communication infrastructure in determining economic performance.[3]

The availability and quality of the ICT infrastructure is not the only definition of a smart or *i*ntelligent city. Without reference to the "smartness" concept, the relation between ICT infrastructure and economic performance has been the object of a flourishing literature since the beginning of the digital era (e.g., Roller and Waverman, 2001). Other definitions stress the role of human capital and education in urban development. Berry and Glaeser (2005) and Glaeser and Berry (2006) show, for example, that the most rapid urban growth rates have been achieved in cities where an educated labor force is available. In particular Berry and Glaeser (2005) model the relation between human capital and urban development by assuming that innovation is driven by entrepreneurs who innovate in industries and products that require an increasingly more skilled labor force.

As not all cities are equally successful in investing in human capital, the educated labor force—or, in Florida's jargon, the "creative class"—is spatially clustering over time. This recognized tendency of cities to have different levels of human capital has attracted the attention of researchers and policy makers. It turns out that cities that had a skilled labor force in the past are able to attract more skilled labor in the present than competing cities. Policy makers, in particular European ones, are most likely to attach a consistent weight to spatial homogeneity; in these circumstances the progressive clustering of urban human capital is a major concern.

An interesting contribution (Fu, 2007) relates the smartness concept to the generation of localized knowledge spillovers (LKS). In this paper, human capital externalities originate from face-to-face contacts between peers in an urban environment. This paper follows the traditional literature on LKS, which encompasses Rauch (1993). Recent and valuable critical reviews of the concept of LKS can be found in Breschi and Lissoni (2001) and in Capello (2009).

The label "smart city" is still, in our opinion, quite a fuzzy concept. Hollands (2008) stresses this point while also providing several examples of self-defined smart cities. In this paper, we move forward by adding a critical review of the literature on smart urban growth from an economist's perspective and an exploratory empirical analysis. With this aim, we summarize the characteristics proper to a smart city that tend to be common to many of the previous findings as follows:

1. *The "utilization of networked infrastructure to improve economic and political efficiency and enable social, cultural, and urban development,"* (Hollands, 2008: 308) where the term "infrastructure" indicates business services, housing, leisure, and lifestyle services, and ICTs (mobile and fixed phones, computer networks, e-commerce, and Internet services). This point brings to the forefront the idea of

a wired city as the main development model and of connectivity as the source of growth.

2. *An "underlying emphasis on business-led urban development"* (Hollands, 2008: 308). According to several critiques of the concept of the smart city, this idea of neo-liberal urban spaces, where business-friendly cities would aim to attract new businesses, would be misleading. However, although caveats on the potential risks associated with putting an excessive weight on economic values as the sole driver of urban development may be worth noting, the data actually shows that business-oriented cities are indeed among those with a satisfactory socio-economic performance.
3. *A strong focus on the aim of achieving the social inclusion of various urban residents in public services* (e.g., Southampton's smartcard; see Southampton City Council 2006). This prompts researchers and policy makers to give attention to the crucial issue of equitable urban growth. In other words: To what extent do all social classes benefit from a technological integration of their urban fabric?
4. *A stress on the crucial role of high-tech and creative industries in long-run urban growth.* This factor, along with "soft infrastructure" ("knowledge networks, voluntary organizations, crime-free environments, after dark entertainment economy"), is the core of Richard Florida's research. The basic idea in this case is that "creative occupations are growing and firms now orient themselves to attract "the 'creative'" (Hollands, 2008: 309). Employers now prod their hires onto greater bursts of inspiration. The urban lesson of Florida's book is that cities that want to succeed must aim at attracting the creative types who are, Florida argues, the wave of the future" (Glaeser, 2005: 593). The role of creative cultures in cities is also critically summarized in Nijkamp (2008), where creative capital co-determines, fosters, and reinforces trends of skilled migration. While the presence of a creative and skilled workforce does not guarantee urban performance, in a knowledge-intensive, and increasingly, globalized economy, these factors increasingly will determine the success of cities.
5. *Profound attention to the role of social and relational capital in urban development.* A smart city will be a city whose community has learned to learn, adapt, and innovate (Coe et al., 2001). People need to be able to use technology in order to benefit from it: this refers to the absorptive capacity literature. This concept has been applied to different economic relations at different levels of spatial aggregation. The basic reference is Cohen and Levinthal (1990); Abreu et al. (2008) bridges the idea from a micro-, firm level to a more aggregated, meso-level; finally, Caragliu and Nijkamp (2011) test the role of regional absorptive capacity in inducing spatial knowledge spillovers.

   When social and relational issues are not properly taken into account, social polarization may arise as a result. This last issue is also linked to economic, spatial, and cultural polarization. It should be noted, however, that some research actually argues the contrary. Poelhekke (2006), for example, shows that the concentration of high skilled workers is conducive to urban growth, irrespective of the polarization effects that this process may generate at a *meso-* (for example, regional) level. The debate on the possible class inequality effects of policies oriented towards creating smart cities is, however, still not resolved.
6. *Finally, social and environmental sustainability as a major strategic component of smart cities.* In a world where resources are scarce and where cities are increasingly basing their development and wealth on tourism and natural resources,

their exploitation must guarantee the safe and renewable use of natural heritage. This last point is linked to the third item, because the wise balance of growth-enhancing measures, on the one hand, and the protection of weak links, on the other, is a cornerstone for sustainable urban development.

Items 5 and 6 are for us the most interesting and promising ones from both a research and a policy perspective; we believe, therefore, that they may represent the object of future research for urban economists. In the next sections we provide quantitative and analytical evidence of the role of the creative class and human capital in sustainable urban development, arguing that it is indeed the mix of these two dimensions that determine the very notion of a smart city. The relational capital side of the story is not evaluated in the present paper, but this will be the subject of further research in future studies.

Along with the previously mentioned critical points, additional critiques have been advanced to question the concept of a smart or intelligent city. Hollands (2008) provides a thorough treatment of the main arguments against the superficial use of this concept in the policy arena. His main points are the following:

- The focus of the concept of smart city may lead to an underestimation of the possible negative effects of the development of the new technological and networked infrastructures needed for a city to be smart (on this topic, see also Graham and Marvin, 1996).
- This bias in strategic interest may lead to ignoring alternative avenues of promising urban development.
- Among these possible development patterns, policy makers would better consider those that depend not only on a business-led model. As a globalized business model is based on capital mobility, following a business-oriented model may result in a losing long-term strategy: "The 'spatial fix' inevitably means that mobile capital can often 'write its own deals' to come to town, only to move on when it receives a better deal elsewhere. This is no less true for the smart city than it was for the industrial, manufacturing city" (Hollands, 2008:314).

From a U.S. perspective, research on smart cities has also evaluated the relevance of smart urban development in fighting urban sprawl (Bronstein, 2009); used a cognitive approach in assessing the role of psychological and cognitive attitudes towards ICTs in reducing the extent of the digital divide (Partridge, 2004); and verified on the field (through a case study on a community project) whether concrete action can be taken against such a digital divide in poor urban areas (Mc Allister et al., 2005).

Our paper will now provide some quantitative evidence on many of these points, supported by spatial statistics, maps, and graphical evidence on each of the points that the literature on smart cities has put forward in order to explore and identify statistical correlations with socioeconomic urban performance.

An Operational Definition of the Smart City

A narrow definition of a much-used concept may help in understanding the scope of the present paper. Although several different definitions of smart city have been given in the past, most of them focus on the role of communication infrastructure. However, this bias reflects the time period when the smart city label gained interest, viz. the early 1990s, when ICTs first reached a wide audience in European

countries. Hence, in our opinion, the stress on the Internet as "the" smart city identifier no longer suffices.

A recent and interesting project conducted by the Centre of Regional Science at the Vienna University of Technology identifies six main "axes" (dimensions) along which a ranking of 70 European middle size cities can be made. These axes are: a smart economy; smart mobility; a smart environment; smart people; smart living; and, finally, smart governance. These six axes connect with traditional regional and neoclassical theories of urban growth and development. In particular, the axes are based—respectively—on theories of regional competitiveness, transport and ICT economics, natural resources, human and social capital, quality of life, and the participation of society members in cities. We believe this offers a solid background for our theoretical framework, and, therefore, we base our definition on these six axes.

We believe a city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

Quantitative and Graphical Evidence on European Smart Cities

In this section we will present graphical and quantitative evidence on the relative performance and rankings of European cities with respect to measures reflecting some of the definitions of a smart city given in the literature. The data source is the Urban Audit data set in its latest wave (2003-2006). The Urban Audit entails a collection of comparable statistics and indicators for European cities; it contains data for over 250 indicators across the following domains:

- demography
- social aspects
- economic aspects
- civic involvement
- training and education
- environment
- travel and transport
- information society
- culture and recreation.

Cities that were surveyed in the latest available wave are depicted in Map 1.

We now present a set of charts which show partial correlations between urban growth determinants and our measure of economic output, which is per capita GDP in purchasing power standards (PPS) in 2004 (the latest data available in the Urban Audit data set). For the sake of readability, cities are indicated with their Urban Audit code. (A complete correspondence table is available as an Appendix to this paper.)

The set of all partial correlations among the variables we use to measure the "smartness" of European cities can be found in Table 1, with corresponding p-values in parentheses. It is evident that most of the variables that we deem as capable of both co-determining long-run urban performance and characterizing a thorough definition of smart city tend to be positively associated with our measure of urban wealth (we chose per capita GDP in PPS in 2004 in order to avoid the problem of size effects and to take into account price differentials

Map 1. Cities in the 2003-2006 Urban Audit survey

Table 1: Partial correlations among the six indicators of Smart Cities

	Per Capita GDP in PPS	*Employment in the Entertainment Industry*	*Multimodal Accessibility*	*Length of Public Transport Network*	*e-Government*	*Human Capital*
Per Capita GDP in PPS	1					
Employment in the Entertainment Industry	0.215 (0.1258)	1				
Multimodal Accessibility	0.7049 0	−0.0059 (0.9553)	1			
Length of Public Transport Network	0.3104 (0.0043)	0.2874 (0.0302)	0.0919 (0.312)	1		
e-Government	0.1418 (0.1751)	−0.0254 (0.8385)	0.141 (0.1004)	−0.0339 (0.7417)	1	
Human Capital	−0.1361 (0.265)	−0.0983 (0.3649)	0.0833 (0.3616)	−0.0741 (0.5946)	0.0665 (0.5733)	1

Note: p-values are in parentheses

across countries, which might be particularly different among EU15 and New Member State [NMS] cities). An interesting but puzzling result arises for the relationship between the level of education of people living in our sample and their average individual income; this issue will be further analyzed later in this

section. Throughout this section, on the map as well as in our charts, we indicate the code of the city associated with each observation. We believe this to be a useful tool of analysis for both researchers and policymakers, allowing them to identify intriguing spatial issues in the Urban Audit data set, to note the possible presence of country effects, and to identify the locational patterns of our smart city measures.

Figure 2 offers partial support for Richard Florida's arguments on the role of the "creative class" in determining long-run urban performance. Positive correlations between the share of people employed in a "creative" industry (Florida, 2002; 2009), and in particular in the "super-creative core," are found in U.S. cities and states. In Florida (2002) the creative class is defined as the merger of two Standard Occupational Classification System codes within the U.S. labor force, viz.:

- A super-creative core with those employed in science, engineering, education, computer programming, research, and with arts, design, and media workers making a small subset. Those belonging to this group are considered to "fully engage in the creative process" (Florida, 2002: 69).
- Creative professionals with those employed in healthcare, business and finance, the legal sector, and education.

Here, we measure these effects with the share of the labor force in European cities in the culture and entertainment industry and find, indeed, that the two measures show a positive and significant correlation (the correlation coefficient equals .2150 with a p-value of .1258).

In the urban economics literature, Florida's view has not been exempt from criticism (Glaeser, 2005). In the opinion of several economists, the argument that the creative professions would drive urban performance is flawed, and it would

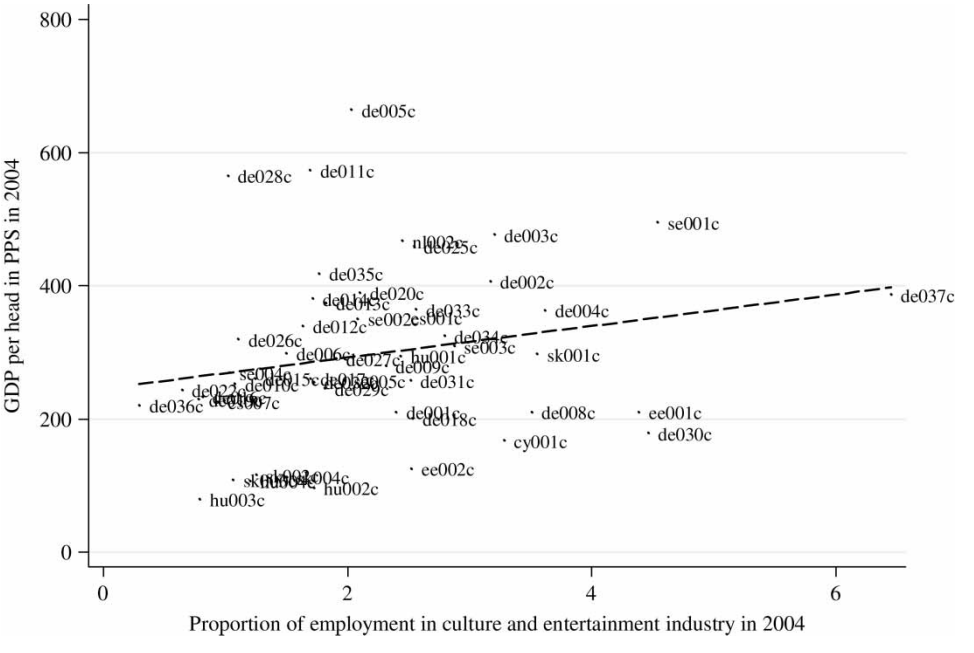

Figure 2. Creative class and wealth in 2004

only be a proxy for the role of the "hard" measurable stock of human capital (i.e., technical professions and total years of schooling) on urban growth. Shapiro (2008) provides an excellent and convincing bridge between the two views. In his paper, he proves with careful econometric estimations that human capital in cities contributes both directly to urban growth (measured by the growth of population, wages, and two land-rent measures) through productivity gains and indirectly through the increase in urban amenities, which in turn may foster the process of attraction of the creative class. Although the productivity effects are still the largest, according to Shapiro's estimates, the amenities effects would account for as much as 20 to 30 percent of total human capital effects on urban growth.

A second positive (and extremely significant) correlation appears to exist between multimodal accessibility and per capita GDP. (See Figure 3.) The multimodal accessibility index is based on the assumption that the attraction of a destination increases with its size (in terms of population and GDP) and declines with distance, travel time, and costs (which in turn lays its foundations in gravitational models of trade). Values of the index oscillate around 100, which is the average for the EU27. In this chart, the accessibility indicator, calculated as a weighted average of the ease with which a city can be reached with a combined set of available transportation modes (i.e., rail, road, sea, or plane), also represents a measure for the market potential available to and from the city itself. Therefore, a better endowment of transportation means might be conducive to wealth and growth; this last statement being in line with the New Economic Geography's theoretical expectations. A good example of the role of the market potential in driving economic performance in the New Economic Geography literature can be found in Redding and Sturm (2008), who in turn follow the rich tradition encompassing, among many, Davis and Weinstein (2003) and Hanson (2005).

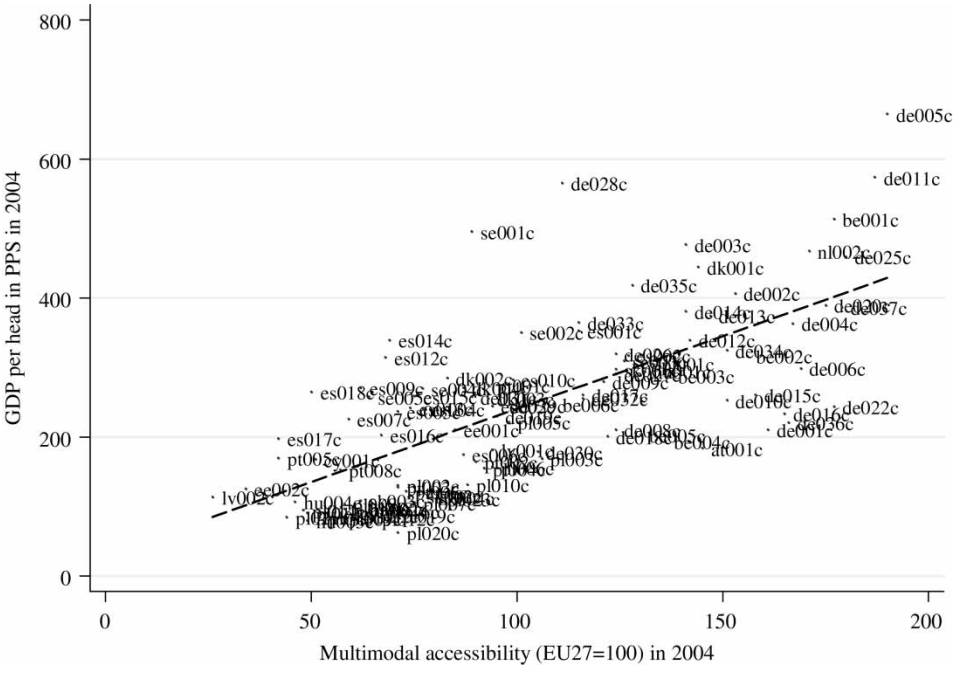

Figure 3. Accessibility and wealth in 2004

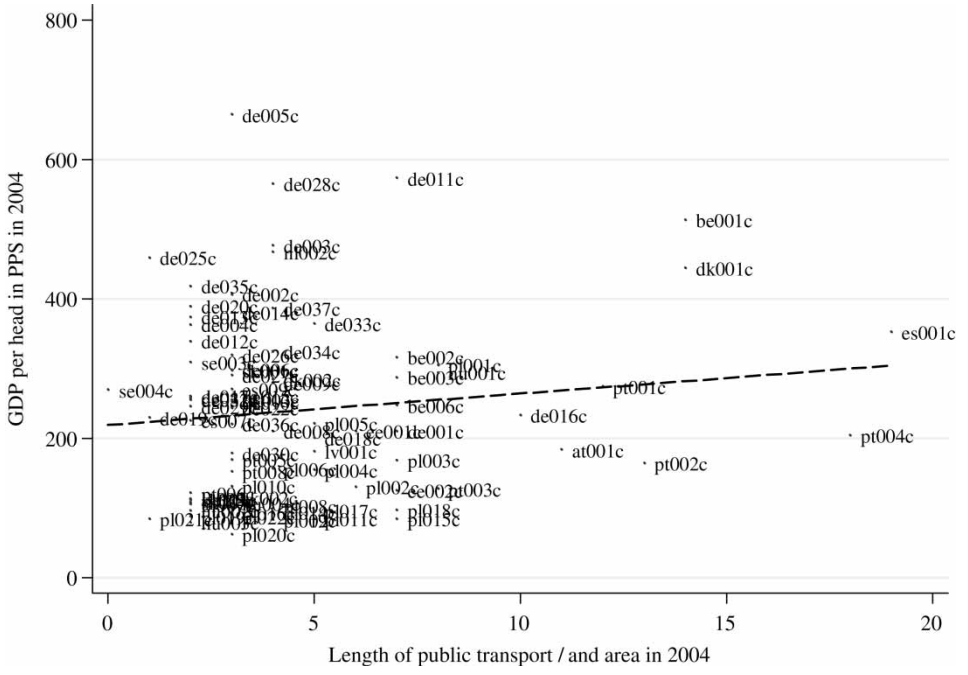

Figure 4. Public transport and wealth

Figure 4 shows instead the relationship between the availability of public transportation (normalized by the city area) and the level of wealth, measured as before with per capita GDP in PPS. The relationship is strongly positive; the city of Stockholm has been excluded from the original dataset as it behaves as an outlier, with an outstandingly high density of public transportation. With the inclusion of Stockholm the interpolation line would become even steeper. It is quite evident that an efficient net of public transportation is associated with high levels of wealth. Although the direction of causality in this relation may go both ways, it seems reasonable to think that a dense public transportation network may help to reverse the negative effects of urban density, thus at least partly releasing the pressure this exerts on the urban landscape and reducing the costs associated with congestion.

A slightly less significant and less steep association can be found between the level of GDP and a measure of e-government. The Urban Audit data set yields both the absolute number of government forms that can be downloaded from the website of the municipal authority, as well as the number of administrative forms which can be submitted electronically. As this last series has slightly more observations, and is, in our opinion, a better measure of the real chance for citizens to interact with the urban Public Administration via the net, we represent this in Figure 5. The city of Krakow is in this case excluded as an outlier (in terms of the number of forms that can be submitted online). The relationship does not change when the e-government measure is normalized by population or labor force (although this operation slightly changes the relative ranking of the cities in our sample).

Although cities with a high level of per capita GDP also tend to devote more attention to smart, e-government solutions, it is interesting to observe that some

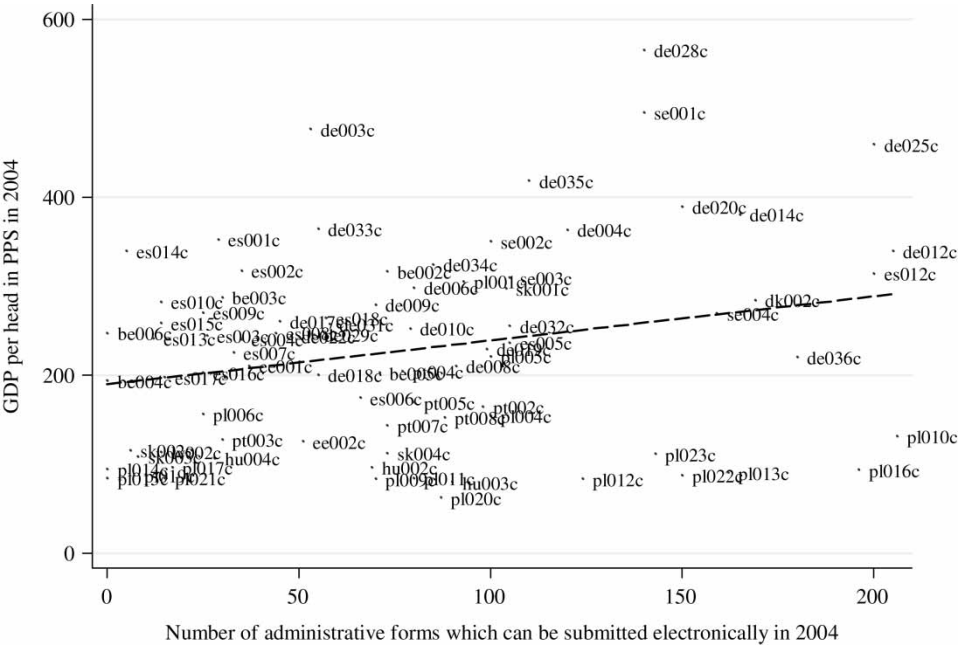

Figure 5. e-Government and wealth

noticeable exceptions characterize this analysis. Some cities in peripheral countries (Krakow in Poland; Zaragoza in Spain; Ponto Delgada in Portugal) have also devised a wide set of forms that citizens can submit online, thus reducing travel and commuting costs, and costs associated with the management of multi-task public administration bodies.

Finally, Figure 6 shows the relationship between the stock of human capital and the level of urban wealth. According to neoclassical theories (Lucas, 1988; Arrow, 1962; Mankiw et al., 1992), human capital levels are good predictors of subsequent economic performance. As Table 1 shows, in our sample this positive relationship has, nevertheless, more complex characteristics. The correlation coefficient between our measure of human capital, i.e., the share of the labor force qualified at ISCED levels 3 and 4, and the level of GDP is negative (although not significant at any statistical confidence level). The International Standard Classification of Education (ISCED) was designed by UNESCO in the early 1970s to serve "as an instrument suitable for assembling, compiling and presenting statistics of education both within individual countries and internationally." It was approved by the International Conference on Education (Geneva, 1975) and was subsequently endorsed by UNESCO's General Conference when it adopted the Revised Recommendation concerning the International Standardization of Educational Statistics at its twentieth session (Paris, 1978) (Unesco, 2006).

Does this imply that more education is associated with poorer economic conditions? If we look at Figure 6 it seems clear that the correct fit of this relationship is through a quadratic interpolation. After an appropriate (quadratic) term has been taken into account, the linear correlation between human capital and GDP is positive and significant at the 1 percent level.[4]

The interpretation of this finding is, however, more difficult. By examining Figure 6 it is possible to identify some observations on the right-hand side of

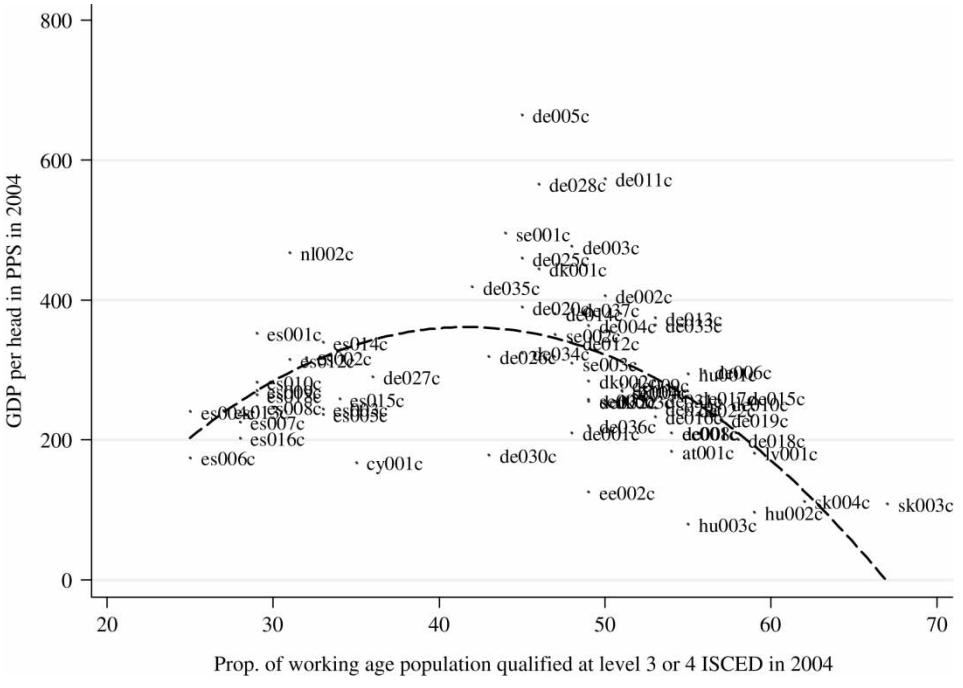

Figure 6. Human capital and wealth

the chart as cities in the NMS of the EU. As a legacy of the Communist period, when levels of education were deliberately held high, labor forces in those countries may still own a large stock of human capital, although overall levels of individual wealth may not yet match those of the old Member States. In this case, therefore, the depicted relationship may actually represent an off-saddle growth path portrait of the real human capital-urban growth equation. Indirect evidence to support this guess comes from splitting the sample into countries that in the 1980s were liberal or "capitalist" in Europe and those which belonged to COMECON, and then fitting the data with a linear trend; the latter turns out to be positive and significant for the first of these two subsamples and negative and significant for the second.

A second key to interpreting the puzzle may be obtained by reconnecting our study to Mayer (2007). She analyzes the different ways in which cities and regions can set up a high-technology cluster even without the presence of a sound research-oriented university, while also criticizing the opposite side of the story, viz. the idea that academic research centers are a necessary and sufficient condition for achieving high-tech oriented urban development. Therefore, cities in NMS may still fail to provide a sound connection between academic research institutes and the real economy, thus failing to attract the human capital-rich workers who raise productivity and wealth.

Conclusions and Policy Implications

In this paper, we have presented an overview of the concept of the smart city, with a critical review of the previous economics and planning approaches to

this concept. We then presented a narrower definition of the concept of the smart city, and reviewed some quantitative and graphical evidence on the correlations of some of the main determinants of economic performance and the most important measure of urban success, viz. per capita wealth.

Data from the 2004 Urban Audit data set show consistent evidence of a positive association between urban wealth and the presence of a vast number of creative professionals, a high score in a multimodal accessibility indicator, the quality of urban transportation networks, the diffusion of ICTs (most noticeably in the e-government industry), and, finally, the quality of human capital. These positive associations clearly define a policy agenda for smart cities, although clarity does not necessarily imply ease of implementation.

All variables shown to be positively associated with urban growth can be conceived of as stocks of capital; they are accumulated over time and are subject to decay. Hence, educating people is on average successful only when investment in education is carried out over a long period with a stable flow of resources; transportation networks must be constantly updated to keep up with other fast-growing cities, in order to keep attracting people and ideas; the fast pace of innovation in the ICT industry calls for a continuous and deep restructuring and rethinking of the communication infrastructure, to prevent European cities from losing ground to global competitors.

This continuous challenge, the "endless frontier" to quote Vannevar Bush's words on scientific research (Bush, 1945), is the only way to ensure a sustainable path of development for cities, while at the same time guaranteeing that cities will maintain their crucial role as the cradle of ideas and freedom.

Notes

1. This Google search was carried out on April 8, 2009.
2. PPP methods make it possible to better represent spatial disparities in the level of prices, and, consequently, more accurately gauge the real spending power of economic agents.
3. Del Bo and Florio (2008) offer a critical perspective on previous studies regarding the role of different forms of infrastructure in economic performance and provide empirical evidence on the contribution of single and aggregate measures of infrastructure on regional growth in the period 1995-2005.
4. Evidence of this last finding is available from the authors upon request.

Bibliography

M. Abreu, V. Grinevich, M. Kitson, and M. Savona, "Absorptive Capacity and Regional Patterns of Innovation," *Research Report* 8/11 (London: Department of Innovation, Universities, and Skills, 2008).

K.J. Arrow, "The Economic Implications of Learning By Doing," *Review of Economic Studies* 29:3 (1962).

C.R. Berry and E.L. Glaeser, "The Divergence of Human Capital Levels Across Cities," *Papers in Regional Science* 84:3 (2005) 407–444.

S. Breschi and F. Lissoni, "Localized Knowledge Spillovers vs. Innovative Milieux: Knowledge 'Tacitness' Reconsidered," *Papers in Regional Science* 80:3 (2001) 255–273.

Z. Bronstein, "Industry and Smart City," *Dissent* 56:3 (2009) 27–34.

V. Bush, *Science: The Endless Frontier* (Washington, D.C.: United States Government Printing Office, 1945).

R. Capello, "Spatial Spillovers and Regional Growth: A Cognitive Approach," *European Planning Studies* 17:5 (2009) 639–658.

A. Caragliu and P. Nijkamp, "The Impact of Regional Absorptive Capacity on Spatial Knowledge Spillovers," *Applied Economics* Forthcoming, <www.tandfonline.com/doi/abs/10.1080/00036846.2010.539549> Accessed July 12, 2011.

A. Coe, G. Paquet, and J. Roy, "E-Governance and Smart Communities: A Social Learning Challenge," *Social Science Computer Review* 19:1 (2001).

W. Cohen and D. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Administrative Science Quarterly* 35:1 (1990) 80–93.

D.R. Davis and D.E. Weinstein, "Market Access, Economic Geography, and Comparative Advantage: An Empirical Test," *Journal of International Economics* 59:1 (2003) 128–152.

C. Del Bo and M. Florio, "Infrastructure and Growth in the European Union: An Empirical Analysis at the Regional Level in a Spatial Framework," *Departmental Working Papers 2008-37* (Milan: University of Milan, Department of Economics, 2008), 1–23.

R.L. Florida, *The Rise Of The Creative Class and How It's Transforming Work, Leisure, Community and Everyday Life* (New York: Basic Books, 2002).

R.L. Florida, "Class and Well-Being" (2009), <http://www.creativeclass.com/creative_class/2009/03/17/class-and-well-being/> Accessed March 17, 2009.

S. Fu, "Smart Café Cities: Testing Human Capital Externalities in the Boston Metropolitan Area," *Journal of Urban Economics* 61:1 (2007) 87–111.

E.L. Glaeser, "A Review of Richard Florida's *The Rise Of The Creative Class*," *Regional Science and Urban Economic* 35:5 (2005) 593–596.

E.L. Glaeser and C.R. Berry, "Why Are Smart Places Getting Smarter?" *Taubman Center Policy Brief 2006-2* (Cambridge, MA: John F. Kennedy School of Government, 2006).

S. Graham and S. Marvin, *Telecommunications and the City: Electronic Spaces, Urban Place* (London: Routledge, 1996).

G.H. Hanson, "Market Potential, Increasing Returns, and Geographic Concentration," *Journal of International Economics* 67:1 (2005) 303–320.

R.G. Hollands, "Will The Real Smart City Please Stand Up? Intelligent, Progressive, or Entrepreneurial?" *City* 12:3 (2008) 303–320.

N. Komninos, *Intelligent Cities: Innovation, Knowledge Systems and Digital Spaces* (London: Spon Press, 2002).

R.E. Lucas, "On the Mechanics of Economic Development," *Journal of Monetary Economics* 22:1 (1988) 3–42.

N.G. Mankiw, D. Romer, and D.N. Weil, "A Contribution to the Empirics of Economic Growth," *The Quarterly Journal of Economics* 107:2 (1992) 407–437.

H. Mayer, "What Is the Role of the University in Creating a High-Technology Region?," *Journal of Urban Technology* 14:3 (2007) 33–58.

L.M. Mc Allister, H.M. Hall, H.L. Partridge, and G.C. Hallam, "Effecting Social Change in the 'Smart City': The West End Connect Community Project," paper presented at *Social Change in the 21st Century* (Brisbane, October 28, 2005).

P. Nijkamp, "E Pluribus Unum," *Region Direct* 2:2 (2010) 56–65.

OECD – EUROSTAT, *Oslo Manual* (Paris: Organization for Economic Cooperation and Development, Statistical Office of the European Communities, 2005).

H.L. Partridge, "Developing a Human Perspective to the Digital Divide in the 'Smart City," paper presented at the *Australian Library and Information Association Biennial Conference* (Gold Coast, Queensland, September 21-24, 2004).

S. Poelhekke, "Do Amenities and Diversity Encourage City Growth? A Link Through Skilled Labor," *Economics Working Papers ECO2006/10* (2006).

J.E. Rauch, "Productivity Gains from Geographic Concentration of Human Capital: Evidence from the Cities," *Journal of Urban Economics* 34:3 (1993) 380–400.

S.J. Redding and D.M. Sturm, "The Costs of Remoteness: Evidence from German Division and Reunification," *The American Economic Review* 98:5 (2008) 1766–1797.

L-H. Roller and L. Waverman, "Telecommunication Infrastructure and Economic Development: A Simultaneous Approach," *American Economic Review* 91:4 (2001).

J.M. Shapiro, "Smart Cities: Quality Of Life, Productivity, and the Growth Effects of Human Capital," *The Review of Economics and Statistics* 88:2 (2008) 324–335.

Southampton City Council, *Southampton On-Line* (2006) <http://www.southampton.gov.uk/thecouncil/thecouncil/you-and-council/smartcities/> Accessed March 13, 2009.

The Science Museum, *Urban Development* (2004) <http://www.makingthemodernworld.org.uk/learning_modules/geography/04.TU.01/?section=2> Accessed April 3, 2009.

United Nations, *World Urbanization Prospects: The 2009 revision* (2009) <http://esa.un.org/unpd/wup/index.htm> Accessed February 15, 2011.

UNESCO. *International Standardization of Educational Statistics* (2006) <www.uis.unesco.org/Library/Documents/isced97-en.pdf>

Appendix: Urban Audit Codes and City Names

Urban Audit Code	City Name
at001c	Wien
at002c	Graz
at003c	Linz
be001c	Bruxelles
be002c	Antwerpen
be003c	Gent
be004c	Charleroi
be005c	Liège
be006c	Brugge
bg001c	Sofia
bg002c	Plovdiv
bg003c	Varna
bg004c	Burgas
bg005c	Pleven
bg006c	Ruse
bg007c	Vidin
ch001c	Zürich
ch002c	Genève
ch004c	Bern
ch005c	Lausanne
cy001c	Lefkosia
cz001c	Praha
cz002c	Brno
cz003c	Ostrava
cz004c	Plzen
cz005c	Usti nad Labem
de001c	Berlin
de002c	Hamburg
de003c	München
de004c	Köln
de005c	Frankfurt am Main
de006c	Essen
de008c	Leipzig
de009c	Dresden
de010c	Dortmund
de011c	Düsseldorf
de012c	Bremen
de013c	Hannover
de014c	Nürnberg
de015c	Bochum
de016c	Wuppertal
de017c	Bielefeld
de018c	Halle an der Saale
de019c	Magdeburg
de020c	Wiesbaden
de021c	Göttingen
de022c	Mülheim a.d.Ruhr
de023c	Moers
de025c	Darmstadt
de026c	Trier
de027c	Freiburg im Breisgau
de028c	Regensburg
de029c	Frankfurt (Oder)
de030c	Weimar

(*Continued*)

Continued

Urban Audit Code	City Name
de031c	Schwerin
de032c	Erfurt
de033c	Augsburg
de034c	Bonn
de035c	Karlsruhe
de036c	Mönchengladbach
de037c	Mainz
dk001c	Copenhagen
dk002c	Aarhus
dk003c	Odense
dk004c	Aalborg
ee001c	Tallinn
ee002c	Tartu
es001c	Madrid
es002c	Barcelona
es003c	Valencia
es004c	Sevilla
es005c	Zaragoza
es006c	Málaga
es007c	Murcia
es008c	Las Palmas
es009c	Valladolid
es010c	Palma di Mallorca
es011c	Santiago de Compostela
es012c	Vitoria/Gasteiz
es013c	Oviedo
es014c	Pamplona/Iruña
es015c	Santander
es016c	Toledo
es017c	Badajoz
es018c	Logroño
fi001c	Helsinki
fi002c	Tampere
fi003c	Turku
fi004c	Oulu
fr001c	Paris
fr003c	Lyon
fr004c	Toulouse
fr006c	Strasbourg
fr007c	Bordeaux
fr008c	Nantes
fr009c	Lille
fr010c	Montpellier
fr011c	Saint-Etienne
fr012c	Le Havre
fr013c	Rennes
fr014c	Amiens
fr015c	Rouen
fr016c	Nancy
fr017c	Metz
fr018c	Reims
fr019c	Orléans
fr020c	Dijon
fr021c	Poitiers

(*Continued*)

Continued

Urban Audit Code	City Name
fr022c	Clermont-Ferrand
fr023c	Caen
fr024c	Limoges
fr025c	Besançon
fr026c	Grenoble
fr027c	Ajaccio
fr028c	Saint Denis
fr029c	Pointe-a-Pitre
fr030c	Fort-de-France
fr031c	Cayenne
fr032c	Toulon
fr035c	Tours
fr202c	Aix-en-Provence
fr203c	Marseille
fr205c	Nice
fr207c	Lens - Liévin
gr001c	Athina
gr002c	Thessaloniki
gr003c	Patra
gr004c	Iraklio
gr005c	Larissa
gr006c	Volos
gr007c	Ioannina
gr008c	Kavala
gr009c	Kalamata
hu001c	Budapest
hu002c	Miskolc
hu003c	Nyiregyhaza
hu004c	Pecs
ie001c	Dublin
ie002c	Cork
ie003c	Limerick
ie004c	Galway
it001c	Roma
it002c	Milano
it003c	Napoli
it004c	Torino
it005c	Palermo
it006c	Genova
it007c	Firenze
it008c	Bari
it009c	Bologna
it010c	Catania
it011c	Venezia
it012c	Verona
it013c	Cremona
it014c	Trento
it015c	Trieste
it016c	Perugia
it017c	Ancona
it018c	l'Aquila
it019c	Pescara
it020c	Campobasso
it021c	Caserta

(*Continued*)

Continued

Urban Audit Code	City Name
it022c	Taranto
it023c	Potenza
it024c	Catanzaro
it025c	Reggio di Calabria
it026c	Sassari
it027c	Cagliari
lt001c	Vilnius
lt002c	Kaunas
lt003c	Panevezys
lu001c	Luxembourg
lv001c	Riga
lv002c	Liepaja
mt001c	Valletta
nl001c	s' Gravenhage
nl002c	Amsterdam
nl003c	Rotterdam
nl004c	Utrecht
nl005c	Eindhoven
nl006c	Tilburg
nl007c	Groningen
nl008c	Enschede
nl009c	Arnhem
nl010c	Heerlen
pl001c	Warszawa
pl002c	Lodz
pl003c	Krakow
pl004c	Wroclaw
pl005c	Poznan
pl006c	Gdansk
pl007c	Szczecin
pl008c	Bydgoszcz
pl009c	Lublin
pl010c	Katowice
pl011c	Bialystok
pl012c	Kielce
pl013c	Torun
pl014c	Olsztyn
pl015c	Rzeszow
pl016c	Opole
pl017c	Gorzow Wielkopolski
pl018c	Zielona Gora
pl019c	Jelenia Gora
pl020c	Nowy Sacz
pl021c	Suwalki
pl022c	Konin
pl023c	Zory
pt001c	Lisboa
pt002c	Oporto
pt003c	Braga
pt004c	Funchal
pt005c	Coimbra
pt006c	Setubal
pt007c	Ponto Delgada
pt008c	Aveiro

(*Continued*)

Continued

Urban Audit Code	City Name
ro001c	Bucuresti
ro002c	Cluj-Napoca
ro003c	Timisoara
ro004c	Craiova
ro005c	Braila
ro006c	Oradea
ro007c	Bacau
ro008c	Arad
ro009c	Sibiu
ro010c	Targu Mures
ro011c	Piatra Neamt
ro012c	Calarasi
ro013c	Giurgiu
ro014c	Alba Iulia
se001c	Stockholm
se002c	Göteborg
se003c	Malmö
se004c	Jönköping
se005c	Umeå
si001c	Ljubljana
si002c	Maribor
sk001c	Bratislava
sk002c	Kosice
sk003c	Banska Bystrica

(*Continued*)

Continued

Urban Audit Code	City Name
sk004c	Nitra
uk001c	London
uk002c	Birmingham
uk003c	Leeds
uk004c	Glasgow
uk005c	Bradford
uk006c	Liverpool
uk007c	Edinburgh
uk008c	Manchester
uk009c	Cardiff
uk010c	Sheffield
uk011c	Bristol
uk012c	Belfast
uk013c	Newcastle upon Tyne
uk014c	Leicester
uk015c	Derry
uk016c	Aberdeen
uk017c	Cambridge
uk018c	Exeter
uk019c	Lincoln
uk020c	Gravesham
uk021c	Stevenage
uk022c	Wrexham
uk023c	Portsmouth
uk024c	Worcester