Smart Cities and a Stochastic Frontier Analysis: A comparison among European cities

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Abstract

The growing interest and debate on smart cities and the vast literature on this topic (Hollands, 2008; Caragliu et al., 2009, Nijkamp et al., 2011) led to the identification of a number of characteristic factors, such as economic development, environment, human capital, culture and leisure, and finally e-Governance. Factors that have been structured in a recent research conducted by the University of Vienna, Delft and Ljubljana (http://www.smart-cities.eu/) in some intangible indicators: smart economy, smart mobility, smart environment, smart people, smart living, smart governance; factors and indicators declined according to a hierarchical and unweighted framework. Having in mind the limits of the methodology used to define the concept of smartness and the resulting ranking of some European cities, the aim of our analysis is to use a more complex empirical model based on the concept of output maximizing. This method allows us to build a stochastic frontier to which decision makers can refer in order to assess the economic distance that separates them from being smart. The methodology, developed by Battese and Coelli (1995), allows to incorporate in the analysis peculiar (or rather structural or context) characteristics of each European city within the error that is called technical inefficiency. Moreover, this approach allows to distinguish the inputs from the factors of efficiency / inefficiency and to calculate the distance of every single city from the frontier of efficiency by splitting the error into a systematic component (which therefore depends on the structural characteristics of city) and in the error itself. The conclusion of the work is the construction of a ranking of European cities that find in the technical inefficiency a kind of weighting term.

Keywords: stochastic frontier, smart cities, technical inefficiency

JEL classification: D63, Q01, R11

1. Introduction

Nowadays half of the population lives in cities and the urbanization process is still at present in all countries. At the beginning of the 20th century, it was thought that cities with 8 or 10 million inhabitants were unimaginable and in each case unmanageable. Sociologists and urban planners believed that the growth of cities should be blocked and alternative solutions should be offered. Though, these hypotheses have been overcome by the reality: the growth of cities is still increasing. More recently, some scholars, such as Sassen (2004), emphasize the phenomenon of irreversibility of city growth and of the centrality of cities in being the engine of development. As a consequence, cities have some negative effects. First, they consume more or less the 80% of energy produced in a country. Second they represent the place in which the majority of communication takes place. Third they are the main source of pollution. For all these reasons, making cities more livable is becoming the most important and no-longer postponable objective of policy makers.

Several actions can be pursued to reach this target. The majority of these measures are related to specific physical, logistical, cultural and economic conditions of each city, even if, in general they should be radical and "heavy" implying significant financial resources and time-consuming.

In these recent years it has been developed the concept of “smart city”, which implies, instead, lighter and less expensive approaches. The smart city concept has been introduced among the European Union keywords in 2009 under the SET (Strategic Energy Technology) Plan. Here is indicated as Smart City, a city (or a large conglomerate), which aims to improve energy efficiency undertaking as target the double level with respect to that decided by EU (i.e. the 20/20/20). However the terminology of smart city and its subsequent definition have been developed before the SET Plan. The description of smart city has been linked to the concept of innovation as an engine for development and of sustainability (economic, social and environmental) as target to aim for. This target is strongly linked to the level of human capital and education – or, in Florida’s jargon, to the ‘creative class’ – in urban context. Berry and Glaeser (2005, 2006) show, for example, that innovation is driven by entrepreneurs who innovate in industries and products which require an increasingly more skilled labour force.

Starting from this framework the aim of our paper is the analysis of the efficiency of the same European cities of Giffinger et al. (2007)’ study. Using data of the Urban Audit dataset, we applied the stochastic frontier approach to estimate the production functions of the selected European cities. On the basis of this approach we are able to separate production inputs such as physical and human capital from efficiency/inefficiency factors described by the Giffinger et al. (2007)’ indicators of a smart city. Moreover, we can disentangle distances from the efficient frontier dividing the error component in two aspects: the systematic and the noise component. Finally, we rank the European cities on the basis of the estimated technical inefficiency.

The increasing importance of the quality of life within a city is mainly related to the economic development of an area. Our results tend to confirm this linkage. For this reason only an efficient city has the requisites to be a focal point for skilled labour force, businesses, students, tourists, etc.. Our empirical estimation finds that the north of Europe (German and UK cities) has the most efficient cities.

The remaining of the paper is organized as follows. The second section provides the background literature on smart cities. In the third section, we describe the methodology used, while in the fourth section we illustrate our specification of the stochastic frontier approach. The fifth section reports data analysis and empirical results. Finally, we conclude in section six.

2. Literature Review

The issue of innovation has found, over the past 30 years, various ways of connection with the territory. The first theorization of this relationship can indeed be detected in the late seventies in the concept of industrial district of the Third Italy (Bagnasco, 1977), paradigm then spread through the concept of industrial clusters (Porter, 1990), meant as a "geographical concentration of industries that take performance advantages through co-location, which refers to agglomeration economies, both of scale or scope". Further developments are traceable in science and technology parks (400 cases in Europe alone) and in the so called Technopolis. In all these cases the mechanism that generates innovation is mainly due to three factors:

1) the concentration of many and diverse expertise in various fields of knowledge and production;
2) networks of cooperation among members;
3) the presence of catalysts that facilitate the combination of different skills and units.

In the '90s the technological paradigm of districts has been replaced by that of the National Innovation System (Lundvall, 1992 and Nelson, 1992), which looks at the macroeconomic factors that influence the processes of technology transfer. However in the late 90s the focus has shifted increasingly to the local dimension, with studies on Learning Regions, Regional Innovation System and Local Innovation Systems (Cooke et al., 2004), characterized by:

- the ability of companies to learn and generate knowledge;
- organizational learning, able to amplify the knowledge produced by individuals;

- systemic innovation (relative to an entire city-region) rather than linear (internal research laboratories);
- institutions that work as switches selecting (on) or rejecting (off) innovations;
- development of social capital.

In this context matured the awareness that, although the production of new knowledge is available on a global scale, innovation processes, i.e. the application of that knowledge, essentially are developed on a local scale. Indeed, it is on a restricted territorial scale that more effectively the processes for collaboration among individuals are triggered. Processes, this lasts, that lead to the creation, hybridization, and finally, the transfer of knowledge and technology from the world of scientific research to industry

Since 1994 the key concepts of the paradigm of learning regions have been adopted by the European Commission taking concrete form in a new family of strategic innovation and technology policies at regional level: Regional Innovation and Technology Transfer Strategies and Infrastructures (RITTS), Regional Technology Plans (RTP), Regional Innovation Strategies (RIS) and Regional Programmes of Innovative Actions (PRIA).

After 2000, due to the gradual dematerialisation of the infrastructure, the progressive digitization of innovation, the new forms of online learning and the advent of ever more virtual technologies, a new approach has emerged linking the regional innovation to the management of the knowledge and information society: the intelligent regions. These correspond to areas characterized by the presence of strong systems of innovation combined with IT infrastructure and services of digital innovation. It is in this context that has been developed the model of the triple helix (Etzkowitz and Lydesdorff, 2000) and the model of the three T, Technology, Talent and Tolerance (Florida, 2002). The first identifies the relationship university-industry-government as a complex of interdependent institutional spheres that overlap and complement each other along the process that leads to innovation. The second shows that is not enough for innovation and growth a good supply of technology and talent, because they should also be accompanied by a significant amount of tolerance (today we call it social cohesion). These models finally have been followed by several contributions on the role of creativity in urban development (Gabe, 2006; Markusen, 2006; Fusco Girard et al., 2009).

The concept of intelligent or smart cities is grounded and rooted in these assumptions. In the early contributions in which this concept is explained (Shapiro, 2003, 2006, Glaeser, 2005; Glaeser and Berry, 2006) the emphasis is mainly on the role of human capital (and therefore in the metaphorical sense of creativity and of intelligence) as an engine of growth and development.

In particular, Shapiro (in quale anno?) finds a positive correlation between human capital and employment growth for the period from 1940 to 1990 in U.S. metropolitan areas. One cause that can explain this relationship is undoubtedly the presence of omitted variables, i.e. variables that are correlated with both the human capital with employment

growth, but not only; Shapiro (in quale anno?) concludes that a highly educated population generates levels of productivity and then further growth through knowledge spillovers. Moreover, in areas inhabited by people with a high level of education there is a rapid increase in the quality of life. Through the use of instrumental variables is also shown how this causal relationship is worth only if, as a proxy for human capital, is used the concentration of university graduates.

Similarly, Glaeser (2005), focusing primarily on U.S. cities, states that the highest rates of urban growth are present where highly educated workforce is available. In particular, one of the mechanisms identified by this model is based on the assumption that innovation processes are promoted by entrepreneurs in sectors that require a workforce more skilled and educated. Finally, high levels of human capital are also associated with a reduction of corruption and governance improvements in performance.

In a subsequent study (Glaeser and Redlick, 2008) next to the concept of human capital, social capital is highlighted as the key determinant of urban growth. In this sense social capital should therefore be encouraged through a series of local activities (place-making: political activism and activities such as group membership). Identified in the study are two possible dynamics. The first outlines a perspective in which the investment in social capital is scarce, fact that makes the area less attractive and therefore urges the inhabitants to relocate. The second outlines instead a virtuous circle in which the residents plan to stay in a particular city, investing in social capital and make the area more attractive. This argument therefore justifies government subsidies in areas in decline with the aim to increase the livability of a given cluster to move from a negative to a virtuous spiral.

However, the first operational definition of Smart city has been given by Giffinger et al. (2007):

"*a smart city is a city well performing in six characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens*"

This description extends previous results by identifying six dimensions or characteristics determinants, (economics, people, governance, mobility, environment and quality of life), in turn broken down into 31 major factors and 74 indicators in total. Thanks to this definition for the first time has been carried out a classification of cities according to their level of smartness. This classification, as has become an important reference in the debate about smart cities, by the authors' own admission (Giffinger and Haindlmaier, 2010) presents a number of limitations relating to for example not being able to measure all the indicators, rather than on the fact that a significant number of indicators (35%) were available only at national level.

Following this approach a recent study (Caragliu, Del Bo and Nijkamp, 2009), includes in the definition of Smart Cities, the following key concepts:

- use of interconnected infrastructures that improve economic and political efficiency facilitating at the same time the development of social, cultural and urban development;
- ability to be "business-friendly", i.e. able to attract and accommodate business projects;
- attention to social inclusion;
- coexistence and complementarity of high-tech and soft infrastructure;
- attention to the role of social and relational capital within the urban area;
- environmental sustainability.

The study, using data sets derived from Urban Audit, measures the effect of some variables, considered essential to urban growth, on the GDP of any city, used as a proxy of "wealth". The analysis confirms the existence of a positive correlation between urban welfare[1] and percentage of people employed in the "creative" sector[2], the efficiency of public transport system, the accessibility to services, the level of e-government and, finally, the quality of human capital[3].

Other studies (Nijkamp et al. 2011) focus on the interrelationships among the components of smart cities (as defined by Giffinger 2007), including human and social relations that link the intellectual capital, health and governance through an approach based on the triple helix model. In this framework, the city is called "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.*" (Caragliu et al., 2009, p.6). "*Furthermore, cities can become "smart" if universities and industry support government's investment in the development of such infrastructures.*" (Nijkamp et al., 2011, p.3)

From another point of view, assuming as target that of social innovation, smart cities are cities that create the conditions of governance, infrastructure and technology to produce social innovation, that is to solve social problems related to growth, to inclusion and quality of life through listening and involvement of different local actors: citizens, businesses and associations.

The raw materials become information and knowledge and the cities can qualify themselves according to the way in which these lasts are produced, collected and shared to produce innovation. Regardless of the type of communication (financial, economic, social or cultural), cities are increasingly active nodes of that intangible flows in addition to physical ones.

In this perspective, and depending on the priority given to different forms of communication and participation, some models of smart cities have been identified:

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1 Measured in terms of GDP

2 A "creative" sector means workforce employed in sciences, engineering, education, information technology, research, arts and design.

3 http://www.urbanaudit.org/

- **net city** (Castells 2004), flexible city able to relate and to its population and to international flows (linked to the areas of finance, economy and culture), hinge connection between the local and the global;
- **open city** (http://opencities.net/), cities that prioritize the transparency of their work (online publication of all acts, live broadcast streaming of council meetings, access to official acts, adoption of open data model, crowdsourcing, etc..);
- **sentient cities** (Shepard, 2011), cities aimed primarily at improving operational efficiency and sustainable development, through infrastructure able to produce and manage information on how it works, actively involving citizens in the priority areas of its functions (e.g. mobility, energy, quality of environment);
- **wiki cities** (Calabrese et al., 2009), cities that allow to their inhabitants to base their actions and decision in a better informed manner (trough real time location-sensitive tools), leading to an overall increased efficiency and sustainability in making use of the city environment.
- **cities 2.0** (Chadwick, 2009), cities that have as fundamental characteristic the involvement of citizens (e-democracy, public contest, wikis government, co-design of services) in the management of public affairs;
- **neo-bohème cities** (Lloyd, 2006), cities which offer scope for bottom-up communication in the form of artistic production, thus creating the conditions for the redevelopment of urban areas;
- **creative cities** (Florida, 2002), cities whose objective is to mobilize and develop human resources and skills hosted for the global competition. To this must be "tolerant" and able to attract creative human capital in innovative and research fields.
- **resilient cities** (Otto-Zimmermann, 2011), cities that help citizens better understand the risks of its territory, especially related to climate change, through education and awareness, and share information in the event of threatening events;
- **cloud cities** (Ballon et al., 2011), cities that make the technology a facilitator of the interaction, a software connection among ideas, initiatives, skills and experiences.

The features of a smart city are therefore very articulated and in order to proceed in the use of this concept becomes a priority starting from a shared definition. In this paper the choice made, although aware of the limits of the approach, is to refer to the definition and measurement given by Giffinger et al. (2007).

3. The Methodology

We have underlined that not only countries but even cities have to face the challenge of combining competitiveness and sustainable urban development simultaneously. In other

words, cities should become efficient. In the economic theory, the neoclassical paradigm is based on the assumption that two agents having the same information on the production function could maximize their profits and thus be efficient identically. We can apply the same hypothesis to those cities which have been defined smart by the analysis carried on by Giffinger et al. (2007).

In reality, however, two cities – even if identical – cannot produce a similar output with the same costs and profits. In other words, the difference between two cities can be explained through the analysis of efficiency and some unforeseen exogenous shocks, as described by Desli et al. (2002).

Traditionally, the empirical analysis of production functions has focused on the standard econometric approach based on OLS model incorporating a random error term which can take both positive and negative values (Thomas, 1993). However, the estimation of these production functions has some limits. The main one is based on the fact that the results represent an average relationship between output and inputs in a particular data sample (Alaudddin et al., 1993).

So, a simple OLS regression is not sufficient to estimate the relationship between output and inputs as described in Feld et al. (2004). Other relevant limits are linked to the impossibility to discriminate between rent extraction and productive efficiency and to measure the distance of each unit of analysis from the efficiency frontier for a given production function.

Consequently, in recent years, several and new econometric techniques have been developed to estimate the frontier of the production function in order to correspond to the economist's theoretical definition (Kalirajan and Shand, 1999).

To estimate a frontier production function, parametric or nonparametric techniques can be undertaken (Coelli et al., 1998). In this paper, we have estimated the production function of cities using the stochastic frontier approach (SFA) [4] initially and independently developed by Aigner et al. (1977) and Meeusen and van den Broeck (1977).

This approach allows to distinguish between production inputs and efficiency/inefficiency factors and to disentangle distances from the efficient frontier between those due to systematic components and those due to noise. This parametric approach is preferred to nonparametric ones since it avoids that outliers are considered as very efficient countries (Signorini, 2000).

The main idea is that the SFA, which represents the maximum output level for a given input set, is assumed to be stochastic in order to capture exogenous shocks beyond the control of cities.

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4 A number of comprehensive reviews of this literature is now available. See for example Forsund et al. (1980), Schmidt (1986), Bauer (1990), Greene (1993) and Coelli et al. (1998).

Since all cities are not able to produce the same frontier output, an additional error term is introduced to represent technical inefficiency[5]. After these early studies, the SFA methodology has been extended in many directions using both cross-sectional and panel data. The availability of panel data allows studying the behaviour of technical inefficiency over time. Among others, Pitt and Lee (1981), Schmidt and Sickles (1984) Kumbhakar (1987) and Battese et al. (1989) treated technical inefficiency as time invariant while for example Cornwell et al., (1990), Kumbhakar (1990), Battese and Coelli (1992) and Lee and Schmidt (1993) allowed technical inefficiency to vary over time even if they modelled efficiency as a systematic function of time.

The search for the determinants of efficiency changes has been firstly pursued by adopting a two stage approach in which the efficiencies estimated in the first stage were then regressed against a vector of explanatory variables. Further development of this technique led to the adoption of a single stage approach in which explanatory variables are incorporated directly into the inefficiency error component[6]. In particular, Kumbhakar, Gosh and McGuckin (1991) noted the inconsistency between the i.i.d. assumption on the inefficiency effects at the first stage and the non identical distribution of the predicted inefficiency effects in the second stage, and proposed a model in which the inefficiency effects were explicit functions of a vector of firm-specific factors and the parameters were estimated in a single stage maximum likelihood procedure.

A further development of this first approach has been the Battese and Coelli (1995) model in which the allocative efficiency is imposed, the first-order profit maximising conditions removed, and panel data is permitted. Thus, the Battese and Coelli (1995) model specification may be expressed as:

$$(1) \qquad Y_{it} = x_{it}\beta + (v_{it} - u_{it}) \qquad i=1,...,N,\ t=1,...,T$$

where Y_{it} is (the logarithm of) the production of the *i-th* city in the *t-th* time period; x_{it} is a $k\times1$ vector of (transformations of the) input quantities of the *i-th* city in the *t-th* time period; β is a vector of unknown parameters. The unobserved random noise is divided into a first component v_{it} which are random variables following the assumption of normally distributed error terms [iid $N(0, \sigma_V^2)$], and a second independent component defined as u_{it} which are non-negative random variables. These variables are assumed to capture the effects of technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(m_{it}, \sigma_U^2)$ distribution.

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5 We follow the Farrel (1957) measure of firm's efficiency consisting in two components: technical and allocative. The former reflects the ability of a firm to obtain maximal output from a given set of inputs while the latter reflects the ability of a firm to use the inputs in optimal proportions given their respective prices. These considerations are obviously true also at the country level considering that the aggregate output comes from the sum of national producers.

6 For a review see Kumbhakar and Knox - Lovell (2000).

The mean of this truncated normal distribution is a function of systematic variables that can influence the efficiency of a city:

(2) $m_{it} = z_{it}\delta + \varepsilon_{it}$,

where z_{it} is a $p\times1$ vector of variables which may have an effect on the production function of a region; and δ is a $1\times p$ vector of parameters to be estimated.

Following Battese and Corra (1977), the simultaneous maximum likelihood estimation of the two equation system is expressed in terms of the variance parameters $\sigma^2=\sigma^2_v+\sigma^2_u$ and $\gamma=\sigma^2_u/(\sigma^2_v+\sigma^2_u)$, to provide asymptotically efficient estimates[7]. Hence, it is clear that the test on the significance of the parameter γ is a test on the significance of the stochastic frontier specification (the acceptance of the null hypothesis that the true value of the parameter equals zero implies that σ^2_u, the non random component of the production function residual, is zero).

The technical efficiency of the *i-th* city in the *t-th* time period is given by:

(3) $TE_i = e^{(-u_i)} = e^{(-z_{it}\delta-\varepsilon_{it})}$

4. Our Empirical Model

In this paper we analyze the economic performance and the efficiency of several European cities, following the 1995 Battese and Coelli specification, using an unbalanced panel dataset. Model results are computed using the program FRONTIER 4.1, which can manage either balanced or unbalanced panel data.

Data of this study have been obtained by Urban Audit dataset of EUROSTAT. The Urban Audit data provides information and comparable measurements on the different aspects of the quality of urban life in European cities. Nowadays the analysis of the quality of life in a city is becoming a crucial aspect for the development of an area and more generally of a country. To be able to attract and retain skilled labour force, businesses, students, tourists and, most of all, residents in a city means to be an efficient city or in other words a smart city.

Unfortunately Urban Audit dataset presents several limits. In particular, data are collected every three years and a lot of variables have missing data problem. Having in mind these limitations on data, we perform our estimation using an unbalanced panel data of European cities in three different waves of survey.

Our dataset has been selected following the 70 cities considered in the ranking of European medium-sized cities by Giffinger et al. (2007). Within the Urban Audit dataset

7 The log-likelihood function and the derivatives are presented in the appendix of Battese and Coelli (1993).

there are several waves of survey[8]. But due to comparability and missing data problem we use only three out of six waves: 1999-2002, 2003-2006 and 2007-2009.

In our model, the production of each city is measured by Gross Domestic Product in PPS of NUTS 3 region (Y_{it}) and, as usual is assumed to be a function of three inputs: physical capital (K_{it}), labour (L_{it}) and human capital (H_{it}). As a city is not a firm, it was not easy how to consider the physical capital of a city. As a first attempt, we have decides to consider two different aspects: houses measured by the number of dwellings and transport measured by the length of public transport network (km) as described by Economist Intelligence Unit (2012). The second input, the labour variable instead is represented by the number of employees as usual. As regards the third input, human capital, we consider the number of residents (aged 15-64) with ISCED level 3 or 4 as the highest level of education due to the impossibility to have data on the level of education of labour force.

By assuming that the production function takes the log - linear Cobb-Douglas form, our stochastic frontier production model can be specified as follows:

$$(4) \qquad ln(Y/L)_{it} = \beta_0 + \beta_1 ln\left(Kdwelling/L\right)_{it} + \beta_1 ln\left(Ktransport_{net}/L\right)_{it} + \beta_2 ln\left(H/L\right)_{it} + v_{it} - u_{it}$$

where the dependent variable is the value of the economic performance of the *i-th* city at time t ($i=1,...,N;\ t=1,...,T$), divided by a scale variable (the labour force) in order to remove potential problems of heteroskedasticity, multicollinearity and output measurement (Hay-Liu, 1997) and the independent variables are: i) physical capital pro-capita (*Kdwelling/L* and *Ktransport_net/L*) which represents the city capital stock per worker of the *i-th* city at time t and ii) human capital (H/L) which is the city education level of residential people per worker of the *i-th* city at time t.

To take into account the technical inefficiencies of European cities, we model the second component of the error as a function of several observable explanatory variables as we show in the following equation:

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[8] The first three waves of survey (1989-1993, 1994-1998, 1999-2002) can be considered as “pilot”, instead the first full-scale European Urban Audit took place in 2003 for the then 15 countries of the European Union. In 2004, the project was extended to the 10 new Member States plus Bulgaria, Romania and Turkey (25 EU countries). For the 2003/2004 data collection exercise, 336 variables were collected, covering most aspects of urban life. The second full-scale data collection for Urban Audit started in 2006 and was completed in 2007. It involved 321 European cities in the 27 countries of the European Union along with 36 additional cities in Norway, Switzerland and Turkey. The basic philosophy was to deviate as little as possible from the concepts used in the 2003/2004 collection. However, in some cases, changes were made with the aim of improving comparability, data availability and quality. In the last two waves 2007-2009 and 2010-2012 small changes are made to the lists of variables and cities compared to 2006.

(5)
$$u_{it} = \gamma_0 + \gamma_1 Smart_{Economy_{it}} + \gamma_2 Smart_{People_{it}} + \gamma_3 Smart_{Governance_{it}} + \gamma_4 Smart_{Mobility_{it}} + \gamma_5 Smart_{Environment_{it}} + \gamma_6 Smart_{Living_{it}} + \sum_{k=7}^{26} \gamma_k Countrydummy + \varepsilon_{it}$$

where $Smart\_Economy_{it}$, $Smart\_People_{it}$, $Smart\_Governance_{it}$, $Smart\_Mobility_{it}$, $Smart\_Environment_{it}$ and $Smart\_Living_{it}$ represents the indicators that jointly describe the factors of a smart city as described by Giffinger et al. (2007). In that analysis, the group of researchers has developed six indicators on the basis of which they have ranked 70 European medium-sized cities. As described above, we are aware of the limits of the Giffinger et al. (2007)' analysis. In particular, we are critic on the inclusion of national data, even if necessary to broaden the database, as factor characteristics of indicators and on the mix of timing of the different factors at the basis of the six indicators. Moreover, the methodology to aggregate factors of the six indicators is too simple[9] and it does not consider the differences among cities. However, these indicators of smart cities represent until now the best description of the performance of 70 European cities. As we have already underlined, the focus of our analysis is the impact of smart city indicators on European cities' performance to somehow try to measure the efficiency of a city in attracting high skilled labour force, high technology businesses, the best students and so on in order to be an efficient city.

Finally, in order to analyze a recent issue emerged in the New Economic Geography literature, which says that a city belonging to a well developed area can perform better than a city belonging to a less developed area; we have introduced m-1 countries dummies to capture the influence of city geographical localization. A country in the north of Europe in fact should influence positively the city's economic performance and thus the technical inefficiency should be less with respect to others; in other words, the gap from the stochastic frontier of this city should be not so big.

5. Descriptive Evidence and Empirical Results

Table 1 provides the basic descriptive statistics for estimating the efficiency of European cities, in particular it describes output and input variables used in the analysis, subdividing cities on the basis of country belonging.

We can observed that only Germany has 17 cities considered in the sample, while the other countries have less and some countries are present with only one city. Moreover, it is clear that the length of public transport network per worker has missing data problem and has very low values.

9 They aggregate additively the factors dividing through the number of values added.

As regards the smart indicators, we can see that the Scandinavian cities are in the top of rank, while Germany and United Kingdom are more or less in the middle of the classification as described in more details in the report of Giffinger et al. (2007).

Table 1: Descriptive statistics

		Y_L	K_dwel_L	K_tran~L	H_L	SE	SP	SG	SM	SEn	SL
BG	**mean**	16,490	1.23	0.00	1.07	52.00	69.50	69.50	64.00	63.00	68.50
	p50	16,700	1.22	0.01	1.07	52.00	69.50	69.50	64.00	63.00	68.50
	sd	2,295	0.10	0.00	0.09	1.15	0.58	0.58	5.77	6.93	0.58
	min	13,970	1.12	0.00	1.01	51.00	69.00	69.00	59.00	57.00	68.00
	max	18,591	1.35	0.01	1.14	53.00	70.00	70.00	69.00	69.00	69.00
	N	4	4	3	2	4	4	4	4	4	4
CZ	**mean**	23,730	0.86	0.00	.	48.50	50.00	58.00	26.50	54.50	32.00
	p50	23,730	0.86	0.00	.	48.50	50.00	58.00	26.50	54.50	32.00
	sd	3,586	0.03	.	.	7.78	1.41	4.24	4.95	0.71	5.66
	min	21,194	0.84	0.00	.	43.00	49.00	55.00	23.00	54.00	28.00
	max	26,266	0.88	0.00	.	54.00	51.00	61.00	30.00	55.00	36.00
	N	2	2	1	0	2	2	2	2	2	2
DE	**mean**	58,722	1.04	0.00	0.67	28.47	43.88	28.82	15.53	22.41	34.88
	p50	56,903	0.94	0.00	0.62	32.00	45.00	27.00	16.00	21.00	38.00
	sd	22,413	0.56	0.00	0.39	15.42	4.91	10.77	4.32	7.87	7.61
	min	39,213	0.64	0.00	0.37	9.00	34.00	19.00	10.00	15.00	22.00
	max	135,669	3.12	0.00	2.10	47.00	50.00	48.00	22.00	38.00	45.00
	N	17	17	17	17	17	17	17	17	17	17
DK	**mean**	42,980	0.86	0.01	0.60	12.00	2.67	5.00	8.33	32.00	13.33
	p50	42,411	0.88	0.01	0.60	15.00	3.00	5.00	9.00	26.00	12.00
	sd	2,064	0.06	.	0.03	7.00	1.53	1.00	3.06	15.87	3.21
	min	41,261	0.79	0.01	0.56	4.00	1.00	4.00	5.00	20.00	11.00
	max	45,269	0.90	0.01	0.62	17.00	4.00	6.00	11.00	50.00	17.00
	N	3	3	1	3	3	3	3	3	3	3
EE	**mean**	16,799	0.85	0.00	0.69	40.00	15.00	30.00	47.00	49.00	60.00
	p50	16,030	0.83	0.00	0.65	40.00	15.00	30.00	47.00	49.00	60.00
	sd	3,184	0.09	0.00	0.19	0.00	0.00	0.00	0.00	0.00	0.00
	min	14,069	0.77	0.00	0.53	40.00	15.00	30.00	47.00	49.00	60.00
	max	20,296	0.94	0.01	0.90	40.00	15.00	30.00	47.00	49.00	60.00
	N	3	3	3	3	3	3	3	3	3	3
ES	**mean**	59,996	1.24	0.00	0.55	35.88	52.50	36.75	49.50	42.50	40.25
	p50	58,832	1.27	0.00	0.56	37.00	53.00	38.00	51.00	32.00	41.00
	sd	6,847	0.16	0.00	0.05	9.16	2.93	2.31	4.72	21.37	5.57
	min	48,843	0.96	0.00	0.47	22.00	48.00	34.00	44.00	24.00	34.00
	max	67,557	1.42	0.00	0.62	44.00	55.00	39.00	54.00	68.00	46.00
	N	8	8	2	6	8	8	8	8	8	8
FI	**mean**	48,508	1.12	0.01	0.63	22.86	7.29	1.71	24.57	11.86	10.00
	p50	49,068	1.12	0.00	0.62	25.00	7.00	2.00	27.00	12.00	9.00

	sd	4,313	0.05	0.00	0.02	6.57	0.76	0.76	3.36	1.07	4.00
	min	42,586	1.05	0.00	0.60	16.00	6.00	1.00	21.00	11.00	8.00
	max	55,202	1.18	0.01	0.65	29.00	8.00	3.00	28.00	14.00	19.00
	N	7	7	5	7	7	7	7	7	7	7
FR	**mean**	46,132	1.13	0.00	.	38.00	30.60	26.40	27.40	7.00	20.60
	p50	44,111	1.03	0.00	.	38.00	31.00	26.00	26.00	8.00	20.00
	sd	6,528	0.22	0.00	.	7.04	5.18	4.39	3.65	3.54	5.32
	min	38,034	1.00	0.00	.	30.00	23.00	22.00	24.00	1.00	15.00
	max	53,768	1.52	0.00	.	48.00	37.00	33.00	33.00	10.00	27.00
	N	5	5	5	0	5	5	5	5	5	5
HU	**mean**	21,798	1.03	0.00	1.00	57.00	64.50	66.00	54.00	67.50	55.50
	p50	22,067	1.03	0.00	1.00	57.00	64.50	66.00	54.00	67.50	55.50
	sd	1,611	0.04	0.00	0.05	1.15	2.89	1.15	4.62	2.89	2.89
	min	19,743	1.00	0.00	0.95	56.00	62.00	65.00	50.00	65.00	53.00
	max	23,314	1.07	0.01	1.06	58.00	67.00	67.00	58.00	70.00	58.00
	N	4	4	4	4	4	4	4	4	4	4
IE	**mean**	85,942	1.02	.	0.74	2.00	26.00	25.00	45.00	66.00	21.00
	p50	85,942	1.02	.	0.74	2.00	26.00	25.00	45.00	66.00	21.00
	sd	.	.	.	.	.	.	.	.	.	.
	min	85,942	1.02	.	0.74	2.00	26.00	25.00	45.00	66.00	21.00
	max	85,942	1.02	.	0.74	2.00	26.00	25.00	45.00	66.00	21.00
	N	1	1	0	1	1	1	1	1	1	1
LT	**mean**	22,084	0.91	.	0.94	55.00	36.00	66.00	55.00	27.00	65.00
	p50	22,084	0.91	.	0.94	55.00	36.00	66.00	55.00	27.00	65.00
	sd	2,626	0.06	.	0.08	0.00	0.00	0.00	0.00	0.00	0.00
	min	20,227	0.87	.	0.88	55.00	36.00	66.00	55.00	27.00	65.00
	max	23,941	0.95	.	0.99	55.00	36.00	66.00	55.00	27.00	65.00
	N	2	2	0	2	2	2	2	2	2	2
LU	**mean**	29,066	0.29	0.00	0.09	1.00	2.00	13.00	6.00	25.00	6.00
	p50	29,066	0.29	0.00	0.09	1.00	2.00	13.00	6.00	25.00	6.00
	sd	.	.	.	.	.	.	.	.	.	.
	min	29,066	0.29	0.00	0.09	1.00	2.00	13.00	6.00	25.00	6.00
	max	29,066	0.29	0.00	0.09	1.00	2.00	13.00	6.00	25.00	6.00
	N	1	1	1	1	1	1	1	1	1	1
LV	**mean**	20,985	1.09	0.01	.	60.00	12.00	63.00	61.00	61.00	70.00
	p50	20,612	1.07	0.01	.	60.00	12.00	63.00	61.00	61.00	70.00
	sd	1,871	0.05	0.00	.	0.00	0.00	0.00	0.00	0.00	0.00
	min	19,328	1.05	0.00	.	60.00	12.00	63.00	61.00	61.00	70.00
	max	23,014	1.16	0.01	.	60.00	12.00	63.00	61.00	61.00	70.00
	N	3	3	2	0	3	3	3	3	3	3
NL	**mean**	50,406	0.87	0.00	0.50	18.75	13.25	15.75	7.25	40.50	19.50
	p50	47,685	0.84	0.00	0.47	19.00	13.50	15.50	3.50	38.00	20.50
	sd	10,059	0.14	0.00	0.12	11.00	3.30	1.71	8.54	7.19	5.07
	min	41,960	0.73	0.00	0.39	6.00	9.00	14.00	2.00	35.00	13.00

	max	64,294	1.06	0.00	0.66	31.00	17.00	18.00	20.00	51.00	24.00
	N	4	4	3	4	4	4	4	4	4	4
PL	**mean**	29,971	1.07	0.00	1.33	66.40	35.20	56.60	48.60	55.20	55.20
	p50	32,809	1.12	0.00	1.36	67.00	27.00	57.00	46.00	56.00	55.00
	sd	11,307	0.27	0.00	0.30	2.41	17.46	2.30	7.44	5.89	3.96
	min	14,932	0.65	0.00	0.86	63.00	19.00	53.00	41.00	47.00	50.00
	max	44,179	1.40	0.00	1.68	69.00	56.00	59.00	57.00	62.00	61.00
	N	5	5	5	5	5	5	5	5	5	5
PT	**mean**	32,308	0.95	0.01	0.32	52.00	63.00	54.00	49.00	16.00	37.00
	p50	32,308	0.95	0.01	0.32	52.00	63.00	54.00	49.00	16.00	37.00
	sd	.	.	.	.	.	.	.	.	.	.
	min	32,308	0.95	0.01	0.32	52.00	63.00	54.00	49.00	16.00	37.00
	max	32,308	0.95	0.01	0.32	52.00	63.00	54.00	49.00	16.00	37.00
	N	1	1	1	1	1	1	1	1	1	1
RO	**mean**	19,372	1.19	.	.	53.50	64.50	62.00	63.00	8.50	60.50
	p50	19,372	1.19	.	.	53.50	64.50	62.00	63.00	8.50	60.50
	sd	4,380	0.18	.	.	4.95	0.71	2.83	1.41	6.36	2.12
	min	16,276	1.07	.	.	50.00	64.00	60.00	62.00	4.00	59.00
	max	22,469	1.32	.	.	57.00	65.00	64.00	64.00	13.00	62.00
	N	2	2	0	0	2	2	2	2	2	2
SE	**mean**	49,115	0.97	0.01	0.69	37.20	8.00	8.20	34.80	31.60	19.60
	p50	48,994	0.99	0.01	0.68	36.00	10.00	7.00	34.00	22.00	26.00
	sd	5,488	0.02	.	0.02	1.64	2.74	1.64	1.10	13.15	8.76
	min	41,914	0.94	0.01	0.66	36.00	5.00	7.00	34.00	22.00	10.00
	max	56,702	0.99	0.01	0.72	39.00	10.00	10.00	36.00	46.00	26.00
	N	5	5	1	5	5	5	5	5	5	5
SI	**mean**	35,066	0.75	0.00	0.74	28.50	16.00	40.00	35.50	2.50	30.50
	p50	34,146	0.74	0.00	0.74	28.50	16.00	40.00	35.50	2.50	30.50
	sd	5,901	0.12	0.00	0.14	22.46	5.48	3.29	4.93	0.55	1.64
	min	26,983	0.60	0.00	0.62	8.00	11.00	37.00	31.00	2.00	29.00
	max	42,326	0.88	0.00	0.87	49.00	21.00	43.00	40.00	3.00	32.00
	N	6	6	6	4	6	6	6	6	6	6
SK	**mean**	21,927	0.76	0.00	0.97	66.00	43.33	51.00	51.00	43.33	47.67
	p50	23,155	0.76	0.00	0.95	66.00	43.00	51.00	52.00	53.00	47.00
	sd	2,907	0.08	0.00	0.12	3.46	2.18	0.87	2.29	18.38	3.50
	min	16,559	0.66	0.00	0.84	62.00	41.00	50.00	48.00	19.00	44.00
	max	25,529	0.88	0.01	1.16	70.00	46.00	52.00	53.00	58.00	52.00
	N	9	9	9	5	9	9	9	9	9	9
UK	**mean**	54,588	0.78	.	0.45	7.00	37.22	46.22	35.89	63.89	38.78
	p50	52,841	0.78	.	0.38	7.00	38.00	47.00	35.00	64.00	40.00
	sd	5,030	0.07	.	0.13	3.57	5.52	2.86	3.98	2.15	4.52
	min	49,483	0.68	.	0.35	3.00	28.00	42.00	32.00	60.00	30.00
	max	66,110	0.92	.	0.71	13.00	42.00	49.00	42.00	67.00	43.00
	N	9	9	0	7	9	9	9	9	9	9

In **Table 2**, we report the results of the stochastic frontiers estimations. Since, in all specifications, we reject the null hypothesis of the insignificance of the non-negative random component of the production function residual (γ), we can conclude that the stochastic frontier specification is a good model to analyze the effect of smart city indicators on cities' economic performance. Moreover, the parameter (γ) also indicates the proportion of the total variance in the model which is accounted for by the inefficiency effects. This parameter, which is significant at the 1% level in all estimations, varies between 0.48 and 0.80 indicating that from 48% to 80% of the variance is explained by the inefficiency effects, confirming that the inefficiency effects are important in explaining the total variance in the model.

In particular, in the first and in the second columns we report the results of estimations which exclude the length of transport net but include the country dummies (column 2). While in the third and fourth columns it is included the length of transport net.

In all columns, the results indicate that production function performs quite well, because physical capital measured by dwellings shows always a positive and significant sign, while human capital and the length of transport net has negative signs but not significant. These amazing results should be explained considering the relevance of the missing data problem within the dataset as described by the number of observations.

However, the coefficients for human and physical capital are both significantly less than 1 indicating that output is inelastic with respect to both inputs. In addition, the sum of the inputs coefficients is less than 1 which implies decreasing returns to scale.

If we observed the signs of the smart city indicators in the first column, we can say that only Smart-People and Smart-Environment show a negative sign indicating that both variables have a positive effect on efficiency and hence a negative impact on inefficiency. The other Smart indicators, instead, show a vice versa effect, they increase inefficiency and decrease the efficiency. However, we have to underline that the signs can change in the other estimation results and that the significance of the coefficients reduces drastically in the other columns of **Table 2**.

Table 2: Inefficiency models with GDP pro-capita as dependent variable

dependent variable: gdp/L	**1**	**2**	**3**	**4**
Const β0	10.66***	10.82***	10.16***	10.58***
T	83.00	81.34	20.80	9.85
K dwelling/L β1	0.57***	0.51***	0.62***	0.51***
t	4.41	4.13	4.15	3.45
K_transport net/L β2			-0.11*	-0.13
t			-1.73	-1.31

H/L β3	-0.14**	-0.06	-0.08	0.16
t	-2.44	-1.06	-0.60	0.79
const γ0	-3.86***	-0.91	-3.98***	-2.22***
t	-11.13	-0.92	-5.85	-2.76
Smart Economy γ1	0.33***	0.44***	0.03	0.14
t	3.30	2.63	0.14	0.48
Smart People γ2	-0.21**	-0.17	-0.11	-0.07
t	-2.43	-0.71	-0.83	-0.16
Smart Governance γ3	0.36***	0.41	-0.07	0.21
t	2.64	1.37	-0.40	0.55
Smart Mobility γ4	0.47***	0.15	0.66***	0.58
t	3.89	0.45	3.67	1.52
Smart Environment γ5	-0.01	0.08	-0.01	-0.14
t	-0.24	0.58	-0.09	-0.57
Smart Living γ6	0.22	-0.33	0.70**	0.19
t	1.08	-1.02	1.96	0.30
CZ γ7		-0.65*		-0.23
t		-1.64		-0.27
DE γ8		-1.32***		-0.61
t		-3.29		-1.07
DK γ9		-0.16		-1.05
t		-0.31		-1.06
EE γ10		-0.05		-0.13
t		-0.14		-0.27
ES γ11		-1.18***		-2.92***
t		-2.82		-2.75
FI γ12		-0.12		0.07
t		-0.17		0.07
FR γ13		-0.87**		-0.72
t		-2.30		-1.08
HU γ14		-0.51**		-0.30
t		-2.40		-0.60
IE γ15		-0.64		
t		-0.76		
LT γ16		-0.54**		
t		-2.16		
LU γ17		0.03		-0.25
t		0.03		-0.25
LV γ18		-0.65		-0.44
t		-1.53		-0.47
NL γ19		-1.16		-0.07
t		-1.57		-0.07
PL γ20		-0.87***		-0.47
t		-3.96		-1.16
PT γ21		-0.86**		-2.26
t		-2.50		-1.59
RO γ22		-0.14		

t		-0.38		
SE $\gamma 23$		-1.25***		-1.71
t		-2.66		-1.49
SI $\gamma 24$		-0.69*		-1.08
t		-1.72		-1.28
SK $\gamma 25$		-0.69***		-0.45
t		-3.57		-1.27
UK $\gamma 26$		-1.29**		
t		-2.49		
n. of cities	54	54	39	39
Observations	101	101	69	69
sigma squared	0.09***	0.04***	0.09***	0.06
t	4.76	3.09	3.75	1.57
gamma	0.59***	0.48***	0.65***	0.80**
t	5.96	3.33	5.98	2.37
Log likelihood	-1.79	32.65	-1.35	9.28

*Note: * significant at 10%; ** significant at 5%; *** significant at 1%*

In order to deepen our analysis, we have estimated technical inefficiencies of each city, using the model described in column (2) on **Table 3** and the model described in column (4) on **Table 4**. In both tables, we report the technical inefficiencies of European cities in three different years: 2000, 2004 and 2008, which represent the three different waves of survey. Then, we rank European cities according to the level of inefficiency reached in 2004.

The results seem to confirm that the inefficient cities are those belonging to the East European countries, but they do not confirm the Scandinavian cities are the best ones. In **Table 3**, in 2004, among the best efficient European cities we find some German and United Kingdom cities. This different result from the analysis of Giffinger et al. (2007) implies that a city belonging to a well developed and best performance country can perform better than a city that belongs to a developing country and/or to a country with a less importance in terms of economic and financial issues.

In order to conclude our analysis, we compare European cities ranking, resulting from our analysis, with the one resulting from Giffinger et al. (2007) analysis. In this comparison we use the rank resulting from the model 2 in 2004 that allow to rank 36 cities. The comparison highlights the gap between the resulting relative positions of the 36 cities under consideration. It is worth to notice that although the gap is not consistent (<3) for 13 out of 36 cities, it quickly increases, reaching a spread of 22 positions in the worst case (Table 5).

Table 3: European city ranking of technical inefficiency based on 2004 for model 2

CITY	COUNTRY	2000	2004	2008
Pleven	BG		1	1
Ruse	BG		2	2
Tartu	EE	1	3	3
Liepaja	LV	3	4	4
Miskolc	HU	5	5	
Pecs	HU	6	6	
Kaunas	LT	7	7	
Banska Bystrica	SK	8	8	5
Nitra	SK	10	9	7
Kosice	SK	12	10	6
Maribor	SI	16	11	8
Aalborg	DK		12	
Odense	DK		13	
Oulu	FI		14	
Umeå	SE	22	15	
Tampere	FI	25	16	9
Oviedo	ES	26	17	11
Turku	FI	24	18	10
Aarhus	DK		19	
Ljubljana	SI	28	20	12
Valladolid	ES	32	21	13
Magdeburg	DE	30	22	18
Kiel	DE	33	23	14
Pamplona/Iruña	ES	34	24	
Enschede	NL		25	
Jönköping	SE	35	26	17
Groningen	NL		27	
Aberdeen	UK		28	16
Nijmegen	NL		29	
Erfurt	DE	36	30	19
Portsmouth	UK	37	31	20
Göttingen	DE		32	21
Eindhoven	NL		33	
Trier	DE	38	34	22
Leicester	UK	41	35	23
Regensburg	DE	40	36	24
Bialystok	PL	15		
Bydgoszcz	PL	17		
Cardiff	UK			15
Clermont-Ferrand	FR	27		
Coimbra	PT	18		
Cork	IE	39		
Dijon	FR	29		
Kielce	PL	14		
Luxembourg (city)	LU	31		
Montpellier	FR	23		
Nancy	FR	21		
Plzen	CZ	13		
Poitiers	FR	20		
Rzeszow	PL	9		
Sibiu	RO	2		
Szczecin	PL	19		
Timisoara	RO	4		
Usti nad Labem	CZ	11		

Table 4: European city ranking of technical inefficiency based on 2004 for model 4

CITY	COUNTRY	2000	2004	2008
Ruse	BG		1	2
Tartu	EE	2	2	3
Miskolc	HU	3	3	
Liepaja	LV		4	4
Banska Bystrica	SK	6	5	5
Nitra	SK	4	6	6
Pecs	HU	7	7	
Kosice	SK	9	8	7
Maribor	SI	12	9	8
Magdeburg	DE	14	10	14
Tampere	FI	20	11	9
Turku	FI	24	12	
Göttingen	DE		13	10
Erfurt	DE	21	14	12
Ljubljana	SI	19	15	11
Enschede	NL		16	
Kiel	DE	22	17	13
Nijmegen	NL		18	
Trier	DE	26	19	15
Eindhoven	NL		20	
Regensburg	DE	28	21	17
Valladolid	ES		22	
Aarhus	DK		23	
Bialystok	PL	8		
Bydgoszcz	PL	10		
Clermont-Ferrand	FR	17		
Coimbra	PT	25		
Dijon	FR	23		
Jönköping	SE			16
Kielce	PL	5		
Luxembourg (city)	LU	27		
Montpellier	FR	16		
Nancy	FR	18		
Oviedo	ES			18
Pleven	BG			1
Plzen	CZ	11		
Poitiers	FR	15		
Rzeszow	PL	1		
Szczecin	PL	13		

Table 5: Comparison between the two European city rankings

CITY	COUNTRY	RANK VIENNA	FRONTIER 2004 MODEL 2	GAP
Liepaja	LV	33	33	0
Nijmegen	NL	8	8	0
Enschede	NL	12	12	0
Joenkoeping	SE	11	11	0
Ruse	BG	36	35	1
Pleven	BG	35	36	1
Pecs	HU	32	31	1
Kaunas	LT	31	30	1
Groningen	NL	9	10	1
Nitra	SK	27	28	1
Banska Bystrica	SK	30	29	1
Miskolc	HU	34	32	2
Kosice	SK	29	27	2
Eindhoven	NL	7	4	3
Magdeburg	DE	19	15	4
Kiel	DE	20	14	6
Ljubljana	SI	10	17	7
Goettingen	DE	13	5	8
Oviedo	ES	28	20	8
Umeaa	SE	14	22	8
Maribor	SI	17	26	9
Tartu	EE	24	34	10
Valladolid	ES	26	16	10
Erfurt	DE	18	7	11
Pamplona	ES	25	13	12
Trier	DE	16	3	13
Regensburg	DE	15	1	14
Aberdeen	UK	23	9	14
Tampere	FI	5	21	16
Portsmouth	UK	22	6	16
Aarhus	DK	1	18	17
Turku	FI	2	19	17
Oulu	FI	6	23	17
Leicester	UK	21	2	19
Odense	DK	4	24	20
Aalborg	DK	3	25	22

6. Conclusions

In this paper, we have analysed how some European cities face the challenge of combining competitiveness and sustainable urban development simultaneously. We have focused our attention on the efficiency of those European cities studied by Giffinger et al. (2007).

On the basis of this report, we select the same 70 European cities considered in the ranking of medium-sized cities. Using the six indicators that jointly describe the factors of a smart city, we analyze the economic performance and the efficiency of these European cities. Applying the stochastic frontier approach, we are able to distinguish between production inputs and efficiency / inefficiency factors and to disentangle distances from the efficient frontier ranking the cities. Results confirm that production function performs quite well. Moreover, results show that only Smart-People and Smart-Environment have a positive effect on efficiency, while the other Smart indicators increase city inefficiency.

Finally, we rank European cities according to the level of inefficiency reached in 2004 highlighting several differences with the study of Giffinger (2007). This allows us to compare different characteristics and to identify strengths and weaknesses of medium-sized cities. Among the best efficient European cities we find some German and United Kingdom cities while the inefficient cities are those belonging to the East European countries. This implies that a city belonging to a well developed and best performance country can perform better than a city that belongs to a developing country and / or to a country with a less importance in terms of economic and financial issues.

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