CASE STUDY

Comparative performance assessment of Smart Cities around the North Sea basin

Andrea Caragliu[a] Chiara Del Bo[b], Karima Kourtit[c] and Peter Nijkamp[d]

A solid knowledge base in combination with innovative entrepreneurship and creative communities are likely to be the prominent success factors putting cities at the forefront of new and innovative developments.

A Smart City is characterized by a clever combination of investments in – and a clever use of – resources (in particular, human, social, creative, infrastructural, technological and business capital) that fuel sustainable economic growth and produce a high quality of life, under conditions of a wise management of natural resources and a broadly supported governance system (see Caragliu et al., 2011, 2012). A series of contributions on the attributes and success factors of Smart Cities can be found in a forthcoming issue of the journal Innovation (2011).

A prerequisite for Smart Cities is the existence of and access to a strong local knowledge base. Such a knowledge base should have a broad base, in which both frontier research and standard research are performed in a balanced combination, while ensuring a sound mix of blue sky research and applicability. Thus, all quadrants of the so-called Pasteur quadrant are to be developed from a balanced perspective in a Smart City (see Figure 1).

The smart combination of all four elements in the Pasteur quadrant in an urban context is, however, not yet sufficient to bring cities at a competitive edge in a global network economy. Knowledge has to be produced, but it should also be disseminated, accessed, absorbed and utilized by all stakeholders in the urban arena (Nijkamp and Kourtit, 2011).

In the past decades we have witnessed a drastic transformation of 'ivory tower' research towards a linear transmission model from knowledge producers (mainly universities) to knowledge consumers (mainly industries and governments), later on followed by interactive science communication models, science valorization and commercialization initiatives, and recently more (pro-)active science marketing programs. In a more general context, we observe also a transition from Mode 1 to Mode 2 in the Gibbons/Novotny terminology (Gibbons et al., 1994; Nowotny et al., 2001), with increasing emphasis on open innovation systems ranging from national to regional or local ones.

+	Frontier research: blue sky **Einstein**	Frontier research: relevance **Pasteur**
Innovation	Standard research: exploration	Standard research: utility **Edison**
-	- **Applicability** +	

Figure 1 | The Pasteur quadrant

An important visual and analytical tool to map out the above mentioned knowledge force field is offered by the so-called triple helix model (Erkowicz and Leijdesdorff, 1997). Clearly, the triple helix model is only a stylized representation of a complex knowledge fabric. It has recently been generalized towards a multiple helix model (Caragliu et al., 2012), which is mapped out in Figure 2. A main question is of course whether sufficient data are available to represent in a comparative sense the smartness (in terms of input or resource indicators) or the socio-economic achievement (in terms of urban output or performance indicators). This calls for applied comparative case study research. For various indicators (e.g., GDP, population, employment, human capital, infrastructure, business, cultural heritage, urban amenities) a wealth of information is available on European cities. For others indicators such as e-Government, ICT quality, social capital, public participation, leisure patterns, segregation, it is much more demanding to acquire relevant information. Of course, Eurostat data, Urban Audit data, EVS data or

[a] Post-doctoral fellow, Politecnico di Milano, Italy. Email: <andrea.caragaliu@polimi.it>. [b] Research fellow, Università degli Studi di Milano, Milano, Italy. Email: <chiara.delbo@unimi.it>. [c] Researcher, VU University Amsterdam, The Netherlands. Email: < k.kourtit@vu.nl >. [d] Professor, Faculty of Economics and Business Administration, VU University Amsterdam, The Netherlands. Email: < p.nijkamp@vu.nl >.

ESS data may offer some assistance, but it is rather cumbersome to build up a comparative and complete data system on all Smart Cities in Europe. For that reason, we have restricted ourselves to a comparative in–depth analysis of nine cities.

Smart Cities around the North Sea Basin: A comparison

In our empirical analysis we have focused on 9 Smart Cities in various countries around the North Sea basin, viz. Bremerhaven, Edinburgh, Karlstad, Kristiansand, Lillesand, Groningen, Kortrijk, Osterholz, and Norfolk. All these cities – or sometimes urban areas – have decided to participate voluntarily in a collaborative project (that enjoys an academic network labelled SCRAN (Smart Cities Regional Academic Network) and works on 9 North-Sea cities) that would focus on the conditions for and implications of Smart City initiatives, in particular from the perspective of knowledge, ICT and creativity. For a systematic comparison, a joint data base had to be designed that was acquired from different sources (European, national, regional and local) as well as from interviews with city officials. These data were collected from the perspective of the multiple helix model (see Figure 2).

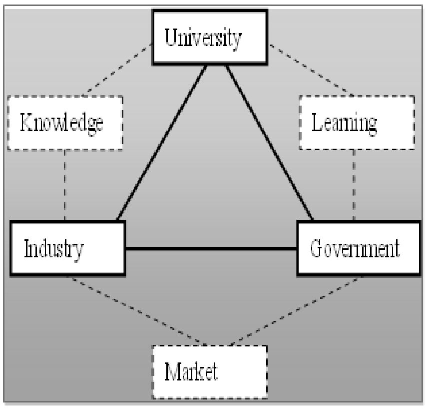


Figure 2 | A multiple Helix model

First, a so-called Knowledge Economy Indicator (KEI) was calculated – an average of economic growth factors, institutional support systems, educational facilities, human resources, effectiveness of innovation systems and ICT absorption – for each of the 9 participating cities. Next, a set of data was collected for assessing the attributes of Figure 3(a), the multiple helix model. Clearly, the hexagonal multiple helix model is still limited in its scope. And therefore, we may design a generalized triple helix model, which contains much more detailed information. The empirical representation of this new triple helix model can be found in Figure 3(b).

These patterns show quite some variation among the 9 Smart Cities under consideration. Cities can of course use this type of information for a benchmark analysis of their performance. But it is also an intriguing question whether the 9 cities concerned can be ranked according to their relative socio-economic achievement levels.

Performance measurement of Smart Cities

Performance analysis has become an important tool in plan or project assessment, especially in a comparative context. Examples are cost-benefit analysis, cost–effectiveness analysis, balance score methods, or benchmarking analysis. In all cases, the aim is to obtain insight into the relative efficiency of an organization, as compared with others. One of the more sophisticated and increasingly popular methods for judging the comparative achievement of organizations is Data Envelopment Analysis (DEA). DEA finds its origin in activity analysis, and more specifically in multi-product linear programming analysis (see Charnes et al., 1978). It has found a great diversity of applications all over the world. Its main idea is to find a numerical expression based on a performance

Figure 3a

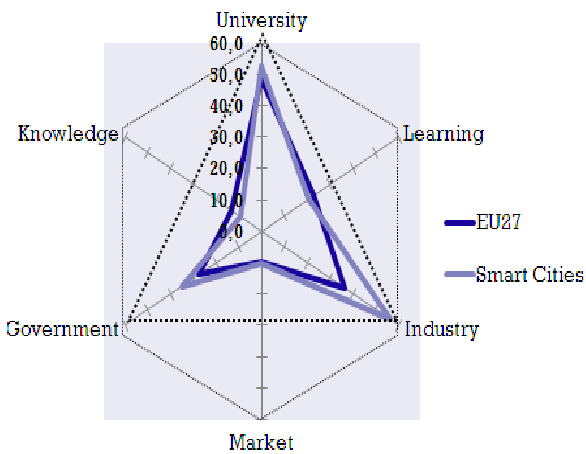


Figure 3b

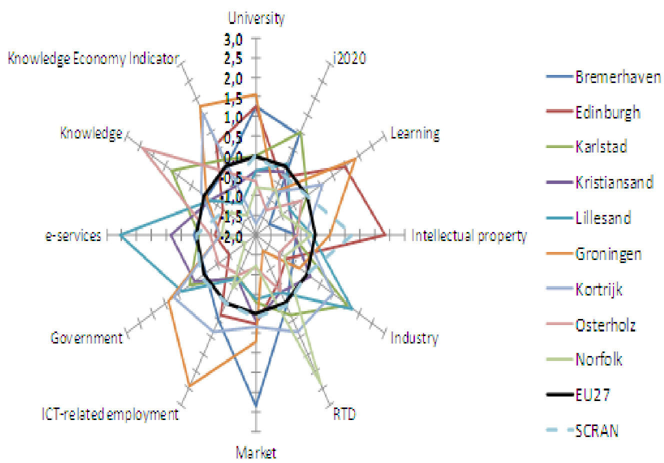
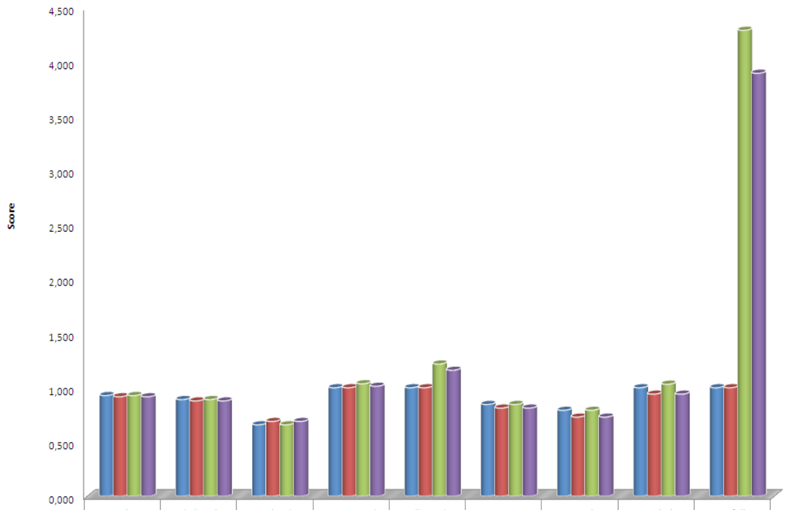


Figure 3a and 3b | The multiple Helix map towards a generlized Triple Helix model for 9 Smart Cities and EU27



	Bremerhaven	Edinburgh	Karlstad	Kristiansand	Lillesand	Groningen	Kortrijk	Osterholz	Norfolk
CCR-I score 9902	0,928	0,891	0,658	1,000	1,000	0,846	0,792	1,000	1,000
CCR-I score 0306	0,917	0,878	0,689	1,000	1,000	0,812	0,730	0,941	1,000
Super Efficiency score 9902	0,928	0,891	0,658	1,037	1,218	0,846	0,792	1,033	4,293
Super Efficiency score 0306	0,917	0,878	0,689	1,014	1,161	0,812	0,730	0,941	3,898

Figure 4 | Standard DEA (CCR-I) and Super Efficiency score of the 9 European cities for two periods of time

score ranging from 0 to 1, with 1 being the highest score or the highest efficiency level. We refer to Suzuki et al. (2011) for DEA applications to smart infrastructures or to smart regions.

Application of DEA by mean of the so-called CCR-method to our sample of 9 cities with a further subdivision over the periods 1999-2002 and 2003-2006– leads to the following results (see Figure 4).: 3 to 4 cities belong to the category of efficient cities, while for all others there is still scope for an improvement of their performance.

Clearly, 3 to 4 cities have an identical efficiency score, which means that they are all located on the efficiency frontier. But this does mean that it is equally easy for these cities to maintain their position or to improve their future position. Thus, the marginal improvement efforts may vary considerably among these actors. By taking into consideration the marginal improvement efforts of these actors, a so-called super-efficiency analysis may be carried out (see Suzuki and Nijkamp, 2011; Suzuki et al., 2011; Nijkamp and Suzuki, 2009). The results of this super-efficient DEA are also presented in Figure 4.

This diagram shows much more variation over the entire set of efficient cities, which means essentially that in the long run there is ample space for improvement among all cities. Thus, the use of DEA allows an informed discussion on the relative achievement levels of these smart cities, in particular since this analysis offers clear information on the strong points of a city as well on the weak points which need due care.

Concluding remarks

Modern cities are faced with grand challenges of a varied nature, ranging from ecological sustainability or climate-neutral architecture to new socio-economic opportunities or global accessibility. Clearly, improvements in urban transportation and communication systems, socio-economic and demographic balanced development and smart governance systems are of critical importance for the success of Smart City strategies. But a solid knowledge base in combination with innovative entrepreneurship and creative communities are likely to be the prominent success factors for sustainable urban development. ★

References

Caragliu,A., M.Deakin, C.Del Bo, S.Giordano, K.Kourtit, P.Lombardi, and P.Nijkamp (2012), "An Advanced Triple-Helix Network Model for Smart Cities Performance", In O.Yalsiner Ercoskun (eds.), *Green and Ecological Technologies for Urban Planning* (Herskey: IGI Global), forthcoming.

Caragliu,A, C.Del Bo, and P.Nijkamp (2011), 'Smart Cities in Europe', *Journal of Urban Technology*, 18 (2): 65-82.

Charnes, A., W.W.Cooper and E. Rhodes (1978), 'Measuring the Efficiency of Decision Making Units', *European Journal of Operational Research*, 2 (6): 429-444.

Etzkowitz, H. and L. Leijdesdorff (1997), *Universities in the Global Economy* (London: Croom Helm).

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P. and Trow, M. (1994), *The New Production of Knowledge - The Dynamics of Science and Research in Contemporary Societies* (London: Sage).

Nijkamp,P, and K.Kourtit (2011), 'Global Challenges and Local Responses in the Urban Century', Scoping Document, JPI Urban Europe, VU University, Amsterdam.

Nowotny, H., Scott, P. and M. Gibbons (2001), *Re-Thinking Science. Knowledge and the Public in an Age of Uncertainty* (Cambridge: Polity Press).

Nijkamp, P. and Suzuki, S. (2009), 'A Generalized Goals-achievement Model in Data Envelopment Analysis: an Application to Efficiency Improvement in Local Government Finance in Japan', *Spatial Economic Analysis*, 4 (3): 249-274.

Suzuki, S. and P. Nijkamp (2011), 'A Stepwise-Projection Data Envelopment Analysis for Public Transport Operations in Japan', *Letters in Spatial and Resource Sciences*, 4(2): 139-156.

Suzuki, S., Nijkamp, P., and P. Rietveld (2011), 'Regional efficiency improvement by means of data envelopment analysis through Euclidean distance minimization including fixed input factors: An application to tourist regions in Italy', *Papers in Regional Science*, 90 (1): 67-89.