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Tracing high-sustainability performers among world cities - design and application of a multi-temporal data envelopment analysis

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ABSTRACT

Sustainability performance is nowadays a major challenge for many cities in the world. Sustainable development refers to the achievement of both ecological and socio-economic objectives over a relevant time period. The present study aims to trace the relative sustainability status of 39 world cities included in the so-called Global City Power Index (GPCI) of the Mori Memorial Foundation in Japan. This is a unique large-scale and detailed multi-temporal data base containing approx. 80 systematically collected urban indicators for the cities concerned. This paper presents and applies a novel and advanced assessment methodology for sustainable and efficient performance strategies of these 39 global cities, by means of an extended and multi-temporal version of a Data Envelopment Analysis (DEA). Using this novel approach, our study seeks to arrive at an unambiguous ranking of the highest performers among 'urban sustainability champions', during the time period 2012–2015. Based on the DEA efficiency assessment by regarding the urban input-output ratio as a performance indicator, we examine here one input indicator (Total Employees) and four sustainability output indicators (CO_2 Emissions, Nominal GDP, Level of Satisfaction of Employees with their Lives, and Percentage of Renewable Energy Used). Our empirical results provide a global sustainability ranking of the cities concerned. We also show that many European cities have a relatively high performance score on the human and urban environment. We present next more detailed information on a selection of a few interesting cities. Our approach appears to be able to address realistic and transparant priorities and complex policy choices aiming at an improvement of relatively inefficient world cities.

1. Setting the scene

Cities have been powerstations for wealth creation and economic progress in the long geographic history of our world (see Tellier, 2009). Despite relatively low urbanisation degrees in pre-Napoleonic centuries, urban agglomerations have always been successful economic, cultural, social, and political power centres of our world, through which both urban and rural settlement patterns were governed and controlled. In the post-Napoleonic age – and in particular after the Industrial Revolution in the mid-nineteenth century – industrial-economic and social-political forces – both centrifugal and centripetal – started to exert a far-reaching influence on city formation and expansion. Economies of density, proximity and connectivity meant a major stimulus for a permanent urbanisation process, a megatrend which has now lasted for more than two centuries (See Fujita & Thisse, 2002; Henderson, 2003). The consequence of this uninterrupted process has been an uninterrupted urban growth, with a rapid increase in the size of cities (up to mega-cities, of more than 10 mln. inhabitants) as well as in the number of new cities, to the extent that nowadays more than 50 per cent of the world population lives in urban agglomerations. We are living in the '*urban century*', in which the unprecedented urbanisation rise leads to the '*New Urban World*' (see Kourtit, 2015).

Mass geographic concentrations of people and economic activity tend to reinforce the agglomeration advantages of urban areas,

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as can be observed in both the developed and the developing world. But it ought to be recognized that beside positive external economies there are also clear diseconomies of scale in urban agglomerations, such as: environmental decay, waste heaps, poor air quality, negative health impacts, social-ethnic tensions, and high crime rates (see also Batabyal & Nijkamp, 2017). Modern urban agglomerations appear to turn also into poles of negative externalities. Consequently, urban welfare – or in a more neutral sense, urban achievement – is determined by a balance between two countervailing powers, implying a trade-off between two mutually conflicting tendencies: higher agglomeration advantages lead to more urbanisation, which may negatively impact the quality of human life in cities. Clearly, sustainability issues are at stake here, which call for a careful, empirically based examination of the plus and minus signs of urban growth.

Since the publication of the Brundtland Report 20 years ago, a wealth of scientific and policy contributions on the concept of sustainability has been published. Such contributions range from general macro studies to detailed sectoral or regional studies. In the past decade, an extant literature has also been published on sustainable cities and regions. We will not summarize here this broad collection of publications, but refer here to a few core publications by Deakin, Mitchell, Nijkamp, and Vreeker (2007), Fusco Girard, Bacan, and Nijkamp (2011) and de Noronha Vaz et al. (2013). Furthermore, contributions on sustainable urban development published in previous issues of Habitat International can be found *inter alia* in Marans (2015), Vaz, Kourtit, Nijkamp, and Painho (2015), Mori and Yamashita (2015), and Yigitcanlar et al. (2015).

We note that there is an important additional intervening factor. This phenomenon arises from the well-known Kuznets-curve in ecological economics (see Stern, 2004), which addresses the question whether economic growth and environmental quality are, in the long-run, necessarily adverse phenomena. The argument used here is that economic growth – with an initial environmental decay – may generate and release more financial resources to cope with environmental quality decline, so that countries with a relatively high GDP will manage to create a more favourable quality of life, as is exemplified by Canada, Japan, Korea, Singapore, Switzerland, Austria, Sweden, Denmark, Germany, or the Netherlands (a so-called a 'U-shaped' environmental Kuznets curve).

A similar phenomenon may hold true for an examination of cities: larger cities may have higher agglomeration advantages and thus generate more resources to stimulate a more effective and efficient treatment of waste and pollution, a higher energy-saving public transportation system or a more client-oriented use of open public space. Consequently, big cities may be relatively more environmentally beneficial in the long run. Clearly, the validity of this Kuznets-type of proposition is a matter of comparative empirical research.

Our approach takes for granted that in a sustainable '*urban century*', urban areas (in particular, large, world or global cities) may function not only as economic growth poles, but also as social and ecological sustainability engines, which stimulate both human welfare and environmentally-friendly outcomes. Proactive and smart world cities may play a critical role as innovative and intelligent power stations for sustainable human welfare (Capello, Nijkamp, & Pepping, 1999; Glaeser & Kerr, 2009; Kourtit & Nijkamp, 2016; Nijkamp, 2008; Sassen, 1991; Shefer & Frenkel, 1998). In other words, access to and use of cognitive and human capital are a major ingredient for such large cities. In this context, the presence and use of a local R&D, knowledge and learning base may be an additional benefactor (Acs, FitzRoy, & Smith, 2002; Kourtit, Nijkamp, & Stough, 2011; Van Geenhuizen and Nijkamp 2011). It should be added that modern global world cities are increasingly also involved in a competitive playing field regarding global products and services. Therefore, large metropolitan areas have to create favourable seedbed and attraction conditions for international economic agents, through a stimulating entrepreneurial climate; an appropriate basis of industrial clusters; a diversified and strong economic structure; an advanced and well-functioning connectivity infrastructure; an ecologically sustainable urban ecology; a sophisticated research and educational supra-structure; a balanced population structure with sufficient skills; and an open international accessibility through majors hubs etc. (see also Cheshire & Magrini, 2009).

In recent years, several attempts have been made to develop a classification or ranking of sustainable world cities based on their actual socio-economic or sustainability performance or their perceived success (see e.g. Taylor, 2004, Grosveld, 2002; Arribas-Bel, Nijkamp, & Scholten, 2011; Kourtit, Nijkamp, & Arribas-Bel, 2012; Kourtit & Nijkamp, 2016). A main challenge in empirical research is of course the development of a consistent, quantitative data base that is appropriate for a strategic benchmark analysis and comparative sustainability assessment of such cities. Our study aims to assess – by means of a quantitative benchmark study – the relative sustainability performance of a large set (39) of world cities from the GPCI databae. It does so by using an extensive, systematically collected data set on relative performance indicators of these cities, on the basis of an extended novel version of Data Envelopment Analysis (DEA), which will be applied to the above sample of cities in order to identify the highest-ranking sustainable cities of the world. The aim to make a comparative social and environmental sustainability study of a large collection of world cities means a focus on measurable policy indicators, in particular pollution, quality of life, energy efficiency and general level of welfare.

One of the most detailed databases on global cities can be found in a recent study on the '*Global Power City Index*' (GPCI), undertaken by the Institute for Urban Strategies (2015) in Tokyo. A thorough analysis of many world cities, 39 in total, was performed in this study report, including not only important megacities in OECD countries, but also large cities from emerging economies. The GPCI database contains six major clusters of relevant information on these cities (e.g., on business, quality of life, accessibility). It is noteworthy that a systematic use of the multi-level data structure and information on the economic and ecological achievement levels of these global cities is needed for a strategic, efficient and sustainable development of such smart or intelligent cities (including so-called *i*-cities, see Kourtit, Nijkamp, & Westlund, 2017). We will employ this database for a benchmark analysis of the sustainability performance of the world cities under investigation. Sustainability will be operationalized here as the quantitative contribution to the achievement of environmental – or quality-of-life – goals (such as pollution or energy use), based on measurable information on ecological indicators.

The objective of the present paper is to present and apply an integrative benchmark method leading to a transparant and quantitative performance assessment of sustainable world cities from the viewpoint of the above mentioned socioeconomic and human environment in these areas. A standard tool by which to judge efficiency – or performance achievement – among different actors is Data Envelopment Analysis (DEA), designed by Charnes, Cooper, and Rhodes (1978) (hereafter CCR) (see for an overview and applications Suzuki & Nijkamp, 2017b). This has become over the past decades an established quantitative assessment method in the evaluation literature. It goes without saying that comparative efficiency analysis in urban performance studies using DEA models has increasingly become an important research topic in recent years (see also Kourtit, Nijkamp, & Suzuki, 2013). Therefore, our

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