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Benchmarking urban energy efficiency in the UK

James Keirstead *

Department of Civil and Environmental Engineering, Imperial College London, London SW7 2AZ, United Kingdom

HIGHLIGHTS

- Benchmarking is a potentially valuable method for improving urban energy performance.
- Three different measures of urban energy efficiency are presented for UK cities.
- Most efficient areas are diverse but include low-income areas of large conurbations.
- Least efficient areas perform industrial activities of national importance.
- Improve current practice with grouped per capita metrics or regression residuals.

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ABSTRACT

This study asks what is the 'best' way to measure urban energy efficiency. There has been recent interest in identifying efficient cities so that best practices can be shared, a process known as benchmarking. Previous studies have used relatively simple metrics that provide limited insight on the complexity of urban energy efficiency and arguably fail to provide a 'fair' measure of urban performance. Using a data set of 198 urban UK local administrative units, three methods are compared: ratio measures, regression residuals, and data envelopment analysis. The results show that each method has its own strengths and weaknesses regarding the ease of interpretation, ability to identify outliers and provide consistent rankings. Efficient areas are diverse but are notably found in low income areas of large conurbations such as London, whereas industrial areas are consistently ranked as inefficient. The results highlight the shortcomings of the underlying production-based energy accounts. Ideally urban energy efficiency benchmarks would be built on consumption-based accounts, but interim recommendations are made regarding the use of efficiency measures that improve upon current practice and facilitate wider conversations about what it means for a specific city to be energy-efficient within an interconnected economy.

1. Introduction

In December 2009, the nations of the world gathered in Copenhagen for the fifteenth conference of parties to the UN Framework Convention on Climate Change. While the delegates were trying to stave off "diplomatic disaster" at the main venue (Grubb, 2010), a Climate Summit for Mayors was being held across town. Attended by nearly 80 mayors from leading international cities, this event was notable for two reasons. First, the presence of these mayors at such a major international conference confirmed the potentially significant contribution of cities to global climate change and energy policy goals. Grubler et al. (2012) have estimated that cities account for 76% of global total final energy consumption and approximately 71% of energy-related direct CO_2 emissions (IEA, 2008). The meeting also highlighted the diversity of cities and the creative tension that exists between their respective approaches to climate and energy policy. In a discussion about bike sharing for example, the Mayor of London Boris Johnson said that cities should be seeking to make each other "green with envy". In response, Copenhagen Mayor Ritt Bjerregaard "looked horrified" and said cities should "not be competing" but cooperating (Londoner's Diary, 2009). Although this anecdote comes from a discussion of a relatively minor issue, evidence of urban competition can also be seen in the desire to attract the large corporations at the centre of the global economy (Sassen, 2001), the 'creative class' of professionals who develop innovative new consumer goods and services (Florida, 2004), or the regenerative potential and publicity that accompanies major global events like the Olympics (Sheng, 2010; Short, 2008). However notable examples of cooperation also exist such as mayoral networks for climate change action like the C40 and Energie-Cités.

While the outcome of these interactions is shaped by complex trade-offs and subjective judgements, one can nevertheless ask about the extent to which key features of urban quality can be

* Tel.: +44 20 7594 6010.
E-mail address: j.keirstead@imperial.ac.uk

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summarized into "objective" indicators. These indicators shape not just the location choices of firms and individuals, but they can also be used by city authorities to analyse and improve their performance, a process known as *benchmarking*. The perceived benefits of benchmarking are improved awareness of an organization's own activities, the definition of best practices, the identification of performance deficits, and facilitating the evaluation of alternative strategies. In other words, benchmarking enables organizations to ask "why do others do it better, what can we learn from this?" (Global Benchmarking Network, 2012). A notable example in the area of climate change is the Carbon Disclosure Project, which surveyed 405 of the world's 500 largest companies by market capitalization about their greenhouse gas emissions and related management strategies. The CDP has recently extended their activities to cities, gathering data from 73 world cities which represent 245 million citizens on five continents (CDP, 2012).

This paper considers the benchmarking of urban energy efficiency. Energy efficiency is a key component of urban sustainability more generally and, since 86% of urban primary energy demand is for fossil fuels (IEA, 2008), it is also a valuable proxy indicator for a city's climate change impact. As will be shown, existing attempts to benchmark urban energy efficiency have relied primarily upon simple ratio indicators (e.g. energy consumption per capita). Although easy to calculate, there is however a risk of misinterpreting these metrics if comparisons are made without duly considering relevant covariates. A notable example is climate: if City A has more heating degree days than City B, then it will consume more energy *ceteris paribus* to meet its citizens' demands for heat. Equally cities can be efficient in different ways depending on their social and economic structures.

A comparative analysis of three urban energy efficiency techniques is therefore performed to determine the UK's most energy efficient city, out of 198 local administrative units (LAUs). After first reviewing the literature on urban benchmarking, the three methods are described (ratio measures, regression residuals, and data envelopment analysis) along with the data sources. The results present ranked lists of LAUs for each method and the discussion then considers their suitability for benchmarking purposes and the implications for UK urban energy policy.

2. Background

2.1. What is benchmarking?

Benchmarking is a technique "characterized by the systematic search for efficient procedures and better solutions for complicated problems and processes" (Global Benchmarking Network, 2012). Applied originally to military logistics and assembly lines, the modern term dates to Xerox's use of the technique in 1979 and it is now widely adopted in industry. The aim is to identify best practices and, for those organizations that fall short of this standard, to introduce changes that improve performance. Benchmarking is also an increasingly common part of public service delivery and "is presented as one of the key tools to help organizations become more 'learning oriented', to adopt a more systematic and rigorous approach to problem solving, and to become more engaged in learning from others." (Auluck, 2002, p. 109).

2.2. Benchmarking urban performance

Urban benchmarking shares many of these characteristics and can be defined as "the systematic continuous method … of identifying, learning and implementing the most effective practices and capacities from other cities in order for one's own city to improve its actions in what it offers" (Luque-Martínez and Muñoz Leiva, 2005, p. 414). The process can be structured in different ways including competitive benchmarking (antagonistic comparison with other cities), co-operative benchmarking (where cities are willing to share some data with third parties), collaborative benchmarking (where insight is shared through joint projects), and internal benchmarking (where local organizations collaborate to support benchmarking activities). A review of the literature suggests that there are at least three fields in which benchmarking techniques have been applied to urban environments: urban competitiveness, urban sustainability, and urban infrastructure systems.

2.2.1. Urban competitiveness

Urban competitiveness is "[t]he ability of an (urban) economy to attract and maintain firms with stable or rising market shares in an activity while maintaining or increasing standards of living for those who participate in it." (Storper, 1997, p. 20). Greene et al. (2007) provide a good review and highlight the conceptual difficulty of assessing this concept at the level of a city. Unlike firms, cities are often pursuing a variety of outputs (e.g. both economic and social) and it can be difficult to define urban boundaries in a way that is both meaningful and comparable to other jurisdictions. Nevertheless their review finds 22 studies in which competitiveness is measured using a series of indicators, conceptually arranged into inputs, outputs, and outcomes. In a related study, Budd and Hirmis (2004) note that measures like GDP per capita are often used for such assessments although they inevitably simplify the full complexities of urban competitiveness.

These studies share many methodological features. Relevant indicators are collected, organized into a conceptual framework (e.g. inputs and outputs), and then may be aggregated to create summary indices and corresponding rankings. This process involves normalizing the data so that the direction and range of each metric is comparable and then using a weighted average to create an aggregate index. The weights may be assigned equally, via expert opinion, or with statistical techniques such as principal component analysis or the analytic hierarchy process (EIU, 2012b; GUCP, 2008; Jiang and Shen, 2010, 2013; Pengfei and Qinghu, 2005; Singhal et al., 2013).

2.2.2. Urban sustainability

Some of the above studies take a wider view of urban economic performance incorporating social and environmental characteristics (e.g. Jiang and Shen, 2010) or assessments of a city's 'liveability' (EIU, 2012a). For convenience, these broader assessments will be grouped here under the label of 'urban sustainability' although individual studies vary their relative emphasis on economic, social, or environmental criteria.

There is a vast literature on urban sustainability indicators and related benchmarking techniques. For example, Walton et al. (2005) have identified 675 urban sustainability indicator frameworks, Parris and Kates (2003) mentioned over 500 efforts (though of sustainable development more generally), and Mihyeon Jeon and Amekudzi (2005) found 186 indicators on sustainable urban transport alone. Yet despite this wealth of indicator activity, "there are no indicator sets that are universally accepted, backed by compelling theory, rigorous data collection and analysis, and influential in policy" (Parris and Kates, 2003, p. 559). This reflects the fact that, like competitiveness, urban sustainability is a difficult concept to define and therefore the selection and use of related indicators is very much the product of subjective social processes and political debates that vary from city to city (Astleithner, 2003). Furthermore, the selected indicators often provide a rather superficial overview of urban sustainability (Brugmann, 1997; Ooi, 2005). An example of this can