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Methodological framework of sustainability assessment in City Sustainability Index (CSI): A concept of constraint and maximisation indicators

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ABSTRACT

This paper presents a framework of City Sustainability Index (CSI) incorporating indicators in the environmental, economic and social dimensions. We define a sustainable city as the spatial entity that maximises the benefits in economic and social dimensions under relevant constraints on environmental limitations and socio-economic distributional equity. Based on the definition, we provide five expressive forms as a framework for judging city sustainability, using a concept of two types of indicators: constraint and maximisation indicators. Constraint indicators judge sustainability of cities based on relevant criteria in terms of environmental sustainability and socio-economic distributional justice. Maximisation indicators measure the benefits cities produce in economic and social aspects. Indicators in the three dimensions – environmental, economic and social indicators – can be categorised into the two types of indicators. In conclusion, we need to assess the two dimensions of cities – limitations and benefits – independently without offsetting one against the other in terms of strong sustainability.

Introduction

More than half of the world population live in cities, and it is projected that the urban population will increase to 6.3 billion of a world population of 9.3 billion in 2050 (UNDESA, 2012). Considering the size of cities in the world, we cannot ignore their impacts on natural environment, economy, and society. Cities provide both positive and negative agglomeration effects: for example, increasing returns to scale on the investment in infrastructure, accumulation of knowledge and skill, costs of traffic congestions, and high housing costs (Henderson, 1974; Krugman, 1993; Saxenian, 1994; Segal, 1976). Successful cities must make choices that balance trade-offs among agglomeration benefits and costs.

Cities play an important role in promoting human socio-economic activities in a concentrated manner (UN-Habitat, 2006, 2008, 2013). On the other hand, negative external impacts of cities on the global environment have become a serious issue: for example, cities' negative contribution to global climate change due to emissions of greenhouse gases is an issue (Dodman, 2009; Kamal-Chaoui & Robert, 2009; OECD, 2010). Since the capacity of natural depletable and renewable resources is limited on the earth, environmental burdens that each city produces have to be restricted. However, social and economic living standards should not be sacrificed only to achieve environmental sustainability. Thus, we have to pursue equally the triple bottom line – environmental, economic, and social dimensions – without compromise (Elkington, 1997; Esty, Levy, Srebotnjak, & de Sherbinin, 2005; Mori, 2011). It is crucial that the assessments among the three dimensions on the basis of strong sustainability alone – physical, social, human, and natural capitals are non-substitutable (Dietz & Neumayer, 2007; Ekins, Simon, Deutsch, Folke, & De Grrot, 2003; Pearce & Barbier, 2000).

For the moment, it is inappropriate to apply existent sustainability indices to the context of cities because no index simultaneously fulfils the three conditions: strong sustainability, distinction between absolute and relative assessments, and leakage effect (Mori & Christodoulou, 2012). In particular, it is important to note that cities are not independently sustainable in that they rely on other areas beyond their boundaries for supply of resources and food, disposition of wastes, emission of pollutants, indirect use of ecosystem services, and so on (Bithas & Christofakis, 2006; Camagni, Capello, & Nijkamp, 1998; Finco & Nijkamp, 2001).

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Apart from these points, lists of urban sustainability indicators have recently been compiled (Haghshenas & Vaziri, 2012; López-Ruiz, Alfaro-Navarro, & Nevado-Peña, 2014; Pires, Fidélis, & Ramos, 2014; Shen, Ochoa, Shah, & Zhang, 2011; Wang, Lam, Harder, Ma, & Yu, 2013). Some of them consider the application of the indicators to the international comparison. It seems that they have focused on making a list of environmental, economic, social and governance indicators in order to cover as many aspects of cities as possible.

These lists of urban sustainability indicators in terms of the triple bottom line can be used to form an assessment system, which is called 'City Sustainability Index (CSI)'. It is commonly believed that the assessments of indicators should not be mutually offset, at least among the three dimensions. Based on the idea, research on making lists of urban sustainability indicators has been carried out, but the methods of assessments of urban sustainability by indicators have not necessarily been discussed sufficiently (Pires et al., 2014; Shen et al., 2011).

The purpose of this paper is to provide a framework of the assessment method in City Sustainability Index (CSI), using two types of indicators – constraint and maximisation indicators – into which all the indicators in CSI can be categorised. It should be noted that the lists of indicators in each dimension of the triple bottom line are still significant as a foundation of CSI. We do not discuss lists of indicators in this paper, but focus on the provision of an assessment method. In the next section, three crucial requirements for CSI – strong sustainability, relative and absolute assessments, and evaluation of leakage effect– are briefly discussed. In the third section, we explain a conceptual framework of the assessment method of CSI in detail, which is the core of this paper. We also should discuss some critical points in the framework in the next section. Concluding remarks are given in the final section.

Fundamental requirements for CSI

Strong sustainability

An important requirement is that cities should remain in a healthy condition over time, without paralysis or malfunction in terms of environmental, economic and social dimensions. Cities should satisfy healthy conditions independently in each dimension. In this respect, CSI should take the perspective of strong sustainability, in which different types of capitals – natural, social, physical, and human - are not substitutable (Brand, 2009; Dietz & Neumayer, 2007; Finco & Nijkamp, 2001).

Based on the viewpoint of strong sustainability, we ought to satisfy the following two conditions in CSI. First, the evaluation in a dimension should not be offset by the others: among environmental, economic, and social dimensions. Cities have been developed to enhance economic and social benefits arising from agglomeration effects, not for pursuing environmental sustainability and distributional justice. However, we cannot prioritise economic and social benefits without considering environmental preservation and equity. Environmental non-sustainability and distributional inequity should not be offset by benefits in economic and social dimensions. For instance, a city that consumes forest resources in an unsustainable way should be judged non-sustainable even if it enjoys economic prosperity.

Second, we have to judge sustainability in each environmental and socio-economic aspect. For example, if a city is evaluated as unsustainable even on a single indicator of environmental sustainability, it should be considered as a non-sustainable city even though it is judged sustainable in all the other aspects. Cities must satisfy all the sustainability conditions in terms of quality of atmosphere, hydrosphere, lithosphere and biosphere, ecosystem services, ecological resilience, biodiversity and so on. Relevant conditions on all aspects of distributional justice must be satisfied in the same way.

Relative and absolute assessments

Another important requirement for CSI is the distinction between relative and absolute assessments. "Sustainability is not a relativistic concept because the biophysical limits to sustaining life on Earth are absolute" (Fischer, Manning, Steffen, Rose, Daniell, Felton, & et al., 2007). Sustainability is an absolute concept due to environmental limitations imposed by planetary boundaries (Rockström, Steffen, Noone, Persson, Chapin, Lambin, & et al., 2009) while economic and social benefits can be relative factors (Finco & Nijkamp, 2001; Fischer, Manning, Steffen, Rose, Daniell, Felton, & et al., 2007; Floridi, Pagni, Falorni, & Luzzati, 2011). Environmental sustainability and distributional equity in cities should be assessed by certain thresholds. It is of no use to say that a city is more sustainable than another city, if both of them are non-sustainable in terms of a certain absolute criterion. In terms of environmental sustainability and distributional justice, the comparison among cities is meaningless. The critical thing is to judge whether a city is sustainable, not to compare cities. For example, if two cities are judged unsustainable in terms of the annual amount of greenhouse gas emissions, the amount of the emissions should be reduced in both cities.

On the other hand, socio-economic benefits that are produced in cities are measurable and comparable. If the necessary minimal value of a socio-economic benefit cannot be defined, or if the target cities exceed the necessary minimal value of a socio-economic benefit, we can compare values among cities. Relative assessments are valid. For example, if gross domestic product (GDP) per capita in a city is larger than that in another city and if GDP per capita in both cities exceeds a threshold of poverty, it is relevant to compare the two cities. This is because higher GDP per capita is desirable, other conditions being sustainable.

Evaluation of leakage effect

The review of existing sustainability index finds that no index/indicator appropriately measures the external environmental impacts of a city on areas beyond its boundaries (Mayer, 2008; Mori & Christodoulou, 2012; Morse & Fraser, 2005). However, the essential point is that cities are not sustainable independently. They are entities that exist to pursue agglomeration benefits in economic and social dimensions. Cities are densely populated and developed areas, which may include undeveloped lands that are biologically and ecologically productive. Cities always depend on areas beyond their boundaries to supply resources and food, disposition of wastes, absorption of pollutants, indirect use of ecosystem services and so forth (Bithas & Christofakis, 2006; Camagni et al., 1998; Finco & Nijkamp, 2001). Cities could not function well without the support of other areas. Thus, to assess city sustainability, it is necessary to focus on the dependencies and leakage effects of cities on other areas beyond their boundaries (Mayer, 2008). Furthermore, indirect leakage effects of cities through the consumption of goods by trade must be taken into consideration for assessing their performance, although it seems to be so challenging on the practical side. Cities are open systems that have negative impacts on other spatial areas and the earth as a whole (Munda, 2006).

Framework of assessment method for city sustainability

Concept of city sustainability

No precise and convincing definition of sustainability is commonly shared although many definitions have been proposed