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Achieving energy savings by intelligent transportation systems investments in the context of smart cities

Yang Chen *, Arturo Ardila-Gomez, Gladys Frame

Transport & ICT Practice, The World Bank, 1818 H Street, NW Washington, DC 20433, USA

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ABSTRACT

Investments in intelligent transportation systems (ITS) are beginning to take place in the context of smart city initiatives in many cities. Energy efficiency and emissions reduction are becoming essential rationales for such investments. It is important, therefore, to understand under what conditions investments in ITS in the context of smart cities produce energy savings. We reviewed existing literature, conducted case studies and interviews, and found that the smart cities context has transformed traditional ITS into "smart mobility" with three major characteristics: people-centric, data-driven, and powered by bottom-up innovations.

We argue that there are four main steps for smart mobility solutions to achieve energy savings and that several institutional, technical, and physical conditions are required at each step. Energy savings are achieved when users change their behavior and result in less travel, modal shift, and reduction of per-km energy consumption in the short term. Smart mobility solutions also enable other energy saving policies or initiatives, which would otherwise not be feasible. In the long term, users' lifestyles could change and lead to further energy savings.

For cities in developing countries with lower motorization, less-developed infrastructure, less financial resources, and less institutional and technical capacity, our recommendations to achieve benefits from smart mobility investments are: (1) involve all public and private players in a collaborative and transparent setting; (2) develop the technical capacity to procure and monitor information services; and (3) focus on basic infrastructure, including a coherent road network and basic traffic management measures.

1. Introduction: ITS, smart cities, and energy savings

Faced with the challenge of providing adequate transport services with limited resources, cities have, for several decades, been investing in Intelligent Transportation Systems (ITS). ITS utilize Information and Communications Technology (ICT) to make more efficient use of existing transport infrastructure with the aim of improving transport services and reducing congestion, accidents, and air pollution. In the past two decades, with the rapid advancement of ICT and intensive advocacy from big technology vendors, the concept of "smart cities" has gained great popularity and many cities have started to undertake a more holistic approach to improving urban services using technology in the name of smart city initiatives.

* Corresponding author.
E-mail address: ychen3@worldbank.org (Y. Chen).

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Smart cities have proven to be more than just a buzzword or short-term hype. It is possible to say that "all cities want to be smart." For instance, India plans to transform 100 cities into smart cities (World Bank, 2015) and China already has more than 500 smart city pilots.[1] It is estimated that the size of the global smart cities market will grow from USD411 billion in 2014 (Markets and Markets, 2015) to USD3 trillion by 2020 (Anthopoulos and Reddick, 2016). Despite different focuses and definitions of the label "smart city" (see Albino et al. (2015) for a review), the core lies in the utilization of technology for the purpose of improving the quality of life. Naturally, ITS become the essential application of "smart city" in the transportation sector as the "smart mobility" (or "smart transport") component (Lombardi et al., 2012). ITS investments are beginning to take place in the context of smart city initiatives in many cities around the world.

Moreover, energy efficiency and emissions reduction are becoming key rationales for smart city investments. In fact, energy saving (and/or greenhouse gas emissions reduction) is regarded as one major benefit and usually calculated in the cost benefit analysis to justify ITS investments (Newman-Askins et al., 2003; Bertini et al., 2005). Indeed, the transport sector is responsible for about one-fifth of total energy use worldwide (World Economic Forum, 2011), with the largest share in passenger road transport (World Energy Council, 2011). However, transport in general and urban transport in particular are sectors in which it has proven difficult to cost-effectively reduce energy use. Urban transport demand management, most of which is enabled by ITS, is regarded as a major solution to mitigate climate change (Creutzig et al., 2015). With environmental sustainability, i.e. energy reduction and climate change mitigation, becoming a more important rationale for ITS investments in the smart cities context, it is crucial to understand under what institutional and technological conditions the energy savings benefit is realized, and what the magnitude the saving is.

To answer the question of how and how much ITS investments in the context of smart cities save energy, this study uses a multi-methods approach. We first reviewed relevant bodies of literature, including on smart cities, ITS, and the linkages to benefits, especially energy savings, and the institutional and technological conditions that underlie these outcomes. Secondly, we conducted case studies of smart mobility initiatives in Amsterdam, Barcelona, London, Madrid, Vienna, Seoul, Singapore, and Tokyo. These case cities were selected based on two criteria: (a) cover major well-recognized "smart cities" around the world to capture the international best practices and (b) existing city (not built from scratch) that is medium to large in size so that the findings could be more useful for World Bank client cities. Smart mobility initiatives in case cities were explored through presentations, document reviews, panel discussions, interviews, as well as site visits during the period from November 2014 to December 2015 to determine the process, outcome, success factors, and lessons learned in deploying and operating these initiatives. Thirdly, we conducted semi-structured and unstructured interviews with players in the smart cities field, including government officials (including mayors, directors in relevant departments, technical staff, etc.), product and service providers, and local and global NGOs, as well as startup entrepreneurs. We sought their views on the conditions under which smart mobility products yield best benefits. Additional cases and interviewees in New York City, San Francisco, Helsinki, as well as cities in developing countries such as Nairobi, Rio de Janeiro, and cities in China were obtained through interviewee references, and conference and exhibition attendance. The research team went through several rounds of theory-building exercises to let major themes emerge and establish an analytical framework. Findings from the mini case analyses as well as interviews of key players were then organized and the results summarized based on the framework.

In the analysis, three themes emerge that characterize the transformation of ITS in the context of smart cities—people-centric, data-driven, and powered by bottom-up innovation. Section 2 introduces these themes, which serve as the analytical framework to understand how smart mobility investments lead to energy savings. The comparison in the search for similarities among the case studies and interviews helped us develop a conceptual model—emphasizing cause and effect, and presented in Section 3—how ITS deployment and operation in the context of smart cities leads to energy saving benefits. This section also provides quantitative empirical evidence, collected from literature and case studies, of energy saving potential of ITS investments. Methodological challenges in quantifying energy saving benefits and how the empirical-evidence-based framework works are further discussed using examples of ridesourcing services and vehicle automation. Section 4 offers detailed discussions of institutional, technological, and physical conditions at each step in the conceptual model. Finally, policy recommendations on the major conditions under which ITS investments in the context of smart cities achieve energy savings are summarized in Section 5 with specific implications for cities in developing countries.

2. From ITS to smart mobility

The evolution of the smart cities movement has transformed traditional ITS into "smart mobility"—a series of transport initiatives that are integrated with broader city efforts aided by technology to improve livability, competitiveness, and sustainability.

Smart mobility initiatives target all types of transport users. For car drivers, vehicle and communication technology innovations provide a wide range of services from navigation, entertainment, tolling, parking, to autonomous driving; public transit riders get real-time service information on their cellphones and do not need to carry cash anymore; people can easily find and rent bicycles in the city as there is no need of docking stations; pedestrians with disabilities are able to enjoy extra green time when crossing a street; logistic industry can take advantages of freight matching platform to save costs and

[1] Xinhuanet, 2015. http://news.xinhuanet.com/fortune/2015-06/27/c_1115742453.htm.