Emerald Insight

Benchmarking: An International Journal

An exploratory evaluation of state road provision to commuters and shippers

Hokey Min Thomas Lambert

Article information:

To cite this document:
Hokey Min Thomas Lambert , (2015),"An exploratory evaluation of state road provision to commuters and shippers", Benchmarking: An International Journal, Vol. 22 Iss 5 pp. 900 - 919
Permanent link to this document:
http://dx.doi.org/10.1108/BIJ-07-2013-0070

Downloaded on: 14 November 2016, At: 00:59 (PT)
References: this document contains references to 52 other documents.
To copy this document: permissions@emeraldinsight.com
The fulltext of this document has been downloaded 99 times since 2015*

Users who downloaded this article also downloaded:

(2015),"Evaluating the comparative efficiency of the postal services in OECD countries using context-dependent and measure-specific data envelopment analysis", Benchmarking: An International Journal, Vol. 22 Iss 5 pp. 839-856 http://dx.doi.org/10.1108/BIJ-10-2013-0098

(2015),"Benchmarking the service quality of airlines in the United States: an exploratory analysis", Benchmarking: An International Journal, Vol. 22 Iss 5 pp. 734-751 http://dx.doi.org/10.1108/BIJ-03-2013-0029

Access to this document was granted through an Emerald subscription provided by emerald-srm:563821 []

For Authors

If you would like to write for this, or any other Emerald publication, then please use our Emerald for Authors service information about how to choose which publication to write for and submission guidelines are available for all. Please visit www.emeraldinsight.com/authors for more information.

About Emerald www.emeraldinsight.com

Emerald is a global publisher linking research and practice to the benefit of society. The company manages a portfolio of more than 290 journals and over 2,350 books and book series volumes, as well as providing an extensive range of online products and additional customer resources and services.

Emerald is both COUNTER 4 and TRANSFER compliant. The organization is a partner of the Committee on Publication Ethics (COPE) and also works with Portico and the LOCKSS initiative for digital archive preservation.

*Related content and download information correct at time of download.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/1463-5771.htm

Received 7 July 2013
Revised 30 October 2013
Accepted 3 December 2013

An exploratory evaluation of state road provision to commuters and shippers

Hokey Min
Department of Management, Bowling Green State University, Bowling Green, Ohio, USA, and
Thomas Lambert
Department of Political Science, Criminal Justice and Organizational Leadership, Northern Kentucky University, Highland Heights, Kentucky, USA

Abstract

Purpose – Due to mounting fiscal pressures, the federal government as well as many state and municipal governments in the USA have had to re-examine their transportation policies. Tax increases and/or spending cuts which aim to trim budget deficits are preoccupations of most policy makers and legislative bodies nowadays. With regard to the task of building new or rehabilitating old bridges, highways, and toll gates, cost-benefit analysis and economic impact studies are often undertaken by various government entities to rank and prioritize spending in the hopes of maximizing fiscal efficiency and road usage benefits. Since most highway construction and maintenance expenditures are absorbed by state governments, it is mostly up to state policy makers to decide transportation priorities. Not much research to date has been conducted to evaluate the comparative efficiency of state road provision to commuters and shippers. Such research would be useful to a state government's budgetary allocation, road planning, and spending plans. The paper aims to discuss these issues.

Design/methodology/approach – This paper uses data envelopment analysis under both constant and variable returns-to-scale and then to explain variations in efficiency ratings by using Tobit regression analysis.

Findings – The authors discovered that the greater the level of state resident income and/or the warmer the weather, the higher the road or mass transit provision efficiency on average. The authors also found that greater urbanization in a state had little to do with efficiencies with respect to road provision.

Originality/value – This paper is one of the first to assess and evaluate the comparative efficiency of road provision across 50 states in the USA and then set a benchmark for utilizing state financial resources to improve road infrastructure. More importantly, this paper helps transportation planners and public policy makers better allocate their limited financial resources to public goods in time of budget cutbacks and shortfalls.

Keywords Performance measurement, Data envelopment analysis

Paper type Research paper

Introduction

Both commuting and shipping times have very important economic implications, because they affect workers' productivity and businesses' ability to serve their customers in a timely manner. They also have important public policy implications, because they can dictate what motor vehicle owners and shippers should pay in taxes and fees each year for road/highway/bridge/mass transit construction, maintenance,

This research was partly funded by the University Transportation Center (UTC) at the University of Detroit-Mercy and the US Department of Transportation as part of the *TranslinkeD* research project.

Benchmarking: An International Journal
Vol. 22 No. 5, 2015
pp. 900-919
© Emerald Group Publishing Limited
1463-5771
DOI 10.1108/BIJ-07-2013-0070

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

debt service, and so forth. That is to say, local business competitiveness may rest heavily on commuting and shipping times that are affected by basic transportation infrastructure such as roads, highways, transit rails, and bridges (roads for short hereafter). Nevertheless, according to a report issued by a panel of experts and former transportation officials, the US investment in the preservation and the development of basic transportation infrastructure lags behind that of China, Russia, and European countries, and such a lack of investment may lead to a steady erosion of the social and economic foundations for American prosperity in the long run (Halsey, 2010). To make matters worse, the ongoing worldwide economic crisis coupled with severe government budget shortfalls continue to limit the US government's effort to increase its spending on infrastructure development and maintenance. In order to align its public transportation policy with economic goals, the federal, state, and municipal governments in the USA actively could generate more revenue streams by increasing toll fees, gasoline and property taxes, mass transit fares, and road-congestion prices. However, these revenue generating ideas may backfire since they can further increase the financial burdens of cash strapped citizens and businesses.

At the same time, while trying to minimize commute time to work and shipping time to deliver products to customers, states must also provide roads that have the capacity to serve resident-commuters as well as trucking firms that deliver consumer products and provide jobs to constituents. A transportation system must serve constituents adequately in their journey to work by providing access for enough commuters. Trucking firms must have roads with enough room to allow a sufficient number of trucks to move safely and to make deliveries at various points within a region without significant traffic delays. For this reason, road provision must not only try to minimize commute and shipping times but also allow access to all consumers of road services who have paid taxes for road provision, although such access creates congestion and road maintenance problems. The conflicts between providing maximum access and reasonable commute times without delays or congestion present many challenges to policy makers.

As such, there is a growing concern over road provision, especially when the government spends its budget excessively on certain construction projects or wastes its resources on less prioritized (i.e. "pork barrel") projects. To ease this concern, public policy makers (especially state and municipal government authorities) should justify their actions on road provision for their constituents, since road provision is mostly financed by state governments with some projects partially funded with federal government aid, although road projects receiving federal funding are usually locally identified and prioritized (US Department of Transportation, 2011a). As state and municipal governments face financial problems that have persisted after the conclusion of the latest economic recession, the efficiency and effectiveness of all governmental programs including road provision have come under closer scrutiny. If commuters and shippers are facing more delays in their travels and suffering from higher transportation costs despite rising road spending, there is a need for a systematic study which can examine and then evaluate road provision policies (Texas Transportation Institute, 2011). In response to such a need, this paper aims to examine ways that state governments in the USA provide transportation infrastructure through road provision so as to help policy makers (state and federal) develop road provision strategies to improve efficient long-term road investment plans. In addition, this paper identifies factors that may significantly influence road provision and

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

infrastructure investment decisions. More specifically, key research questions to be addressed by this paper are:

RQ1. How efficiently government budgets including tax monies are utilized to sustain proper road infrastructure?

RQ2. Which state's road provision practices are considered to be best-in class practices (i.e. benchmarks) that other lagging states can emulate?

RQ3. What are the main causes of road provision inefficiencies?

RQ4. How significantly road provision can affect commuting and shipping times that, in turn, may influence regional economies?

RQ5. What are the public policy implications (e.g. state tax policies, toll fee pricing) of road provision efficiencies?

Literature review

Since approximately 70 percent of road provision decisions regarding highway construction and maintenance spending are made by state governments, it is mostly up to state policy makers to decide transportation budget priorities (US Department of Transportation, 2010). Despite the significance of road provision on state fiscal plans and regional economic development, the research for this paper has found no published literature to date that has been conducted to compare the 50 states with respect to their efficiency in providing road services to commuters and shippers. Though not directly related to state road provision issues, Della and Nelson (1991) assessed the economic efficiency of a sample of mid-western (Illinois, Minnesota, and Wisconsin) township governments in providing low-volume, rural road services. Their empirical test revealed that the local government's separate, small scale operations were less efficient and more costly than multiple local governments' consolidated but larger scale operations due to economies of scale. This finding implied that road provision decisions have to be made at the state government level as opposed to the local township level.

Extending the concept that the efficient allocation of financial resources by the government could affect the quality of road services, Min and Lambert (2006) attempted to compare a group of states on their abilities to raise and spend tax dollars with regard to their road provision. Although their study was one of the first to measure the comparative efficiency of state governments' highway expenditures and road finances relative to their peers and previous years of performances using data envelopment analysis (DEA), it was still confined to the comparison of only 11 states. Its other shortcoming was the failure to identify exactly what environmental factors might have caused the inefficiency.

Later, De la Garza *et al.* (2009) attempted to measure the relative efficiency of highway maintenance operations undertaken by the state department of transportation and its private contractors. Their study also tried to assess the effects of environmental variables such as climate, geography, pavement conditions, and privatization of the road maintenance programs. This study, however, was limited to the comparison of local highways within 200-250 miles of Virginia's interstate highways. In other words, this study neither provided any cross-state comparison, nor discussed any state road provision implications of highway maintenance.

To overcome the aforementioned shortcomings of prior studies on road provision, this paper measures the comparative efficiencies of all 50 states in the USA using DEA

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

and then uncovers the main sources of relative efficiency or inefficiency of state road provision using a series of Tobit regression analyses. Herein, we chose DEA over other alternative techniques, such as Cobb Douglas functions and analytic hierarchy process, because DEA reflects the multiple aspects of organizational performances, does not necessitate a priori weights of performance measures, does not require an explicit a priori determination of input and output functional relationships, and provides valuable insights as to how road provision efficiency can be improved (Min *et al.*, 2008). Also, DEA is known to be useful for developing strategic action plans to enhance performances or efficiencies of lagging organization units such as state governments (Wu *et al.*, 2013). To elaborate, DEA determines the following (Sherman and Ladino, 1995; Min and Joo, 2009; Min *et al.*, 2013):

- the best practice organizational unit that uses the least resources to provide its products or services at or above the performance standard of other organizational units;
- the less efficient organizational units compared to the best practice organizational units;
- the amount of excess resources used by each of the less efficient organizational units; and
- the amount of excess capacity or ability to increase outputs for less efficient organizational units without requiring added resources.

As *post hoc* analysis of the DEA results, we chose Tobit regression over ordinary least squares because the dependent variable of the proposed regression model is truncated with a DEA efficiency score ranging from 0 to 1 (Amemiya, 1973).

Research methodology

To gauge the efficiency of many different organizations and institutions, DEA is employed in this paper. DEA is a special application of linear programming (LP) based on the frontier methodology of Farrell (1957). In general, DEA is a non-parametric modeling or estimation method that uses a LP technique to construct a production possibility frontier based on common inputs and outputs used by similar "decision making units (DMUs)." DMUs refer to the collection of private firms, non-profit organizations, departments, administrative units, and groups with the same (or similar) goals, functions, standards, and market segments. The frontier represents the optimal amounts of output given various combinations of inputs, and DMUs are ranked relative to one another according to how close they come to reaching an optimal level of output on the frontier with a score of 1.0 representing efficiency, which means a DMU has matched an optimal point on the frontier (Cook and Zhu, 2005). It establishes a "relative" benchmark standard. Also, DEA production techniques can have either constant returns-to-scale (CRS) or variable returns-to-scale (VRS), while the analysis of DMUs can be approached from either an input minimization or output maximization orientation as one is a dual of another.

DEA can be employed for measuring the comparative efficiency of any entities including banks (Casu and Molyneux, 2003), hospitals (Ferrier and Valdmanis, 2004; Anderson *et al.*, 2008), municipal services (Moore *et al.*, 2005), transit agencies (Nolan *et al.*, 2001), trucking firms (Min and Joo, 2006), third-party logistics (3PL) providers (Min and Joo, 2006; Joo *et al.*, 2013; Min *et al.*, 2013), hotels (Min *et al.*, 2008;

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Wu *et al.*, 2013), national economies (Knox Lovell *et al.*, 1995; Margaritis *et al.*, 2007; Afonso *et al.*, 2010), paratransit systems (Min and Lambert, 2011), retail distribution networks (Lau, 2012), clinical departments (Pantouvakis and Mpogiatzidis, 2013), and many other different types of DMUs.

The general DEA model can be mathematically expressed as (Charnes *et al.*, 1978; Fare *et al.*, 1994; Nolan *et al.*, 2001):

$$\text{Maximize efficiency score } (jp) = \frac{\sum_{r=1}^{t} u_r\, y_{rjp}}{\sum_{i=1}^{m} v_i\, x_{ijp}} \tag{1}$$

$$\text{Subject to } \frac{\sum_{r=1}^{t} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \leqslant 1, \quad j = 1, \cdots, n, \tag{2}$$

$$u_r, v_i \geqslant \varepsilon, \quad \forall r \text{ and } i, \tag{3}$$

where y_{rj} is the amount of output r produced by DMU j; x_{ij} the amount of input i used by DMU j; u_r the weight given to output r; v_i the weight given to input i; n the number of DMUs; t the number of outputs; m the number of inputs; ε a small positive number.

The fractional, non-LP model described above can be converted to a LP model without much difficulty. A major assumption of LP is a linear relationship among variables. Therefore, an ordinary LP for solving DEA often utilizes a constant returns-to-scale so that all observed production combinations can be scaled up or down proportionally (Charnes *et al.*, 1978). On the other hand, by using a piecewise LP, DEA can consider a non-proportional returns-to-scale including increasing or decreasing returns-to-scale (Banker *et al.*, 1984). The aforementioned DEA model was utilized to compare the relative efficiency of providing road services to commuters, mass transit riders, and shippers based on the following input and output secondary data:

(1) Average of Total Tax Receipts for Highways in thousands, 2007-2009. Since mostly state along with federal and local tax revenues were invested for highway maintenance and construction, these data are categorized as an input in the delivery of road services to commuters, shippers, and transit riders.

(2) Average of Total Disbursements for Highways, Operating and Capital Expenditures, in thousands, 2007-2009. Since this comprises and represents a major source of road provision, this is also regarded as an input to the delivery of road services to commuters, shippers, and transit riders. It is composed of federal, mostly state and local funds.

(3) Average of Total Tax Receipts and Disbursements for Mass Transit Projects, in thousands, 2007-2009. Since revenues and disbursements for each state for mass transit projects were identical (matched) for each year, just two inputs were combined into one here. Some states did not spend any financial resources on mass transit projects during this time period, and so these states were not included in the mass transit DEA. These amounts are used as inputs for the delivery of mass transit services.

(4) Total Urban and Rural Lane Miles, 2009. Total urban and rural lane miles are used as an input for road provision to commuters, shippers, and transit riders (US Department of Transportation, 2011b).

(5) Average of Construction Cost Index, 1997-2005 (1987 base year prices). This index measures how much costs have increased from one year to the next for each state for road maintenance and construction projects that have received federal highway funding. Some states have seen more rapid and higher increases in costs than others. (US Department of Transportation, 2011b). Thus, this index affects the efficiency of road provision and is treated as an input for road provision to commuters, shippers, and transit riders.

For DEA outputs, the following data are used:

(1) Average time to work in minutes for those not working at home and using car, truck, or van, 2007-2009 (US Census Bureau, 2007-2009; American Community Survey). Since commuting time reflects the efficiency of road provision, this data are regarded as an output for commuters.

(2) Estimated number of commuters driving alone or carpooling (US Census Bureau, 2007-2009, American Community Survey). This is used as an output for commuters and reflects the total capacity or access that states must offer to motor vehicle operators.

(3) Average time to work in minutes for those not working at home using mass transit, 2007-2009 (US Census Bureau, 2007-2009, American Community Survey). Taking into account those who commute to work using the mass transit system, this data are also viewed as an output for transit riders.

(4) Estimated number of mass transit riders (US Census Bureau, 2007-2009, American Community Survey). This is a capacity and output measure for mass transit riders.

(5) Average score on estimated trucking congestion (1 = weak, 2 = moderate, 3 = strong). Since most "choke points" are in the urban metropolitan areas, the average score on estimated trucking congestion is calculated primarily based on the extent of traffic jams and bottlenecks in the selected urban metropolitan areas representing the state (e.g. Detroit in the state of Michigan; Chicago in the state of Illinois; Indianapolis in the state of Indiana). Given that no statewide estimates of traffic congestion exist, we used maps showing chronic bottlenecks in the urban metropolitan areas throughout the USA as the surrogate traffic congestion measure of each state (US Department of Transportation, 2011c, FHWA). Those states which had metro areas that had severe bottlenecks (often more than an hour of delays) received a score of 3, whereas those that showed no metro areas displaying bottlenecks received a score of 1. Those that displayed moderate traffic delays scored a 2. This was used as an output for shippers.

(6) Ton miles of truck shipment per state in millions (US Department of Transportation, Federal Highway Administration, Freight Facts and Figures 2009 (2011d)). For shippers this was used as an output to reflect the capacity that states have to offer to commercial shippers. This includes shipments leaving, entering, and passing through the state as well as local and within state shipments.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Since DEA constructs a production frontier based on output maximization, the reciprocals of the values for outputs 1, 3, and 5 above are used to make the longer commuting or shipping times smaller. For example, in comparing average commuting times of ten and 20 minutes as outputs, maximizing output would indicate that 20 is a better score for commuting time rather than ten, although shorter commute times are preferred over longer ones. Therefore, these outputs are converted into 0.10 for ten minutes and 0.05 for 20 minutes so that outputs are scaled correctly.

The descriptive statistics for the preceding input and output variables are summarized in Table I, and the scores of the CRS and VRS generated by DEA for each form of travel are displayed in Tables II-IV. CRS efficiency assumes that there is a constant or fixed increase in output for each equivalent increase in inputs. For instance, under this scale, a 10 percent increase in inputs should yield a 10 percent increase in output. VRS efficiency is slightly different from CRS efficiency in that it assumes that any increases in output due to increases in inputs are variable. For example, under this scale, a 10 percent increase in inputs can yield a 5, 10, or 20 percent increase in output. VRS efficiency may perhaps be a more realistic assumption for many production settings, especially those involving large economies of scale.

In examining the CRS and VRS efficiency scores in Tables II-IV, Hawaii is the one state that scores 1.0 either under CRS or VRS efficiency for all the three forms of transportation. Only a handful of states score a 1.0 for both CRS and VRS efficiency with regard to mass transit, and all of them are states with large urban populations with the exception of Alaska. With regard to truck shipping and commuting times, those states which score 1.0 under both types of efficiency are varied with regard to

Variable	Mean	SD
CRS efficiency commuters	0.854	0.117
VRS efficiency commuters	0.890	0.115
CRS efficiency mass transit	0.356	0.326
VRS efficiency mass transit	0.409	0.336
CRS efficiency truck shipping	0.778	0.200
VRS efficiency truck shipping	0.836	0.167
Climate	0.6	0.4949
% Population urban 2009	69.62	14.2
Median household income, 2007-2009	$51,124	8,476
Land area of state in square miles	70,748	85,987
Inputs for DEA, commute to work, mass transit, and truck shipping efficiency		
Avg. total receipts, 2007-2009, thousands	$2,738,668	2,927,361
Avg. total disbursements, 2007-2009, thousands	$2,565,914	2,717,528
Total urban and rural lane miles, 2009	169,609	114,036
Avg. receipts and disbursements, mass transit, 2007-2009, thousands	$77,097.3	195,119.5
Average of construction cost index, 1997-2005	146.25	40.3
Outputs for DEA, commute to work, mass transit, and truck shipping efficiency		
Avg. time to work in minutes for those not working at home 2007-2009	23.35	3.5
Estimated number of commuters driving alone/carpool, 2007-2009	2,418,522	2,552,572
Avg. time to work in minutes using mass transit, 2007-2009	42.47	6.81
Estimated number of commuters mass transit, 2007-2009	156,544	394,402
Avg. score on trucking congestion (1 = weak, 2 = moderate, 3 = strong)	2.06	0.89
Ton miles of truck shipment per state in millions	42,279	38,288

Table I.
Descriptive statistics

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Inputs	*Outputs*
Construction cost index avg 1997-2005, 1987 base year prices	Reciprocal of avg time to work × 100, car truck or van, 2007-2009
Avg total receipts, all sources, used for highways, 2006-2008	Commuters, carpool or drive alone (estimate)
Avg total disbursements for highways, 2006-2008	
Total lane miles, urban and rural	

DMU name	*VRS efficiency*	*CRS efficiency*
Alabama	0.81612	0.80806
Alaska	1.00000	0.92854
Arizona	0.88060	0.87030
Arkansas	0.86280	0.84518
California	1.00000	1.00000
Colorado	0.89391	0.88676
Connecticut	1.00000	1.00000
Delaware	1.00000	0.78872
Florida	1.00000	1.00000
Georgia	1.00000	0.99376
Hawaii	1.00000	1.00000
Idaho	0.84771	0.77110
Illinois	0.77509	0.77388
Indiana	0.82343	0.81740
Iowa	0.70423	0.69651
Kansas	1.00000	0.78562
Kentucky	0.76727	0.75020
Louisiana	0.71321	0.70099
Maine	0.74164	0.71772
Maryland	1.00000	0.96540
Massachusetts	0.95163	0.94198
Michigan	1.00000	1.00000
Minnesota	0.74259	0.74126
Mississippi	1.00000	1.00000
Missouri	0.65070	0.65061
Montana	0.66798	0.64281
Nebraska	1.00000	0.64605
Nevada	1.00000	0.91399
New Hampshire	0.85538	0.83022
New Jersey	1.00000	1.00000
New Mexico	0.85034	0.78231
New York	1.00000	0.87887
North Carolina	0.93202	0.93082
North Dakota	0.77639	0.73128
Ohio	0.97436	0.91764
Oklahoma	0.77275	0.76992
Oregon	0.82415	0.80122
Pennsylvania	0.77803	0.74880
Rhode Island	1.00000	1.00000

(*continued*)

Table II. DEA scores for commuting to work using car, truck or van

Table II.

South Carolina	1.00000	1.00000
South Dakota	1.00000	0.93562
Tennessee	1.00000	1.00000
Texas	0.88360	0.80459
Utah	0.83939	0.79861
Vermont	1.00000	1.00000
Virginia	0.87550	0.85699
Washington	0.66119	0.66050
West Virginia	1.00000	1.00000
Wisconsin	0.92581	0.90825
Wyoming	0.73566	0.71383

geographic location, degree of urbanization, and median household income. California, Florida, Mississippi, Tennessee, and West Virginia are states that score 1.0 on both types of efficiency scores for both truck shipping and commuting times.

To further identify the main sources of efficiency or inefficiency of road provision, we paired these DEA scores against a set of independent variables using a special form of regression analysis called Tobit regression. In general, Tobit regression aims to analyze continuous data that are censored, or bounded at a limiting value. The Tobit regression model is well suited to measure the transformed efficiency such as DEA efficiency scores, when dependent variables have sensible partial effects over a wide range of independent variables (see, e.g. Amemiya, 1973, 1985; Breen, 1996; Wooldridge, 2006 for details of Tobit regression). A Tobit regression model assumes that the dependent variable has its value clustered at a limiting value, usually zero. But, in the DEA model that is proposed in this paper, the dependent variable is right censored at 1.0, and the model can be written in terms of the underlying or the latent variable that is mathematically expressed as:

$$y_i^* = x_i\beta + \varepsilon_i \text{ and } \varepsilon_i \sim N\left(0, \sigma^2\right), \quad i = 1, \cdots, n \tag{4}$$

where y_i^* is the dependent variable; x_i the vector of independent variables; β the vector of unknown coefficients; ε_i the independently distributed random error terms assumed to be normal with zero mean and constant variance σ^2; and n the number of observations.

In our sample, we observe $y = \left(y_i^*\right)$ only when $y_i^* < c$ (right censored), where c is a constant. The values of y are censored to the right at one, and thus we need to estimate:

$$E\left(y_i | y_i < c, x_i\right) = E\left(y_i | \varepsilon_i \leqslant c - x_i\beta_i\right) \tag{5}$$

The probability that $\varepsilon_i \leqslant c$ is mathematically expressed as:

$$\Phi\left[\frac{c}{\sigma}\right] = \int_{-\infty}^{c/\sigma} \frac{1}{\sqrt{2\pi}} \exp\left(-t^2/2\right) dt \tag{6}$$

The expected value is calculated as:

$$\begin{aligned} E\left(y_i | y_i < c, x_i\right) &= x_i{}'\beta - \sigma\frac{\phi(c)}{\Phi(c)} \\ &= x_i{}'\beta - \sigma\hat{\lambda}_i(c) \end{aligned} \tag{7}$$

where $\hat{\lambda}_i(c)$ is an inverse Mill's ratio that is a ratio of the probability density function to the cumulative distribution function of a distribution.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Inputs	*Outputs*	
Avg. total receipts and disbursements 2007-2009	Reciprocal of avg. time to work using mass transit	
Total lane miles, urban and rural	Commuters using mass transit (estimate)	
DMU name	*VRS efficiency*	*CRS efficiency*
Alaska	1.00000	1.00000
Arizona	0.12806	0.11904
Arkansas	0.13430	0.10309
California	0.23383	0.23362
Colorado	0.08272	0.07805
Connecticut	0.29492	0.26933
Delaware	0.80551	0.71537
Florida	0.75151	0.75065
Georgia	1.00000	1.00000
Hawaii	1.00000	1.00000
Idaho	0.29608	0.19939
Illinois	1.00000	1.00000
Iowa	0.39487	0.12517
Kansas	0.10808	0.10180
Kentucky	0.16705	0.07338
Louisiana	0.20073	0.17199
Maryland	0.43792	0.42515
Massachusetts	0.46747	0.46335
Michigan	0.05358	0.04590
Minnesota	0.10550	0.05683
Mississippi	0.13934	0.12030
Montana	0.16381	0.14690
Nebraska	0.16351	0.15867
New Hampshire	0.55115	0.40419
New Jersey	0.57966	0.56682
New Mexico	0.09048	0.07018
New York	1.00000	1.00000
North Dakota	1.00000	0.23373
Ohio	0.46734	0.46600
Oklahoma	0.10293	0.10130
Oregon	0.30394	0.29253
Pennsylvania	0.14485	0.14445
Rhode Island	0.70436	0.63493
South Carolina	0.13509	0.12547
South Dakota	0.37428	0.15049
Tennessee	0.08615	0.06611
Texas	0.04654	0.04385
Vermont	0.79343	0.70795
Washington	0.28103	0.27474
West Virginia	0.27254	0.24461
Wisconsin	0.13268	0.12561
Wyoming	1.00000	0.95406

Table III. DEA scores for commuting to work using mass transit

It should be noted that the Tobit model accounts for truncation. A regression of the observed "y" values on "x" will lead to an unbiased estimate of β (or the independent variables). While the Tobit regression analysis does not yield a measure of variation in the dependent variable as opposed to the coefficient of determination (r^2) in ordinary least squares regression, it does yield a log-likelihood statistic that indicates the

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Inputs	*Output*	
Construction cost index avg. 1997-2005, 1987 base year	Reciprocal truck freight congestion	
Avg. total receipts, all sources, used for highways, 2006-2008	Total ton miles of truck shipments	
Avg. total disbursements for highways, 2006-2008		
Total lane miles, urban and rural		
DMU name	*VRS efficiency*	*CRS efficiency*
Alabama	0.84454	0.82960
Alaska	0.95138	0.95138
Arizona	0.92199	0.83477
Arkansas	1.00000	0.99696
California	1.00000	1.00000
Colorado	0.53896	0.37444
Connecticut	0.89596	0.50625
Delaware	1.00000	0.76109
Florida	1.00000	1.00000
Georgia	0.91150	0.90374
Hawaii	1.00000	1.00000
Idaho	0.85357	0.85357
Illinois	0.87352	0.87174
Indiana	0.90884	0.89902
Iowa	0.59870	0.59870
Kansas	0.64365	0.64365
Kentucky	0.89900	0.85233
Louisiana	0.77751	0.68999
Maine	0.70118	0.70118
Maryland	0.88994	0.71663
Massachusetts	0.63533	0.38038
Michigan	0.73417	0.73318
Minnesota	0.42223	0.28715
Mississippi	1.00000	1.00000
Missouri	0.58869	0.56727
Montana	0.80862	0.80862
Nebraska	0.60524	0.60524
Nevada	0.71730	0.71730
New Hampshire	0.75251	0.75251
New Jersey	0.79830	0.61390
New Mexico	1.00000	1.00000
New York	0.55122	0.47173
North Carolina	0.75301	0.72303
North Dakota	0.86784	0.86784
Ohio	0.96704	0.96464
Oklahoma	0.96307	0.96160
Oregon	0.74500	0.65039
Pennsylvania	0.79638	0.78609
Rhode Island	1.00000	0.47949

Table IV.
DEA scores for truck shipping efficiency

(*continued*)

South Carolina	0.98849	0.85182
South Dakota	1.00000	1.00000
Tennessee	1.00000	1.00000
Texas	1.00000	1.00000
Utah	0.81630	0.65818
Vermont	1.00000	1.00000
Virginia	0.98795	0.94677
Washington	0.41460	0.40948
West Virginia	1.00000	1.00000
Wisconsin	0.65799	0.65403
Wyoming	1.00000	1.00000

Table IV.

explanatory power of the model employed, and the larger the absolute value of the log-likelihood statistic, the greater the explanatory power of a model.

The following variables were used as independent variables to predict the DEA efficiency scores for each form of travel for each state:

- Climate. Since extreme temperatures and/or the extent of precipitation can lead to sub-optimal road provision, the state's climate is regarded as an explanatory or environmental variable (Ladd, 1992; Garcia-Sanchez, 2006). For example, the greater the precipitation, the slower the traffic movement (i.e. greater commuting or shipping time). The US National Oceanic and Atmospheric Administration provides data for average temperatures, precipitation, and other weather conditions within the US at the city level but not at the state level (US National Oceanic and Atmospheric Administration, 2011). Because weather can vary so much within some states, an attempt to provide such data would be very problematic, yet some attempt to account for weather variation must be made since weather (temperature and precipitation especially) is such an important factor in road construction and rehabilitation costs/expenditures. This paper used a dummy variable where northern states (north-eastern, mid-western, north-central, and north-western states including Alaska) were coded with a "1" and southern states (south-eastern, south-central, and south-western states including California and Hawaii) were coded with a "0." This dichotomy was based mostly upon differences in precipitation and temperature, where southern states usually have warmer year round temperatures and in some cases less precipitation. This dichotomy is not perfect, but is the best that can be done absent other data. The hypothesis is that colder states with more precipitation should have lower DEA scores because of higher maintenance costs due to their having more rain, ice, and freezing weather.
- Average of state median household income, 2007-2009 (US Census Bureau, 2007-2009, American Community Survey). This is used as a proxy for a state's ability and capacity to raise the tax revenues necessary to carry out road construction and maintenance projects. In other words, we made a premise that higher income states, *ceteris paribus*, can afford to invest more in their road infrastructure because they have better tax bases and greater financial resources (Lambert and Meyer, 2008). The state resident's income level is also highly correlated with the State Growth Domestic Product, another measure of state tax

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

capacity. The rationale being that greater financial capacity would lead to higher efficiency scores since wealthier state residents can afford to pay more for roads.

- Urban population as a percentage of the state's population, 2009 (US Census Bureau, 2007-2009, American Community Survey). Since the majority of a state's labor force lives and works in metro areas and most trucking bottlenecks occur in metro areas according to the FHWA (US Department of Transportation, 2011c), the urban composition of a state is essential for gauging the state's road provision efficiency. The rationale being that greater urbanization is associated with greater traffic congestion, which would lead to lower DEA efficiency scores, although urbanization may provide greater economies of scale in road provision, which could lead to higher DEA scores.
- Land area of each state in square miles (US Census Bureau). Obviously, the larger the land mass of the state, the more it has to spend on roads, so this variable is used as a control variable that can account for road expenditures. Also, it is noted that the sheer size of the state may help to create economies of scale that can influence road provision efficiency.

Tables V-VII show the results of the Tobit regression analysis used to assess the DEA scores for the three types of travel using roadways.

Results and discussions

The results of the three different sets of Tobit models show that only two explanatory variables at the most are statistically significant at $\alpha = 0.05$ in most models. The Tobit regression models explain only small amounts of variation in the dependent variable due to the low log-likelihood scores. In Table V, the average median household income of state residents and climate are the strongest predictors of CRS road provision efficiency with regard to car, truck, or van commuters (carpooling or driving alone). Apparently, the greater the financial resources of a state resulting from a higher income tax base, the more it can spend to build and maintain road infrastructure. Additionally, warmer weather is a benefit to a state – those states in the south, south-western, and western parts of the US scored higher on CRS efficiency than other states. These

Table V. Commuter travel efficiency car, truck or van

Predictor	Coefficient	SE	*Z*	*p*-value
Response variable: CRS efficiency scores for commuting by car, truck, or van				
Intercept	0.5883	0.1274	4.6200	0.0000
Climate	−0.1274	0.0461	−2.7600	0.0060
Land area of state in sq. miles	0.00001	0.0000	−1.5000	0.1340
Avg. median household income, 2007-2009	0.00001	0.0000	2.5400	0.0110
Pct. pop urban 2009	−0.0011	0.0019	−0.5700	0.5710
Log-likelihood = 12.299				
Response variable: VRS efficiency scores for commuting to work by car, truck, or van				
Intercept	0.5522	0.1769	3.1200	0.0020
Climate	−0.0904	0.0626	−1.4500	0.1480
Land area of state in sq. miles	0.00001	0.0000	−0.4200	0.6710
Avg. median household income, 2007-2009	0.00001	0.0000	1.8400	0.0660
Pct. pop urban 2009	−0.0001	0.0025	−0.0500	0.9620
Log-likelihood = −5.609				

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Predictor	Coefficient	SE	*Z*	*p*-value
Response variable: CRS efficiency scores for mass transit				
Intercept	−0.6702	0.3143	−2.1300	0.0330
Climate	−0.0625	0.1215	−0.5100	0.6070
Land area of state in sq. miles	0.00001	0.0000	0.5500	0.5800
Avg. median household income, 2007-2009	0.00001	0.0000	2.4200	0.0150
Pct. pop urban 2009	−0.0003	0.0047	−0.0700	0.9450
Log-likelihood = −16.001				
Response variable: VRS efficiency scores for mass transit				
Intercept	−0.3980	0.3517	−1.1300	0.2580
Climate	0.0169	0.1358	0.1200	0.9010
Land area of state in sq. miles	0.00001	0.0000	0.4000	0.6880
Avg. median household income, 2007-2009	0.00001	0.0000	2.2000	0.0280
Pct. pop urban 2009	−0.0042	0.0053	−0.7900	0.4310
Log-likelihood = −21.447				

Table VI. Commuter travel efficiency, mass transit

Predictor	Coefficient	SE	*Z*	*p*-value
Response variable: CRS efficiency scores for truck shipping				
Intercept	1.2777	0.1900	6.7300	0.0000
Climate	−0.1920	0.0690	−2.7800	0.0050
Land area of state in sq. miles	0.00001	0.0000	1.3600	0.1730
Avg. median household income, 2007-2009	0.00001	0.0000	−0.1800	0.8590
Pct. pop urban 2009	−0.0049	0.0029	−1.7200	0.0850
Log-likelihood = −2.162				
Response variable: VRS efficiency scores for truck shipping				
Intercept	0.9444	0.1514	6.2400	0.0000
Climate	−0.1457	0.0556	−2.6200	0.0090
Land area of state in sq miles	0.00001	0.0000	0.0300	0.9780
Avg. median household income, 2007-2009	0.00001	0.0000	0.7600	0.4450
Pct. pop urban 2009	−0.0026	0.0023	−1.1300	0.2580
Log-likelihood = 14.297				

Table VII. Truck shipping efficiency

factors may explain why some wealthier and warm weather states such as Hawaii, California, and Florida did relatively well on the CRS and VRS DEA scores for commuters using car, van, or truck. Hawaii ranked fifth, California ranked eighth, and Florida ranked 22nd in median household income in 2007 (US Census Bureau, 2009).

No variables worked well with regard to predicting commuter VRS efficiency scores. Average median household income is statistically significant at $\alpha = 0.10$, again implying that higher income states have the resources to provide road services efficiently. VRS efficiency provides a lower threshold for a DMU to demonstrate efficiency, and so more states can attain efficiency under VRS conditions. Therefore, it is probably more difficult to pinpoint-specific conditions under which VRS efficiency holds.

In Table VI, median household income is also a good predictor for both types of mass transit efficiency scores. Again, this is used as a proxy for a state's tax base, and

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

the results show that the greater the median household income, the more efficient transit provision is in a state. More financial resources can be used to provide greater access to those not traveling to work by motor vehicles and to try to minimize commuter congestion problems through providing mass transit alternatives. As recapitulated in Table III, Georgia, Illinois, New York are among the states receiving efficiency scores of 1.0 under both CRS and VRS conditions. Although the urban population variable is not significant in either model shown in Table VI, each of these states has substantial rail networks to serve transit riders, and each of these states had median household rankings in the upper half of the rankings for all states with Georgia ranked 23rd, Illinois ranked 16th, and New York ranked 18th for 2007.

Next, in Table VII, climate is the only variable in the models that impacts truck shipping. The warm weather states have higher efficiency scores on average probably due to the ease of maintaining roads in parts of the country that have less cold weather and precipitation, which in turn makes it easier for goods to move easily in these areas. Also, less precipitation means fewer shipping delays due to the less likelihood of having possible inclement weather which may disrupt traffic movements. State median household income is not a factor with regard to truck shipping efficiency unlike in the other two sets of models. Under CRS conditions, the urban population variable is statistically significant at $\alpha = 0.10$ and has a negative sign. This implies that more urbanized states are less efficient in accommodating truck traffics, all else held constant, because of their greater congestion problems.

Many public services such as road provision can gain efficiencies from the economies of scale that urban areas often provide. In our models, the percentage of a state's population that is urban had no impact on any of the efficiency scores with maybe the exception of the truck shipping CRS scores. This finding is somewhat parallel with that of an earlier study conducted by Winston and Langer (2006) which showed that road infrastructure investment in highly urbanized areas tended to be inefficient, even when the investment was made for new road construction that attempted to alleviate traffic congestion and provide greater access to motor vehicle commuters. According to Winston and Langer (2006), every dollar in urban road spending yields less than a dollar in benefits because the congestion relief is only temporary – as new roads are built to relieve traffic congestion in one part of an urban area, these new roads later become other choke points as drivers see them as good alternatives to old ways of traveling. Also, the authors believe that there will never be any way for road construction to keep up with annual increase in the total number of vehicles on the roadways. Instead, they recommended peak travel time or congestion pricing for major roadways during peak usage times, such as rush hour traffic. Such pricing could take the form of tolls with shippers probably willing to pay a little more to prevent delays. On the other hand, they suggest that exemptions to the peak load pricing, or tolls, should be granted to mass transit providers or to commuters that carpool in order to relieve traffic congestion in the urban settings.

Concluding remarks

To the best of our knowledge, this paper is one of the first to comprehensively measure and benchmark the comparative efficiency of state road provision in the USA, while identifying the factors (e.g. resident income, urbanization) most influential for road provision efficiency. In most of the models tested, the greater the level of state resident income and/or the warmer the weather, the higher the road or mass transit provision

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

efficiency on average. We also found that greater urbanization in a state had little to do with efficiencies with respect to road provision. This finding is contradictory to the notion that more dense development in an urban environment usually accompanies economies of scale in providing some public services such as road or mass transit provision, although some scholars point out that certain population thresholds have to be reached first before mass transit provision is viable (Hirsch, 1973, 1984; Ladd, 1992; Carruthers and Ulfarsson, 2003; Garcia-Sanchez, 2006; O'Sullivan, 2007). With regard to mass transit specifically, the population density of most US metro areas is not considered dense enough to provide enough ridership to make it economically viable unless large subsidies are provided (O'Sullivan, 2007).

Overall, Hawaii is the clear benchmark after it registered perfect CRS and VRS efficiency scores of 1 in each category. Hawaii's success is unique in that it is isolated from the mainland, and thus its transportation access for those coming in from outside the islands is limited to a non-surface mode of transportation such as air carriers, cruise ships, and ferries. Since a lack of transportation access could undermine Hawaii's tourism industry, which is a major economic engine for Hawaii, the state government of Hawaii has made a conscious effort to properly maintain transportation infrastructure and alleviate increased traffic congestion on state and county roads and highways. These efforts include: the Statewide Transportation Improvement Program which includes the improvement of overall ground transportation services, a $20 million investment for a commuter rail project in Honolulu, and the construction of a $3.7-6 billion rail system in Honolulu. Hawaii's success in road provision is peculiar since its budget health was ranked one of the lowest (47 out of all 50 states) and it suffered from a budget deficit of $214 million in 2011 after state tax collections dropped by 0.9 percent in 2010 (Zimmerman, 2011; State Budget Solutions, 2011. This finding implies that budget shortfalls alone cannot be a legitimate excuse for road provision inefficiency.

Since state income is so important to efficient road provision, the need for a continued federal role to help poorer states provide better roads and mass transit systems is verified somewhat by the results presented in this paper. Some have pointed out that some states receive less back in federal gasoline taxes collected in their jurisdictions whereas others receive more (Winston and Langer, 2006), yet with income being a key to efficient state road provision, some form of redistribution by the federal government of gasoline tax revenues from wealthier to poorer states appears to be justified. Lower income states do not have the tax base to raise motor vehicle taxes and other road user fees too high in the first place in order to boost their efficiency in road provision.

Meanwhile, the higher income states may be justified in raising tolls and gasoline taxes higher because their residents may be able to better afford any tax increases. Additionally, higher tolls and gasoline taxes would probably help to lessen the traffic congestion experienced by commuters, shippers, and transit riders by equating the benefits of traveling to the true costs of traveling. That is to say, as economists such as O'Sullivan (2007) argued, traffic congestion is a negative externality created when costs of road travel are too low and subsequently too many vehicles are on the road. By increasing the costs of road travel through higher tolls and gasoline taxes, the marginal benefit of road travel would be no greater than the social marginal costs of road travel and thus more commuters would likely choose to carpool or use mass transit. This, in turn, should lower average commute times to work and increase road provision efficiency.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Policy implications and future research directions

Based on study findings summarized in previous sections, we would like to propose several transportation policies that can not only improve road provision efficiency, but also better allocate the limited government budget. These policies may include:

(1) Given that increases in higher tolls and gasoline taxes alone would not necessarily improve road provision efficiencies of poorer states, policy makers of such states may consider diversifying their revenue sources such as increased property taxes. Although increased property taxes may depress local property values, more road and mass transit investments resulting from greater tax revenues would eventually increase property values and thus offset the potential loss of the property values.

(2) Considering the fact that private enterprises including local trucking firms and 3PL service providers can reap the benefit of improved road infrastructure and networks, state policy makers should consider forming private-public partnerships to finance future road (e.g. toll road or bridge) construction or mass transit projects. This kind of policy will alleviate the financial burden of state governments, while reducing the tax burden of road users and increasing the long-term value for money for transferring risks and partial ownerships to the private sector over the life span of the road construction or mass transit project.

(3) Rather than simply building more roads and bridges to alleviate traffic congestion, urban transportation planners, and policy makers need to consider attracting more passengers to underutilized mass transit systems by improving their access to daily commuters with increased park-and-ride lots or bike-and-ride options.

Despite aforementioned policy implications of this exploratory study, this study is far from being perfect due in part to its reliance on a limited time frame (three-year period) and surrogate measures extracted from secondary data sources available in the public domain. To overcome some of the shortcomings of this study, future research efforts can be geared toward:

- expansion of time-series data across multiple time periods;
- examination of both short-term and long-term effects of states' budget health, transportation budget, and highway maintenance patrols on road provision;
- investigation of the impact of major road infrastructure developments (i.e. rapid rail systems) on road provision; and
- a comparison of road provision efficiency at the international level (e.g. USA vs Australia).

References

Afonso, A., Schuknecht, L. and Tanzi, V. (2010), "Income distribution determinants and public spending efficiency", *Journal of Economic Inequality*, Vol. 8 No. 3, pp. 367-389.

Amemiya, T. (1973), "Regression analysis when the dependent variable is truncated normal", *Econometrica*, Vol. 41 No. 6, pp. 997-1016.

Amemiya, T. (1985), *Advanced Econometrics*, Harvard University Press, Cambridge, MA.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Anderson, D.R., Sweeney, D.J., Williams, T.A., Camm, J.D. and Martin, K. (2008), *An Introduction to Management Science: Quantitative Approaches to Decision Making*, 13th ed., South-Western Cengage Learning, Mason, OH.

Banker, R.D., Charnes, A. and Cooper, W.W. (1984), "Some models for estimating technical and scale inefficiencies in data envelopment analysis", *Management Science*, Vol. 30 No. 9, pp. 1078-1092.

Breen, R. (1996), "Regression models: censored, sample-selected, or truncated data", in Lewis-Beck, M. (Ed.), *Sage University Paper Series on Quantitative Applications in the Social Sciences*, Sage Publications, Thousand Oaks, CA, pp. 7-111.

Carruthers, J.I. and Ulfarsson, G.F. (2003), "Urban sprawl and the cost of public services", *Environment and Planning B: Planning and Design*, Vol. 30 No. 4, pp. 503-522.

Casu, B. and Molyneux, P. (2003), "A comparative study of efficiency in European banking", *Applied Economics*, Vol. 35 No. 7, pp. 1865-1876.

Charnes, A., Cooper, W.W. and Rhodes, E. (1978), "Measuring the efficiency of decision making units", *European Journal of Operational Research*, Vol. 2 No. 6, pp. 429-444.

Cook, W.D. and Zhu, J. (2005), *Modeling Performance Measurement: Applications and Implementation Issues in DEA*, Springer, New York, NY.

De la Garza, J.M., Triantis, K. and Fallah-Fini, S. (2009), "Efficiency measurement of highway maintenance strategies using data envelopment analysis", *Proceedings of 2009 NSF Engineering Research and Innovation Conference, Honolulu, HI*, available at: www.champs.eng.vt.edu/docs/research/2009%20NSF%20Grantees%200726789_paper.pdf (accessed October 3, 2011).

Della, S.C. and Nelson, C.H. (1991), "Measuring the economic efficiency of rural road services", *American Journal of Agricultural Economics*, Vol. 73 No. 1, pp. 194-201.

Fare, R., Grosskopf, S. and Knox Lovell, C.A. (1994), *Production Frontiers*, Cambridge University Press, Cambridge.

Farrell, M.J. (1957), "The measurement of productive efficiency", *Journal of the Royal Statistical Society, Series A (General)*, Vol. 120 No. 3, pp. 253-290.

Ferrier, G. and Valdmanis, V.G. (2004), "Do mergers improve hospital productivity?", *Journal of the Operational Research Society*, Vol. 55 No. 1, pp. 1071-1080.

Garcia-Sanchez, I.M. (2006), "The efficiency measurement in Spanish local government: the case of municipal water services", *Review of Policy Research*, Vol. 23 No. 1, pp. 355-371.

Halsey, A. III (2010), "Failing US transportation system will imperil prosperity, report finds", *The Washington Post*, October 4, available at: www.washingtonpost.com/wp-dyn/content/article/2010/10/04/AR2010100402269.html (accessed October 24, 2011).

Hirsch, W.Z. (1973), *Urban Economic Analysis*, McGraw-Hill Publishers, New York, NY.

Hirsch, W.Z. (1984), *Urban Economics*, Macmillan Publishing, New York, NY.

Joo, S.-J.J., Keebler, J.S. and Hanks, S. (2013), "Measuring the longitudinal performance of 3PL branch operations", *Benchmarking: An International Journal*, Vol. 20 No. 2, pp. 251-262.

Knox Lovell, C.A., Pastor, J.T. and Turner, J.A. (1995), "Measuring macroeconomic performance in the OECD: a comparison of European and non-European countries", *European Journal of Operational Research*, Vol. 87 No. 3, pp. 507-518.

Ladd, H.F. (1992), "Population growth, density and the costs of providing public services", *Urban Studies*, Vol. 29 No. 2, pp. 273-295.

Lambert, T.E. and Meyer, P.B. (2008), "New and fringe residential development and emergency medical services response times in the United States", *State and Local Government Review*, Vol. 40 No. 2, pp. 115-124.

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)

Lau, K.H. (2012), "Distribution network rationalisation through benchmarking with DEA", *Benchmarking: An International Journal*, Vol. 19 No. 6, pp. 668-689.

Margaritis, D., Fare, R. and Grosskopf, S. (2007), "Productivity, convergence and policy: a study of OECD nations", *Journal of Productivity Analysis*, Vol. 28, pp. 87-105.

Min, H. and Joo, S.-J. (2006), "Benchmarking the operational efficiency of third party logistics providers using data envelopment analysis", *Supply Chain Management: An International Journal*, Vol. 11 No. 3, pp. 259-265.

Min, H. and Joo, S.-J. (2009), "Benchmarking third-party logistics providers using data envelopment analysis: an update", *Benchmarking: An International Journal*, Vol. 16 No. 5, pp. 572-587.

Min, H. and Lambert, T.E. (2006), "Evaluating the comparative efficiency of eleven states' highway expenditures", *Journal of Transportation Management*, Vol. 17 No. 2, pp. 46-62.

Min, H. and Lambert, T.E. (2011), "Benchmarking and evaluating the comparative efficiency of urban paratransit systems in the United States: a data envelopment analysis", *Journal of Transportation Management*, Vol. 21 No. 2A, pp. 48-62.

Min, H., Demond, S. and Joo, S.-J. (2013), "Evaluating the comparative managerial efficiency of leading third-party logistics providers in North America", *Benchmarking: An International Journal*, Vol. 20 No. 1, pp. 62-78.

Min, H., Min, H., Joo, S.-J. and Kim, J. (2008), "A data envelopment analysis for establishing the financial benchmark of Korean hotels", *International Journal of Services and Operations Management*, Vol. 4 No. 2, pp. 201-217.

Moore, A., Nolan, J. and Geoffrey, F.S. (2005), "Putting out the trash: measuring municipal service efficiency in US cities", *Urban Affairs Review*, Vol. 41 No. 2, pp. 237-259.

Nolan, J.F., Ritchie, P.C. and Rowcroft, J.R. (2001), "Measuring efficiency in the public sector using nonparametric frontier estimators: a study of transit agencies in the USA", *Applied Economics*, Vol. 33 No. 7, pp. 913-922.

O'Sullivan, A. (2007), *Urban Economics*, 6th ed., McGraw-Hill Publishers, New York, NY.

Pantouvakis, A. and Mpogiatzidis, P. (2013), "Measuring clinical department efficiency – the impact of clinical leadership job satisfaction: an application to public hospitals", *Benchmarking: An International Journal*, Vol. 20 No. 3, pp. 305-321.

Sherman, H.D. and Ladino, G. (1995), "Managing bank productivity using data envelopment analysis", *Interfaces*, Vol. 25 No. 2, pp. 60-73.

State Budget Solutions (2011), available at: http://statebudgetsolutions.org/state/detail/hawaii

Texas Transportation Institute (2011), "2011 urban mobility report", available at: http://mobility.tamu.edu/ums/report/ (accessed October 3, 2011).

US Census Bureau (2007, 2008, 2009), "American Community Survey", available at: www.census.gov (accessed September 26, 2011).

US Census Bureau (2009), "Median household income for states, 2007 and 2008", American Community Survey, available at: www.census.gov/prod/2009pubs/acsbr08-2.pdf (accessed April 25, 2013).

US Department of Transportation (2010), "Federal highway administration", available at: www.fhwa.dot.gov/policyinformation/statistics/2008/hf2.cfm (accessed October 4, 2011).

US Department of Transportation (2011a), "Federal highway administration", available at: www.fhwa.dot.gov/federalaid/guide/index.cfm (accessed October 4, 2011).

US Department of Transportation (2011b), "Federal highway administration", available at: http://ops.fhwa.dot.gov/freight/freight_analysis/freight_story/congestion.htm (accessed October 4, 2011).

US Department of Transportation (2011c), "Federal highway administration", available at: http://ops.fhwa.dot.gov/freight/freight_analysis/freight_story/index.htm (accessed October 4, 2011).

US Department of Transportation (2011d), "Federal highway administration", available at: www.ops.fhwa.dot.gov/freight/freight_analysis/nat_freight_stats/docs/09factsfigures/table3_10.htm (accessed April 18, 2013).

US National Oceanic and Atmospheric Administration (2011), "Climate trends", available at: www.noaa.gov/index.html (accessed October 4, 2011).

Winston, C. and Langer, A. (2006), "The effect of government highway spending on road users' congestion costs", *Journal of Urban Economics*, Vol. 60 No. 3, pp. 463-483.

Wooldridge, J.M. (2006), *Introductory Econometrics: A Modern Approach*, 3rd ed., Thomson South-Western, Mason, OH.

Wu, W.-W., Lan, L.W. and Lee, Y.-T. (2013), "Benchmarking hotel industry in a multi-period context with DEA approaches: a case study", *Benchmarking: An International Journal*, Vol. 20 No. 2, pp. 152-168.

Zimmerman, M. (2011), "Hawaii ranks worst among in country for state budget health", *Watchdog News Network*, September 28, available at: www.hawaiireporter.com/hawaii-ranks-among-worst-in-county-for-state-budget-health/123 (accessed November 6, 2011).

Further reading

Maudos, J., Pastor, J.M. and Serrano, L. (2000), "Convergence in OECD countries: technical change, efficiency and productivity", *Applied Economics*, Vol. 32 No. 6, pp. 757-765.

Rodrigue, J.-P., Comtois, C. and Slack, B. (2009), *The Geography of Transport Systems*, 2nd ed., Routledge, Taylor-Francis Group, Abingdon.

Corresponding author
Dr Hokey Min can be contacted at: hmin@bgsu.edu

For instructions on how to order reprints of this article, please visit our website:
www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: **permissions@emeraldinsight.com**

Downloaded by TASHKENT UNIVERSITY OF INFORMATION TECHNOLOGIES At 00:59 14 November 2016 (PT)