

FINAL REPORT OF THE 2008 SEED GRANT PROJECT

Submitted to

Professor John Wu, Director

Leonard Transportation Center

California State University San Bernardino

5500 University Parkway

San Bernardino, CA 92407-2397

By

Yong Lao, Professor

Division of Social, Behavioral and Global Studies

100 Campus Center

California State University Monterey Bay

Seaside, CA 93955-8001

Project Background and Design

In April, 2008, I submitted a grant proposal titled "Evaluating Service Effectiveness of Bus Lines: A Combined Approach Using Geographic Information Systems (GIS) and Data Envelopment Analysis (DEA)" to the Leonard Transportation Center at CSU San Bernardino. The goal of the project is to develop a scientific approach to evaluate the service effectiveness of bus lines, taking into account critical elements in the operational environment. Methodologically, this project aims to integrate geographic information systems (GIS) and data envelopment analysis (DEA). It is based on a case study of Monterey-Salinas Transit (MST), a public transit bus system in Monterey County, California. MST has been a vital part of the central coast community since its establishment in 1981. Currently the MST transit system serves a 275 square-mile area of Monterey County and Southern Santa Cruz County. With an annual budget of \$20.2 million, MST employs more than 2100 people, operating 86 vehicles and 33 routes.

In July, 2008, I was awarded \$5000.00 to pursue this project. The funding was used to pay my salary as well as to hire a student research assistant.

Project Implementation

The project mainly addresses the following three questions:

1. How to identify the service corridor and estimate the potential passenger demand associated with a bus line?
2. How to measure and compare the service effectiveness of bus lines?
3. How to plan transit routes and stops based on the evaluation of bus lines?

Phase one: Literature Review

As the first step of this project, I searched and reviewed previous studies in public transit evaluations, focusing on books and articles using Data Envelopment Analysis (DEA) approach. Another area of research I explored is so called GIS-T (GIS for Transportation). A large number of case studies were reviewed to see how GIS technology was used by both researchers and practitioners for public transit analysis. The literature review provided me insightful information on important issues surrounding public transit evaluation as well as gaps and neglects in existing approaches.

Phase Two: GIS Mapping of MST Bus Lines and Service Areas

In this phase, a GIS database was created for the fixed bus lines operated by Monterey-Salinas Transit (MST). There were three major steps:

Step 1. Collecting data related to the operations of bus lines from MST. The main data variables were: operating costs, number of bus drivers, number of vehicles, level of service in terms of frequency and vehicle operating hours, and ridership information.

Step 2. Constructing a GIS database for the service area of each bus line. The database consisted of digital maps of bus lines, bus stops, as well as the latest census data (at census block groups level). Several demographic variables were used, including population density, elderly population, low-income household, private vehicle ownership, mode of commuting, and people with physical disability.

Step 3. Using GIS to create demographic profiles associated with each bus line. Through an analytical model, the data variables identified in step 2 will be combined to provide the estimated level of demand, then mapped and analyzed in accord with a quarter mile buffer zone surrounding each route's bus stops. The result represented the market potential and service corridor for each bus line.

Phase Three: DEA Model Design

In this phase I designed two DEA-based optimization models to assess performance of bus lines. One model focused on evaluating operational efficiencies, another focused on evaluating spatial effectiveness. Both models utilized data collected in phase two. This approach allowed for close inspection and comparison of operational and spatial aspects of bus lines. Dr. Lin Liu, a professor of geography from University of Cincinnati helped me with solving and testing these two DEA models.

Phase Four: Data Analysis and Interpretations

The results from both GIS analysis and DEA modeling were carefully evaluated. Using cluster analysis, the twenty-two fixed bus lines were classified into four groups based on their DEA scores in spatial efficiency and effectiveness. Recommendations were given on how to improve bus line performances.

Detailed discussions of project implementation and findings were summarized into a research paper (see appendix A). The paper has now been accepted to be published in *Computers, Environment and Urban Systems*, a peer reviewed international journal on geographical analysis. I also gave a presentation of the project as part of the CSUMB Faculty Scholarship and Creativity Showcase on March 11, 2009.

Conclusions

The findings of this project can be used in several ways:

- The study can help Monterey Salinas Transit (MST) to improve the efficiency of its operations, to better serve the existing population, and to establish transit service in new locations across the region. For instance, we have identified bus lines that need be expanded, subsidized, or re-planned and have made recommendations on operational strategies.
- It is demonstrated that GIS can help to visualize the distribution of bus routes, examine service coverage, and analyze the spatial variation of effectiveness against demographic settings. This combined GIS and DEA approach can be extended to the study of public transportation of other regions and places.
- This project will be used as a case study in two GIS courses offered at CSUMB next year.

Acknowledgement

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