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Understanding Delivery Routes in Urban Areas

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UNDERSTANDING DELIVERY
ROUTES IN URBAN AREAS

Formulas effectively describe the tradeoffs associated with urban commercial distribution systems.

Issue

Supply chains and urban areas cannot thrive without the efficient movement of goods. A recent study indicates that commercial vehicles carrying goods or providing services account for, on average, almost 10 percent of the total vehicle miles traveled (VMT) in medium to large urban areas. A predominant share of these trips takes place within a multi-stop tour. In order to develop a well-organized system for moving freight through urban areas, it is crucial to understand and quantify how routes and distribution decisions affect commercial vehicle flows and VMTs.

In the past, transportation planning models have focused on passenger movements but not on freight routes or on estimating commercial vehicle activities or VMT. This research provides new methods to quantify the effect of delivery size and time windows in urban areas. This project aimed to determine how best to obtain practical and intuitive approximations on the length of commercial vehicle tours and miles traveled in urban areas. Additionally, the project tested various means of estimating the impact of time windows and delivery sizes on commercial VMTs.

Research

The project team examined various formulas for approximating the average vehicle routing problem (VRP) distance when there is variability in the number of customers, time-window constraints and demand level. The researchers proposed and tested 15 formulas using the well-known Solomon benchmark problems, a variety of routing instances that contains the most common routing constraints.

The formulas tested in the project varied in terms of the factors they incorporated. For instance, the first two approximations tested used only information about the number of customers served and the number of routes needed. Models 3 and 4 took into consideration increases in

THE ISSUE

Commercial vehicles account for nearly a tenth of miles traveled in urban areas and most of these happen on multi-stop trips. However, the literature does not adequately address the average distance of vehicle routing problem solutions for actual customers and different levels of routing constraints.

THE PROJECT

Miguel Figliozzi of Portland State University examined how to approximate the length of these trips and to estimate how the window of time and size of delivery affect the miles traveled.

IMPLICATIONS

The formulas can be used for a wide range of planning scenarios and new technologies. Researchers are applying the results to study the feasibility of electric commercial vehicles and their energy and emissions benefits.

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connecting distances. In models 5 and 6, information was included about the effects of a centrally located depot versus a suburban depot. The project team tested the models both with and without the additional factor of time-window constraints.

In addition to the tests performed using the Solomon benchmark problems, the project also tested one of the regression models on actual customer distribution data from a freight forwarding company based in Sydney, Australia. This company serves hundreds of customers in various local industrial suburbs. To test the model, the research team randomly chose five sets of customers in the suburb of Bankstown to simulate a daily demand scenario.

Tests of the different formulas and the Bankstown data showed very high R^2 values, indicating that the formulas are likely to predict future outcomes well, and low mean absolute error for all models tested. However, there are tradeoffs among model simplicity (number of variables and terms in the formulas), data requirements (data inputs that are readily available) and explanatory power of the formulas (R^2). Descriptive statistics for all regression predictors also were statistically significant at a 99 percent confidence level.

Implications

The results of this research are widely applicable for aggregated or strategic planning and analysis of transportation and logistics problems with varying customer demands and constraints. The project proposed and successfully tested several approximations to VRP length using different patterns of customer spatial distribution, time windows, customer demands and depot locations. A relatively simple approximation formula can be used to estimate reasonably well the impact of

the number of time-window constraints and the demand level on the number of additional routes needed.

This project also successfully tested one of the regression models on actual customer distribution data. The results of this test are encouraging and show that the proposed models may have useful applications in urban networks and modeling. The formulas can be applied to a wide range of planning scenarios or new technologies. For example, researchers are applying some of these results to study the feasibility of commercial electric vehicles and their energy and emissions benefits.
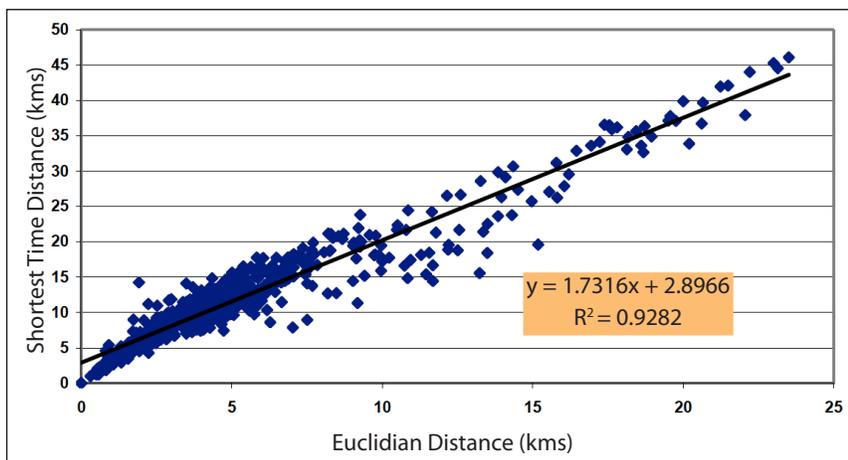

Figure: Euclidian distance vs. shortest time distance among suburban and depot customers

The R^2 of 0.93 indicates that the Euclidian distance is a fairly good predictor of actual distance traveled between customer pairs or depot-customer pairs. The high concentration of short-distance points close to the origin correspond to the distances between suburban customers while the longer distances are mostly depot customers.