

Mode Choice and Travel Distance Decisions: A Copula-based Joint Multinomial Discrete-Continuous Model

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Policymakers and urban planners have recently faced an increase in the use of private cars in school trips, and thereby a decline in the use of active transportation modes (i.e. walking and biking). A study ^[1] in the U.S. showed that share of active modes has diminished from 40.7 to 12.9 percent during 1969 to 2001. Further, share of walking mode in school trips declined from 53% to 42% and from 39% to 31%, respectively, for 11-13 and 14-15 year old students during 1986 to 2001 in Toronto ^[2]. Reduction in the use of active modes of transportation in school trips is not limited to North America, and this alarming trend has been observed in many other countries. Surveys conducted in Sydney, for instance, showed that the share of motorized modes has increased from 41% to 51% between 1991 and 1999 ^[3]. Following this increase, the share of walking mode has decreased from 32% to 24% ^[3]. Use of active modes of transportation in the UK fell from 60% to 51% while the share of private car increased from 29% to 41% between 1993 and 2002 ^[4].

The above-mentioned behavioral shift in the use of active modes has tremendous adverse consequences that include: physical inactivity among students, increasing direct and indirect costs of obesity, traffic jams at peak hours, adverse environmental impacts such as rising energy consumption and air pollution, and even negative social consequences for students that are rooted into the reduction in their dependency. Hence, detecting factors that affect this change is very crucial for controlling this trend and promoting active modes of travel. Studies found that parents have a dominant role in choosing their kids' mode of travel, and several decisions about their kids' school trip are made concurrently ^[5]. Two important decisions that are made jointly by parents are to choose travel mode and to decide on the travel distance. In other words, when parents are deciding on the school to register their kids in, they consider different travel options for them. Such decisions are expected to be made jointly, not independently. For instance, parents that tremendously care about their kids' safety may choose a school location that either has a safe walkway to home or is easily accessible by private car. Therefore, travel mode and distance are determined concurrently. Hence, it is pivotal to perceive such decisions interdependently, as some studies ^[5] have pointed to the importance of this issue.

This study is an effort to address certain shortcomings that are found essential in the literature, to a possible extent. First, a few studies have considered all the travel modes that are typically used for school trips. Rather, they have, understandably, focused on the active modes. Second, decisions on the travel mode and distance are considered independently, while in practice one may make them jointly. Third, all the previous studies have focused on the impact of distance on travel mode, and as a result, factors that influence travel distance are overlooked. Fourth, parents have strong concerns such as safety, comfort, and reliability when deciding on school trip mode and distance. These factors have received little attention, if any, in previous studies that can lead to misleading policies.

For analyzing the choice of transportation mode and distance from home to school, a copula-based joint modeling framework was used. Also, a multinomial logit model for the mode choice and a linear regression model for travel distance are utilized. To select the appropriate model, four common types of copula formulations, namely Frank, FJM, Clayton, and Joe were studied. Four categories of data, including students travel information, socio-economic data of the households, built environment specifications, and transportation characteristics were used in this study. The last two sets of data were obtained from Tehran Comprehensive Traffic and Transportation Study Co. while, an extensive survey was conducted in May 2011 in Tehran to collect students' travel information and socio-economic information of households. Questionnaires were submitted to 4,900 middle and high school students, 72 percent of whom participated. Since schools in Tehran are gender-segregated, cluster sampling with respect to gender, level, and area of residence was conducted. Tehran, with an area of over 700 square kilometers and a population of over 7.5 million is ranked the 16th most densely populated city in the world. Over 15 million journeys are made every day in this city, 27 percent of which are educational. Five common modes of transportation, including walking, cycling, school bus, private car, and public transport were considered.

This study, investigated the effect of a variety of influential variables on school transportation mode choice and distance from home to school in a joint model. Results showed that the two decisions – choice of school transportation mode and the home-to-school distance – are interdependent and therefore should be analyzed simultaneously. This dependency was found to be more pronounced for the walking mode than other modes, with its kendall's dependency parameter ^[6] indicating that choice of walking to school and the decision of the location of school are highly interdependent. Furthermore, this study evaluated the effect of a range of variables such as distance from home to school, travel cost, safety, and traffic limits on the school travel mode choice behavior among different demographic segments. For example, this study showed that eliminating parents' concern about safety can double the propensity of walking to school. Also, the demographic heterogeneity was considered in evaluating the effect of each variable. High and low income families, for instance, are expected to respectively show 106 and 67 percent increase in the probability of walking, if their safety concerns are eliminated. Such results can provide information to policy makers for devising targeted policy measures to increase physically active travel to school among the different segments of the society. Particularly, we found that the probability of walking reduces by 0.85 percent due to a 1 percent increase in distance between home to school, also it propels parents to select non-active modes, especially school bus.

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