# DISSERTATION PROPOSAL

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# "Essays on Designing Resilient Solutions for Problems in Transportation and Analyzing Conditional Promotional Offers"

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This thesis consists of three chapters. In the first and third chapter, we analyze major problems faced by students and policymakers in present day school bus transportation. In the second chapter, we attempt to observe the effects of a specific conditional price promotion on customer and firm behavior and use it to design better future offers.

In the last three decades, there has been a significant increase in school transportation costs in the U.S. The main reasons for this growth are the changes in student school choices, strict federal and state mandates, and high fuel prices. In addition, transportation funding is being cut. To accommodate transportation needs, schools use complex routing policies that eventually result in long bus riding times for students and worse student experience. One possible solution to improve school bus transportation is collaboration between schools and school districts. In the *first chapter*, we study the tactical design of school bus collaboration using continuous approximation of traveling salesperson problems (TSPs). We derive closed-form approximations as metrics to evaluate the performance of school bus collaboration, such as the total bus cost and students travel time under collaboration. We evaluate the conditions under which the benefits from collaboration among schools is worthwhile. We also analyze the impact of collaboration on the social welfare of students and find the conditions under which collaboration is the most beneficial. Overall, this analysis is in the spirit of a cooperative game, where we consider multiple levels of players (i.e., schools, school districts) with different objectives, and aim to design a solution that aligns with the objectives of different players at each level.

The *second chapter* focuses around how firm managers should plan their promotional spending given dynamic offers. Specifically, we want to understand how to optimize conditional price promotional offers based upon transaction histories. The conditional promotional offers that we consider are of the form: "If a consumer spends more than $X$ during $P$ time periods then give $B$ bonus points". Our goal is to develop a method to optimize $X$, $P$ and $B$ at a personalized level. Furthermore, we are interested in being able to develop these offers using only transaction histories without any previous promotions (e.g., determine promotional sensitivity using past price promotions). We develop theoretical results about when firms should make conditional promotional offers versus traditional promotions, and an empirical framework for aiding managers interested in planning their conditional promotional offers.

Parents and policymakers have been documenting frequent school bus delays and no-shows. Such events pose societal and educational burdens. Data on school bus delays show that the main risk factors are weather, traffic, aging buses, and bus driver shortage. Driver shortage is due to early retirement, lower pay, lack of benefits (most bus drivers are part-time), COVID-19 impacts (health issues and concerns), and lengthy qualification process. The goal of *third chapter* is to address the problem in two stages: (1) design a machine learning (ML) model that estimates potential delays in school bus routes due to traffic, weather, bus maintenance issues, etc., and (2) an optimization model that predicts (using above ML model) and avoid delays. The idea is to predict the disruptions and then minimize these disruptions amid driver shortage.