Eftekhar, M, A Masini, A Robotis, LN Van Wassenhove (2014) Vehicle Procurement Policy for Humanitarian Development Programs. Production and Operations Management, 23(6): 951-964.

Summary: This article aims to identify optimal vehicle procurement policies for organizations engaged in humanitarian development programs and to derive general insights on the characteristics of these policies. We follow an inductive approach. First, we study the operations of the International Committee of the Red Cross (ICRC) in three representative countries: Sudan, Afghanistan, and Ethiopia. Using a linear programming (LP) model primed with field data provided by the ICRC, we calculate the optimal vehicle fleet size and compare it with the policies actually implemented. Second, drawing from results of the LP model, we develop a stylized quadratic control model and use it to characterize the general structure of the optimal policy under different demand scenarios and operational constraints. After demonstrating that the results of the control model are consistent with those of the LP model in the specific context analyzed, we discuss the optimal policies and the applicability of the former as a practical tool for strategic asset planning.

Setting: This study centered on a *centralized* procurement model in which sub-delegations submit procurement requests to the national delegation. The national delegation then utilizes the data from these sub-delegations to formulate an estimate of the total demand, which is relayed to headquarters. Headquarters subsequently determines the quantity of vehicles to purchase and distribute to delegations globally, often basing these decisions on national estimates that may not be entirely accurate or complete. When we were tasked with addressing this issue, we learned that most humanitarian organizations lack precise data on their fleets. Remarkably, even some prominent international organizations were unaware of the exact number of operational vehicles they possessed in each specific country. We adopted an inductive methodology, executed in two phases. Initially, we examined the operations of the ICRC in three illustrative countries–Sudan, Afghanistan, and Ethiopia–where comprehensive data was accessible. Utilizing this information, we empirically derived the cost and capacity parameters for vehicles. (We gained insights into the utilization patterns of vehicles based on their type and age, analyzing the average monthly mileage of a vehicle at five months old compared to that of a fifty-month-old vehicle.) Subsequently, we employ a linear programming (LP) model to determine the ideal fleet size for each country, comparing these findings against the ICRC's actual policies. The LP model incorporates a wide range of constraints at both the micro-level, such as the optimal vehicle replacement strategy, and the macro-level, including budgetary considerations. In the subsequent phase, leveraging the outcomes of the LP model, we formulate a streamlined quadratic control (QC) model. This model maintains the integrity of the LP solution's properties but is more succinct and aligns with the data availability often found at headquarters. Utilizing the QC model, we delineate the structure of the optimal policy across various demand scenarios and explore its relevance for strategic asset planning.

Results: Our analysis uncovers several noteworthy insights. The linear programming (LP) model reveals that, contrary to the practices of most humanitarian organizations (HOs), the optimal fleet size should remain relatively stable across fluctuating demand scenarios, as observed in the three selected countries. This finding contrasts starkly with current policies that often adjust fleet sizes in response to demand changes.

The quadratic control (QC) model further refines our understanding of the optimal policy's structure, demonstrating how it adapts to variations in demand characteristics, desired service levels, and vehicle replacement thresholds. This model provides a nuanced view of how strategic fleet management should be approached to maintain efficiency and effectiveness.

Additionally, the control theory model offers closed-form policies suitable for a broad spectrum of scenarios, including scenarios with increasing or decreasing demand, as well as oscillating demand patterns. A key aspect explored is the interaction between individual vehicle replacement strategies and overarching fleet budget constraints, highlighting the complex dynamics at play in achieving optimal fleet management.

Further reading: For researchers interested in this area, there are many intriguing modeling papers focused on commercial settings. However, one that I particularly enjoyed was:

Vemuganti, R. R., M. Oblak, A. Aggarwal. 1989. Network models for fleet management. Decision Science 20(1): 182–197.