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Cargo Consolidation, Routing, and Location Optimization to Reduce Traffic Congestion by Minimizing Commercial Heavy Vehicle Trips

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POLICY BRIEF

BACKGROUND AND OBJECTIVES

Traffic congestion is a global phenomenon that is expected to worsen in the future. If ignored, traffic congestion could negatively impact the competitiveness of a country (Kesuma et al., 2019). Because large trucks are heavier than passenger cars and take up a lot of space, these heavy vehicles have a significant impact on traffic, especially during rush hour. Congestion also results in increased travel time and uncertainty. The travel time/distance between customers and distribution centers is an important component that influences congestion. As traffic congestion worsens, the number of vehicles required to provide a certain level or service and complete the tour also increases, forming a vicious cycle between the number of vehicles and congestion. Therefore, reducing the number of commercial heavy vehicles reduces their negative effect on traffic flow.

The purpose of this project aligns with the pillars established by the National Institute for Congestion Reduction (NICR) by developing a methodology for reducing congestion while simultaneously lowering the number of trips and total distance required to meet market demand. The NICR pillars “Battling Congestion Using Innovative Mobility Platforms,” “Battling Congestion on the Freeway Corridor,” “Incentivizing Transit in the Face of Innovative Alternatives,” and “Urban and Rural Traffic Management in the Age of Big Data” are covered in this project through the development of a methodology that consolidates cargo and lowers trip distance, number of trips, and consequently congestion. To achieve this goal, the project developed a survey and a methodology aimed at lowering the number of commercial heavy trucks on the road while improving truck capacity usage to consistently move the same commodity volumes needed by the market.

The goals of this project were as follows:

1. Optimize commercial truck trips, resulting in traffic reduction and improved travel reliability.
2. Develop different scenarios and evaluate improvements in transit and congestion.
3. Focus on mixed-cargo consolidation from different locations and companies as an approach for reducing, or optimizing, the number of trucks on the road.

METHODOLOGY

The methodology of this work is split into two parts: contextual and technical. The contextual part provides information on the current status of cargo consolidation strategies and practices, and optimization and improvement techniques. The technical part collects and handles data to build the dataset for the analysis, develops the model and algorithm, and applies the model and algorithm to evaluate and obtain results.

The contextual part of this work includes:

1. Literature review – Reviews economic context, cargo consolidation strategies, optimization models, and heuristic algorithms.
2. Survey and interviews – Surveys and interviews for both the private and public sectors were developed to obtain views and opinions from professionals in those sectors.

The technical part comprised the following three main elements:

1. Data assessment and dataset production – Focused on assessing available data sources and the activities needed to produce and build the final dataset for the analysis.
2. Model and algorithm development – Focused on developing the mathematical and programming model, as well as the heuristic (algorithm) for routing and location optimization.
3. Design of experiment – Focused on designing the application of the model and algorithm to evaluate their performance and benefits. This included the sampling design.

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RESEARCH FINDINGS

Results show that the cargo consolidation model could achieve initial annual benefits of 172,170 vehicle-kilometers less congestion, which is roughly 107,000 vehicle-miles, while the algorithm could yield 72,797 vehicle-kilometers less congestion, which in turn is roughly 45,233 vehicle-miles. These reductions in congestion stemmed from a small set of 20 clients in the area of analysis (i.e., Houston, Texas) for two commodities: wood and metal. The algorithm presented provides an idea of the potential benefits of cargo consolidation practices when using optimization and heuristics tools for operation design.

In addition, the quantitative benefits of the model, algorithm, and location optimization steps are estimated using the single-demand (i.e., nonconsolidated cargo) scenario as a benchmark. It is important to note that this baseline scenario is also a model-optimized scenario for nonconsolidated cargo. In the real world, this is not common since companies generally perform routing operations without any optimization tools. Thus, the benefits estimated in this work may represent the lower bound of the actual benefits range when implementing this methodology in real-world operations.

POLICY AND PRACTICE RECOMMENDATIONS

Based on the findings and methodology of this project, the research team proposes several policy and practice recommendations aimed at reducing traffic congestion, as well as enhancing sustainability and efficiency.

1. **Implementation of Cargo Consolidation Practices:** Encourage the adoption of cargo consolidation strategies among businesses to reduce the number of commercial heavy vehicles on the road. This can be facilitated through incentives for companies that participate in mixed-cargo consolidation programs, and in return optimizing truck usage and reducing congestion.
2. **Development and Utilization of Optimization Tools**: Invest in the development and deployment of advanced optimization models and heuristic algorithms for routing and location optimization. Making these tools accessible to companies can significantly improve travel reliability by minimizing the distance and number of trips required for cargo delivery.
3. **Public-Private Partnerships:** Foster collaborations between the public and private sectors to develop integrated strategies that address traffic congestion. This includes sharing data and insights to improve the effectiveness of cargo consolidation and routing optimization efforts.
4. **Policy Frameworks to Support Sustainable Practices:** Establish policy frameworks that incentivize sustainable optimization practices within metropolitan shared ridership programs. This could include tax breaks, subsidies, or preferential treatment in procurement processes for companies that demonstrate a commitment to reducing congestion and enhancing sustainability.
5. **Education and Awareness Programs:** Launch education and awareness campaigns to highlight the benefits of sustainable cargo consolidation and optimization practices. By informing companies and the public about the potential reductions in congestion and environmental impact, support for these initiatives can be galvanized.
6. **Continuous Improvement and Innovation:** Encourage continuous innovation in sustainable transportation strategies by supporting research and development in this field. This includes exploring new technologies, such as AI and big data analytics, to further enhance efficiency and sustainability.

By adopting these recommendations, policy makers and practitioners can significantly contribute to the reduction of traffic congestion and promote sustainability in metropolitan areas. These efforts will not only enhance the competitiveness of urban centers but also improve the quality of life for their inhabitants by creating more efficient and environmentally friendly transportation systems.