Optimization of Multimodal Logistic Hub Locations for Munich

Master‘s Thesis of Abbas Rammal

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Problem Statement

E-commerce Growth

Surge in small, frequent, time-sensitive deliveries creating pressure on logistics chains. Global sales expected to reach $7.385 trillion by 2025 (Lebow, 2021).

Last-Mile Challenges

- Travel congestion and higher operating costs (53% of total delivery costs) (OptimoRoute, 2020)
- Increased environmental footprint (50% of urban transport emissions) (Dablanc, 2007)
- Limited loading spaces in dense urban areas

Munich Case Study

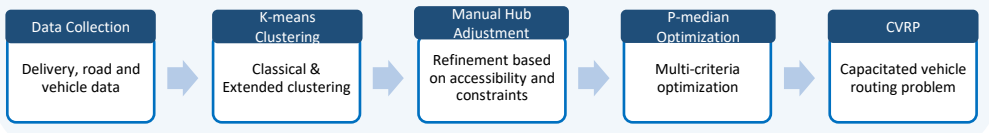
Fast-growing city with dense urban fabric, congested road network, and cargo bike initiatives.

56,397 Delivery Points Analyzed

Research Questions

- How can multimodal logistic hubs in Munich be strategically positioned to maximize last-mile delivery effectiveness and minimize operating costs?
- How does the integration of cargo bike delivery and multimodal logistic hubs affect CO2 emissions and environmental sustainability in Munich's urban logistics?
- How sensitive are the key performance indicators (KPIs) and ideal hub locations to changes in hub opening costs, capacity limitations, and the relative weighting of environmental versus economic objectives?
- Which key performance indicators (KPIs) show how successful and efficient a multimodal logistics network is in Munich when compared with conventional last-mile delivery techniques?

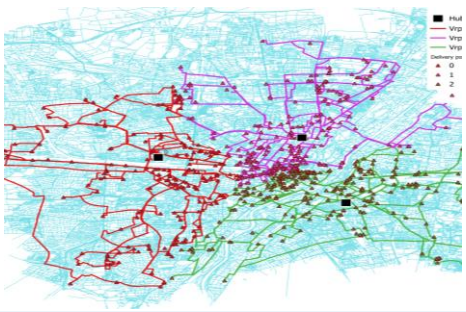
Methodology



KEY RESULTS

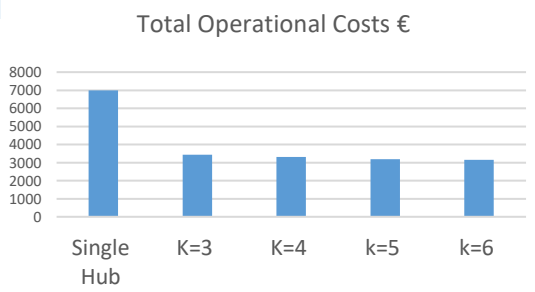
Optimal Hub Configuration (k=3)

Hub 0: 30.60% (17,263 deliveries)
Hub 1: 30.60% (17,240 deliveries)
Hub 2: 38.80% (21,894 deliveries)



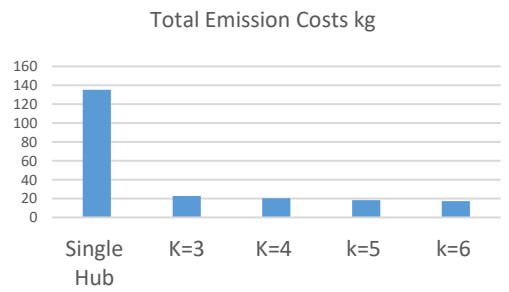
Operational Cost Reduction

51% Cost Reduction
€7,000 to €3,433



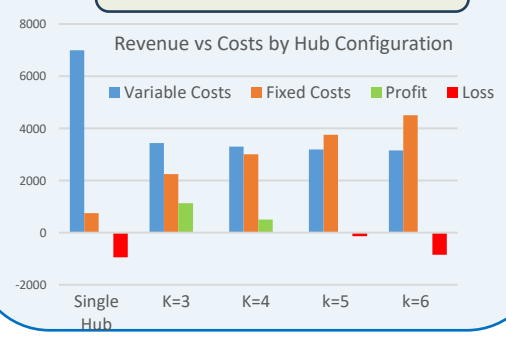
CO_2 Emissions Reduction

83% CO_2 Reduction
135.06 kg to 22.78 kg



Profit Analysis

Only k=3 & k=4 configurations are profitable



Sensitivity Analysis

Objective Weights

No effect on hub selection due to strong correlation between distance, cost, and CO_2

Hub Opening Costs

Significant impact on optimal number of hubs:

- k=3 hubs at a cost penalty of 80 units per hub.
- k=4 hubs when the price dropped to 70.
- k=5 hubs after the cost penalty dropped to 40

Capacity Limits

- k=6 hubs with a maximum delivery of 500 per hub
- A minimum of 100 unique deliveries per hub till reaching 300 which gave us the same results for k=5
- Above 400 we start having the same results as k=4.

Strategic Benefits:

- City Planners: Framework for sustainable urban logistics infrastructure
- Logistics Companies: Competitive advantage through sustainability
- Environment: Significant contribution to air quality improvement

Conclusion

Strategic multimodal hubs
Transform urban delivery systems
Sustainability & economic viability
Key benefits
Reduce congestion, emission and delivery costs
Contribution
Solid methodological foundation
Support future research

References

Lebow, S. (2021, August 19). *EMARKETER*. Retrieved from Worldwide ecommerce continues double-digit growth following pandemic push to online: https://www.emarketer.com/content/worldwide-ecommerce-continues-double-digit-growth-following-pandemic-push-online

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