Identifying costly delivery points

33nd Conference on Postal and Delivery Economics, Limassol
22.5.2025

Ramon Gmür, Dr. Matthias Hafner, Andreas Stritt, Dr. Urs Trinkner

Background, Research Question, Contents

Background

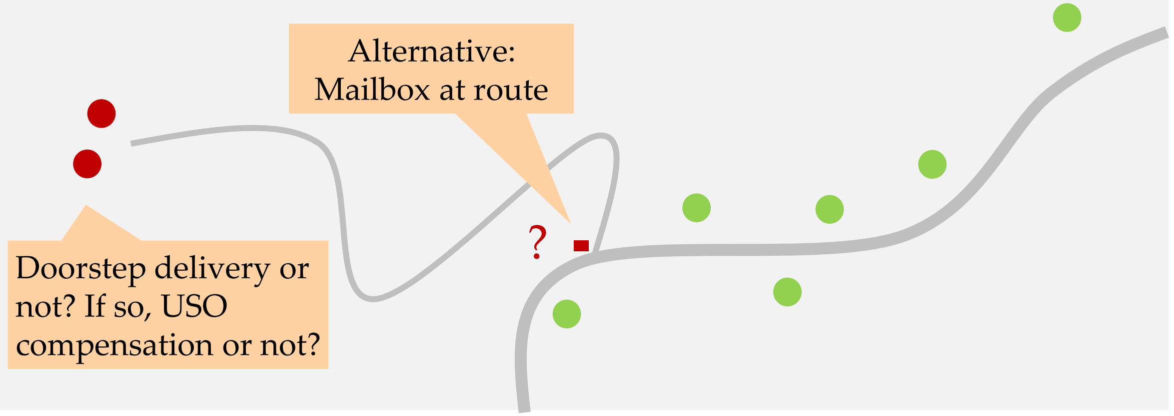
- Doorstep mail delivery is a core component of the Universal Service Obligation (USO) in many countries.
- Remote deliveries have a high impact on delivery route time and therefore also delivery costs.
- If costly delivery points are offered an alternative delivery point at the main route of the mail carrier, delivery costs and USO costs can be reduced
- Estimating the cost impact of individual delivery points is complex due to dynamic route formation.

Research Question

- Develop and test algorithms which can identify the costliest delivery points

Contents

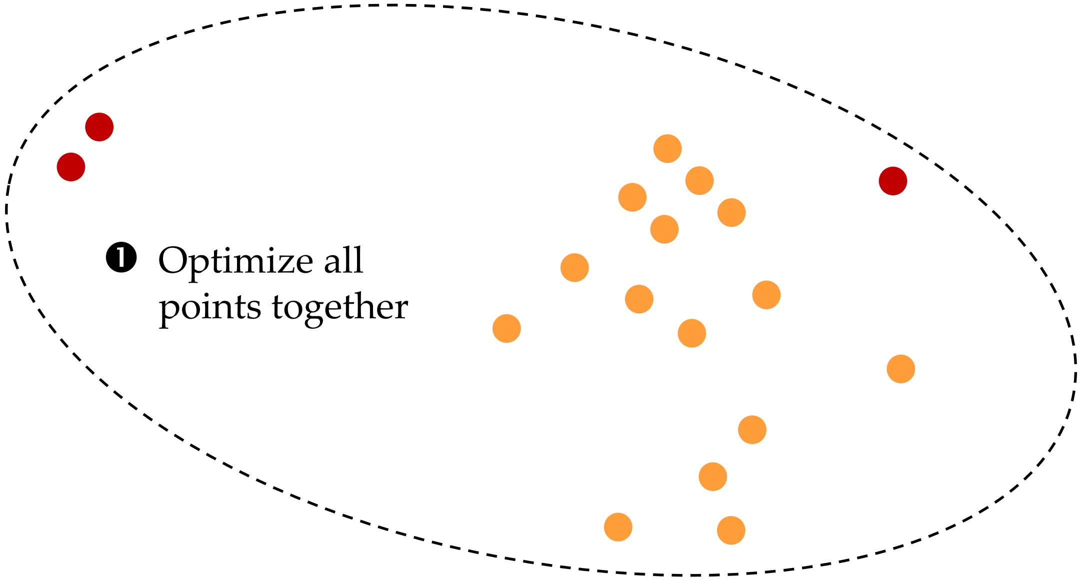
- Scope
- Literature
- Algorithms
- Approach and Evaluation
- Identified costly delivery points
- Resulting savings
- Conclusions



Scope of paper

Approach 1: “Within-Optimization”

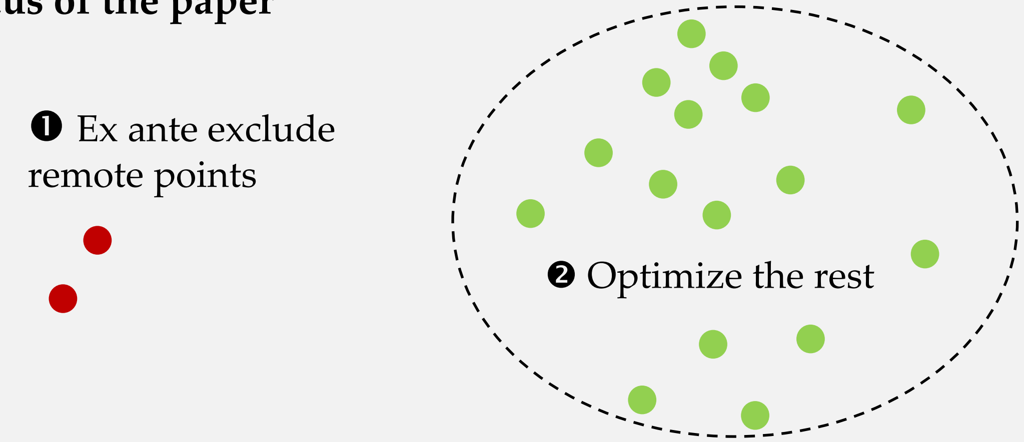
- Costly delivery points are identified within route optimization algorithm
- Advantages
  - Potentially highest accuracy
  - Flexible



Approach 2: “Pre-Optimization“

- Separate steps for outlier detection and route optimization
- Advantages
  - Transparent, traceable, same standards for entire country, independent of route optimization
  - Robustness: keep outliers constant, i.e. decide once on delivery form (at doorstep or at route)
  - Reduces computational power (route optimization grows exponentially with number of delivery points)

→ **Focus of the paper**



Literature

swiss economics

Within-Optimization

- Route optimization usually based on algorithms solving the travelling salesman problem (TSP)
- The aim is then to identify delivery points that disproportionately increase travel time or cost. Different approaches have been developed which are able to identify these costly points within the route optimization
- Examples include:
  - Clustered TSP (Chisman, 1975 or Mestria, 2016): Groups nearby delivery points to simplify large problems and identify remote clusters.
  - Prize-collecting TSP (Balas, 1989 or Pantuza et al., 2022): Allows skipping cities at a penalty cost, balancing tour length and the value of including/excluding points.
  - Orienteering problem (Golden et al., 1987 or Santini, 2019), balancing route constraints with the value of visited points. Golden et al. use a gravity-based heuristic inspired by Newtonian physics.

Pre-Optimization

- Pre-Optimization filtering techniques identify and exclude remote delivery points before route optimization for computational feasibility with large datasets
- Trinkner et al. (2012) tested multiple heuristics to preselect costly points before TSP optimization based on airline distances (linear distance to closest neighbor; number of houses within a certain radius, chain length of nearest neighbors, gravity model)
- Haller et al. (2014) use the distance of a delivery point to the next neighbor as a measure of remoteness.
- Akkerman et al. (2022) remove customers with the highest marginal cost (distance) approximated by a linear regression

Algorithms

swiss economics

- Four different types of algorithms are selected to identify the costliest delivery points
- The algorithms use real route times between delivery points for a higher accuracy
- Each algorithm has its own advantages and limitations:

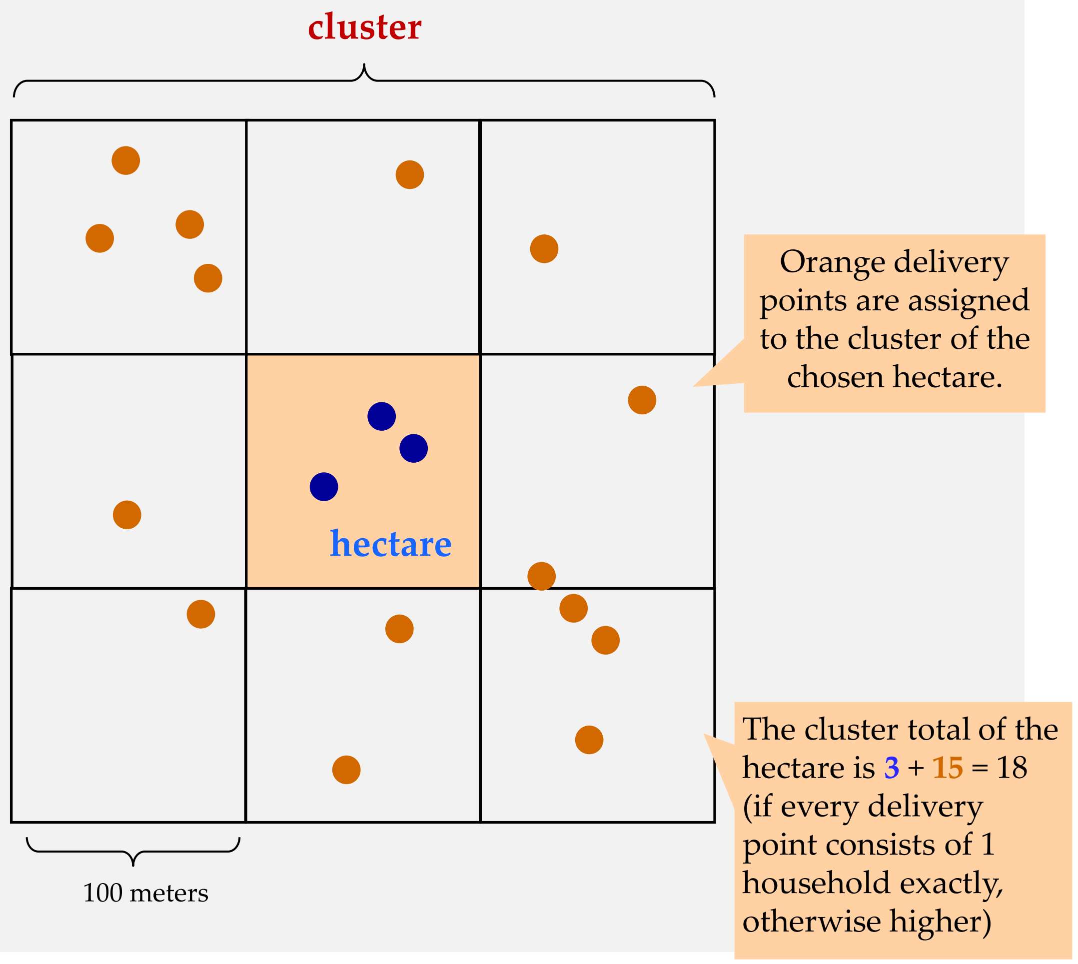
	«Marginal Costs»	«Chain»	«Gravity»	«Cluster»
Key Idea	Route time to closest neighbor divided by the number of households at delivery point	Builds chains of delivery points; evaluates route time per household for each chain	Based on gravity equation: household counts weighted by inverse square of route time for the x nearest households $G_i = \sum_{\forall\, j \neq i} \frac{nHH_i * nHH_j}{(route\ time\ i - j)^2}$	Builds clusters of delivery points based on a hectare grid (explication on next slide)
Advantage	Directly identifies highest marginal-cost households	Detects expensive delivery route segments	Incorporates both population density and proximity	Highlights isolated delivery points or remote groups of houses
Limitation	Ignores neighborhood context (“masking”); misses clusters	Sensitive to chain length; may not catch distant clusters	Strongly influenced by gravity model assumptions (e.g., exponential decay)	Depends on grid resolution and does not incorporate route times

Description of cluster algorithm

Methodology

- The Cluster-algorithm divides Switzerland into hectares; around each hectare a cluster consisting of one hectare and neighboring hectares is formed
- Each hectare is then part of nine clusters. Hectares are ranked according to the maximum value of its nine clusters.
- Work steps:
  1. Subdivision of Switzerland into the official hectare grid of the federal statistical office[1]
  2. Calculation of the number of households within a hectare
  3. Calculation of the cluster total: Addition of all households from neighboring hectares
  4. The maximum of the nine cluster totals for each hectare is assigned as a score for that hectare
  5. Removal of the hectares with the lowest score up to the targeted coverage of households
- This means that hectares with a few households remain served if they are part of a larger cluster

Example



[1] BFS STATPOP 2018

Approach to evaluate the algorithms

1 Specification of 4 algorithms and 5 sensitivities

- **Marginal costs**
- **Chain:** Length of 10, Sensitivity: length of 5
- **Gravity:** 50 nearest points, Sensitivities: 20, 100
- **Cluster:** 1 ha perimeter, Sensitivity: 2 ha

2 Definition of coverage scenarios

- 95 % percent of all households are served
- 90 % percent of all households are served

3 Delivery points (not) served in coverage scenario

Calculation of the costliest delivery points per coverage scenario / algorithm / sensitivity

The most expensive delivery points identified by the algorithm in the coverage scenario are removed

A travelling salesman problem (TSP) is solved using the Farthest Insertion Heuristic to determine the fastest route connecting all points

4 TSP evaluation and comparison to counterfactual

- Route time in Status Quo (all delivery points)
- Route time in coverage scenario (selection of points)

Difference = Route time savings without most expensive delivery points

Data

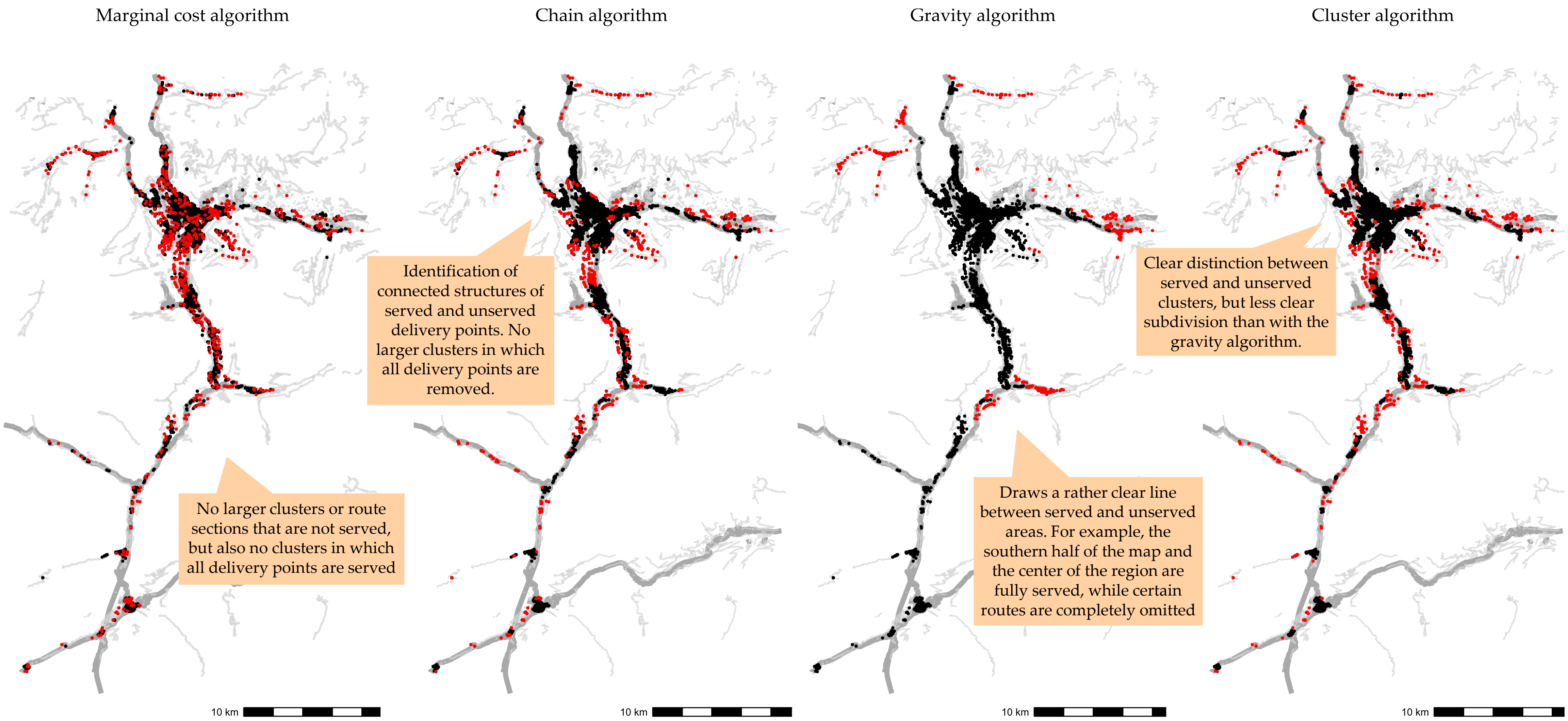
Sample
- 18'034 households in a region of Switzerland

Data Sources:
- Swiss Post: Household data
- Federal Statistical Office (STATPOP): Hectare-level population data
- OpenStreetMap
- Point-to-point route time estimates according to Gmür et al., 2025)

swiss economics

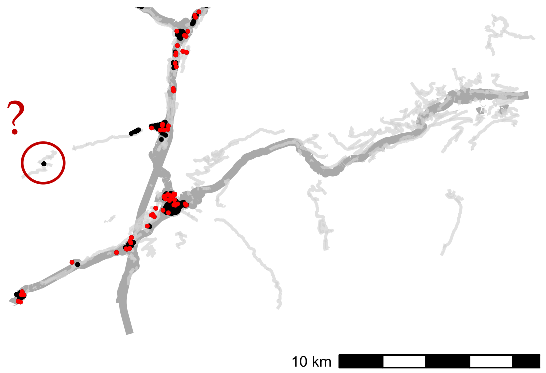
Identified costly delivery points

5 % excluded households (red) layered above the remaining households (black)

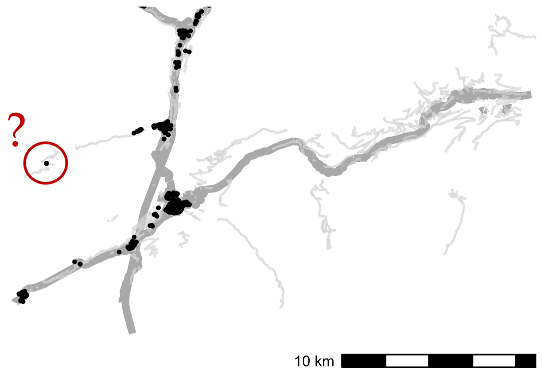


Example: Treatment of a remote settlement

Marginal costs

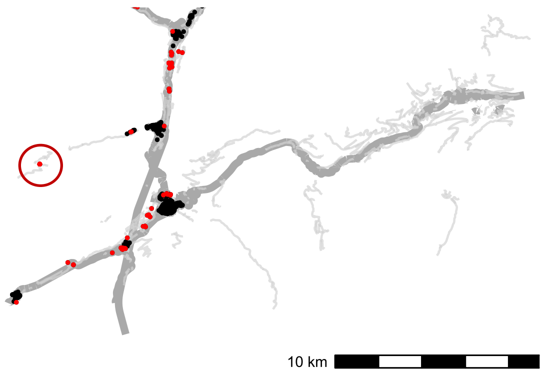


Gravity

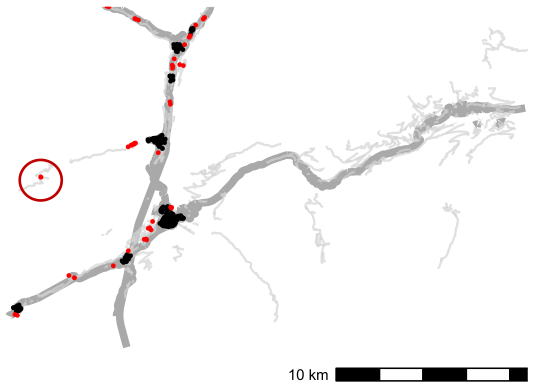


The marginal cost and the gravity algorithm fail to identify the remote settlement with 9 delivery points

Chain



Cluster



The chain algorithm and the cluster algorithm correctly identify the remote settlement as costly delivery points

Resulting savings per algorithm

Savings

- All algorithms result in significant route time reductions (between 21 and 32 percent with a coverage of 95%), showing the high impact of the costliest/most remote delivery points. The savings increase disproportionately when coverage is reduced from 95% to 90%.
- There are significant differences between algorithms. The best algorithm (cluster) results in 13 percent higher route time savings compared to the worst algorithm (marginal costs)

Route time savings	Marginal costs	Chain	Gravity	Cluster
95% coverage	24.1%	28.7%	21.3%	31.9%
90% coverage	30.1%	39.3%	33.2%	42.8%

Comparison of algorithms

- The cluster algorithm performs best in both coverage scenarios, demonstrating that spatial clustering based on geographic proximity is highly effective in identifying inefficient delivery zones.
- The chain algorithm also performs well, especially in identifying linear, time-intensive delivery stretches that other algorithms might miss.
- The marginal costs algorithm shows limited performance because it fails to recognize spatial groupings of costly households.
- The gravity algorithm underperforms despite factoring in population density and distance. Its weakness lies in applying a generalized proximity weighting that may dilute the identification of true outliers especially when dense clusters exist far from the rest of the network.

Summary of main results and conclusions

swiss economics

Summary

- The paper explored algorithms to identify costly delivery points prior to the TSP optimization
- Four algorithms were further developed and tested: Marginal Cost, Chain, Gravity, and Cluster
- In the explored Swiss region, excluding the 5% most remote households results in route time savings of 21% to 32%, depending on the chosen algorithm
- The cluster algorithm performed best:
  - It achieves about 10% more savings than the least efficient method.
  - It successfully identifies sparsely populated areas without oversimplifying spatial context.
- Applied to all delivery points of Switzerland, the cluster algorithm leads to estimated savings of 33% of route time. The result indicates that the chosen region represents the Swiss situation well (32% vs. 33%).

Conclusions

- Significant cost-saving potential exists through targeted exclusion of high-cost delivery points.
- The discussed algorithms vary considerably in their efficiency to detect costly delivery points.
- Coverage has a significant impact on USO net costs
- Expansion to a nationwide analysis could improve the generalizability of the results
- Future research:
  - Incorporate route times into the cluster algorithm to improve spatial accuracy.
  - Test more refined methods for clustering, e.g. based on TSP algorithms

Thank you for your attention!

Andreas Stritt, Economist
andreas.stritt@swiss-economics.ch, +41 78 883 49 12

Swiss Economics, Ottikerstrasse 7, CH-8006 Zürich
www.swiss-economics.ch

About Swiss Economics

In Brief

- Founded in 2008
- Independent
- Based in Zurich
- Consulting worldwide
- Collaboration with universities
- Committed to Excellence in Economics

Topics / Expertise

- Regulation
- Economic policy
- Competition economics
- Claims and damages
- Valuation
- Strategy and Pricing
- Efficiency
- Crypto economics

Sectors

- Communications: Post, Telco, Platforms, Media
- Energy: Power, Gas, District Heating
- Transport and mobility: Rail, Air, Road
- Health
- Financial Intermediaries: Banks, insurances

Core Competencies

- Economics
- Econometrics
- IO Modelling
- Impact assessment
- Market design
- Sector knowhow
- Expert reports and testimony