Decision Support for an Optimal Choice of Subsidised Routes in Air Transportation

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Introduction

- Deregulation led to lack of air service along routes with insufficient demand
- Countries adopted subsidy schemes to guarantee accessibility for small communities
- Subsidy schemes are implemented based on defined criteria:
  - Accessibility to a major city, advanced health care, an international airport, etc.
  - Related to a time target e.g., 4 hours

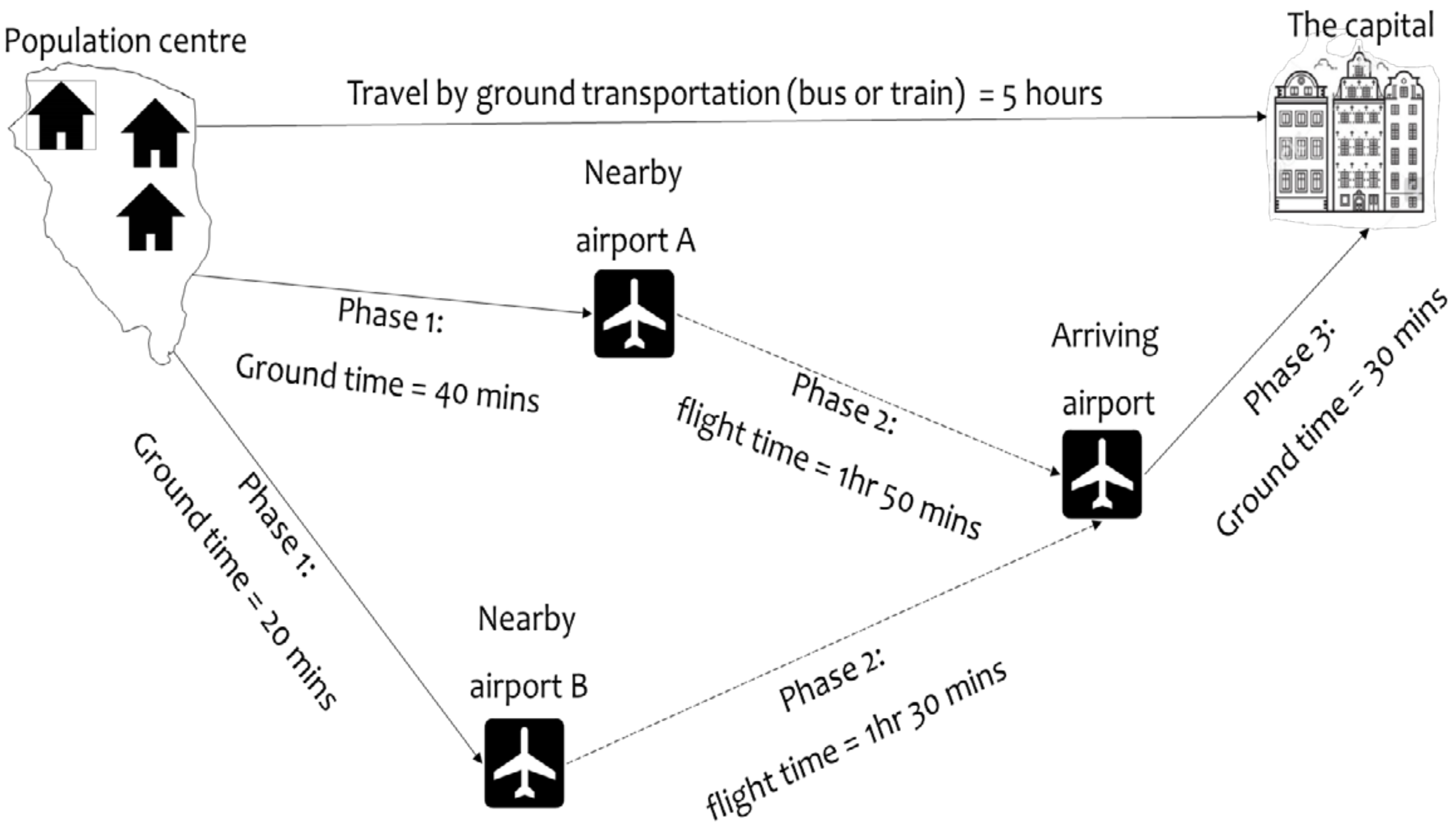
Aim of the study

- Develop a decision support tool that can assist decision makers select an optimal network of subsidised routes
- How?
    1. Assumptions
    2. Estimate the cost of subsidising a route
    3. Use a budget constrained optimisation model
    4. Assess both the current and optimal network of subsidised routes

Related work

- Flynn and Ratick (1988)
  - Maximised coverage and minimise the system-wide cost
  - Used Euclidean distance
  - Applied to the US
- Pita et al. (2014)
  - A socially oriented flight scheduling and fleet-assignment optimisation model
  - Minimise social cost
  - Applied to Norway

Model assumptions



- Three phases of a journey
- The transportation mode offering the shortest travel time is chosen
- Given target time
- Evaluate the suggested networks by the associated increase in the number of people served

Estimate the cost of subsidising a route

- Subsidisation cost (c_f) depends on the total route-ticket revenue (*f(Demand)*) and the route operating cost (*f(Availabe Seat Miles, number of legs)*)
- $c_f = A + B \times legs + D \times Demand + C \times ASM$

New routes Demand:

- Catchment size
- Ground-flight time
- Number of flights

Binary IP for MaxCoverage

$$Max\ Z = \sum_{p \in P} D_p y_p$$

$Subject\ to:$

$$y_p \leq \sum_{f \in F} A_{pf} x_f \qquad \forall\, p \in P$$

$$\sum_{f \in F} c_f x_f \leq B$$

$$\sum_{f \in O_{fk}} x_f \leq 1 \quad \forall\, k \in K$$

$$y_p \in \{0,1\} \qquad \forall\, p \in P$$

$$x_f \in \{0,1\} \qquad \forall\, f \in F$$

- $p - population\ centres$
- $route\ f\ with\ cost\ c_f$
- $B - Budget$
- $x_f = 1\ if\ route\ f\ is\ selected$
- $y_p = 1\ if\ p\ is\ covered$

Each airport k has at most one route

Case study: Swedish PSO network (1/2)

Accessibility Criterion	Target
To Stockholm	1. Less than 4 hours
	2. Less than 5 hours
	3. Prioritise 5 hours over 4 hours
To an international airport	4. Less than 4 hours
To Stockholm and an international airport	5. Less than 4 hours to Stockholm and Less than 4 hours to an international airport

International airports

Case study: Swedish PSO network (2/2)

- $c_f = A + B \times legs + D \times Demand + C \times ASM$
- B = -1,228,000, C = -102, D = 3
- More reasonable results with no constant A
- Re-estimated cost of current 11 PSO routes is SEK 120.4 million

- 11 PSO routes to Stockholm-Arlanda (2 direct routes)
- 799 possible PSO routes
- 2778 binary variables
- 3200 constraints

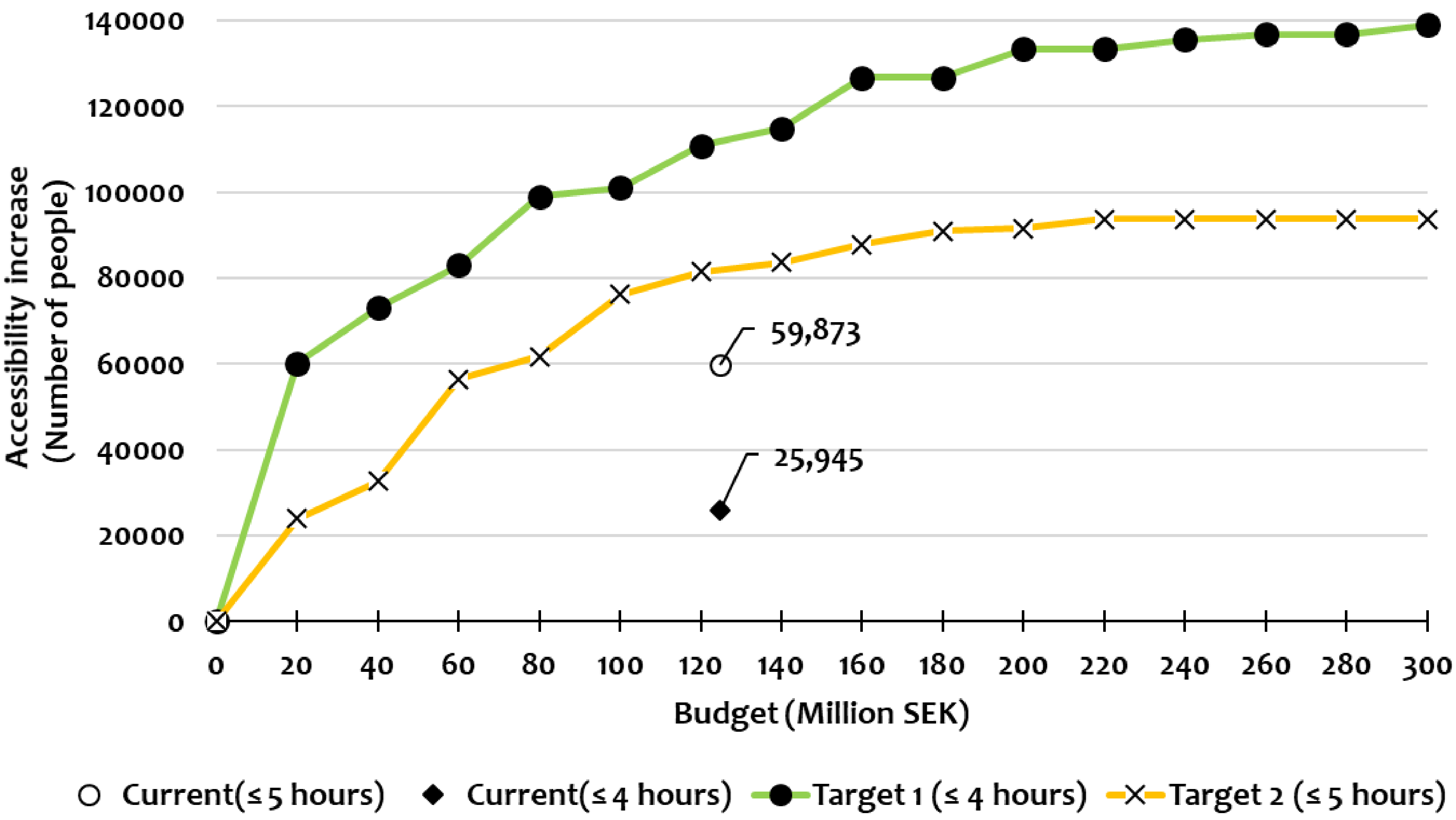
Results

1. How many people would need PSO routes
   - Accessibility without PSO routes
2. How many people with improved accessibility
   - Accessibility with current PSO routes
   - Accessibility with optimal PSO routes

Accessibility without PSO routes

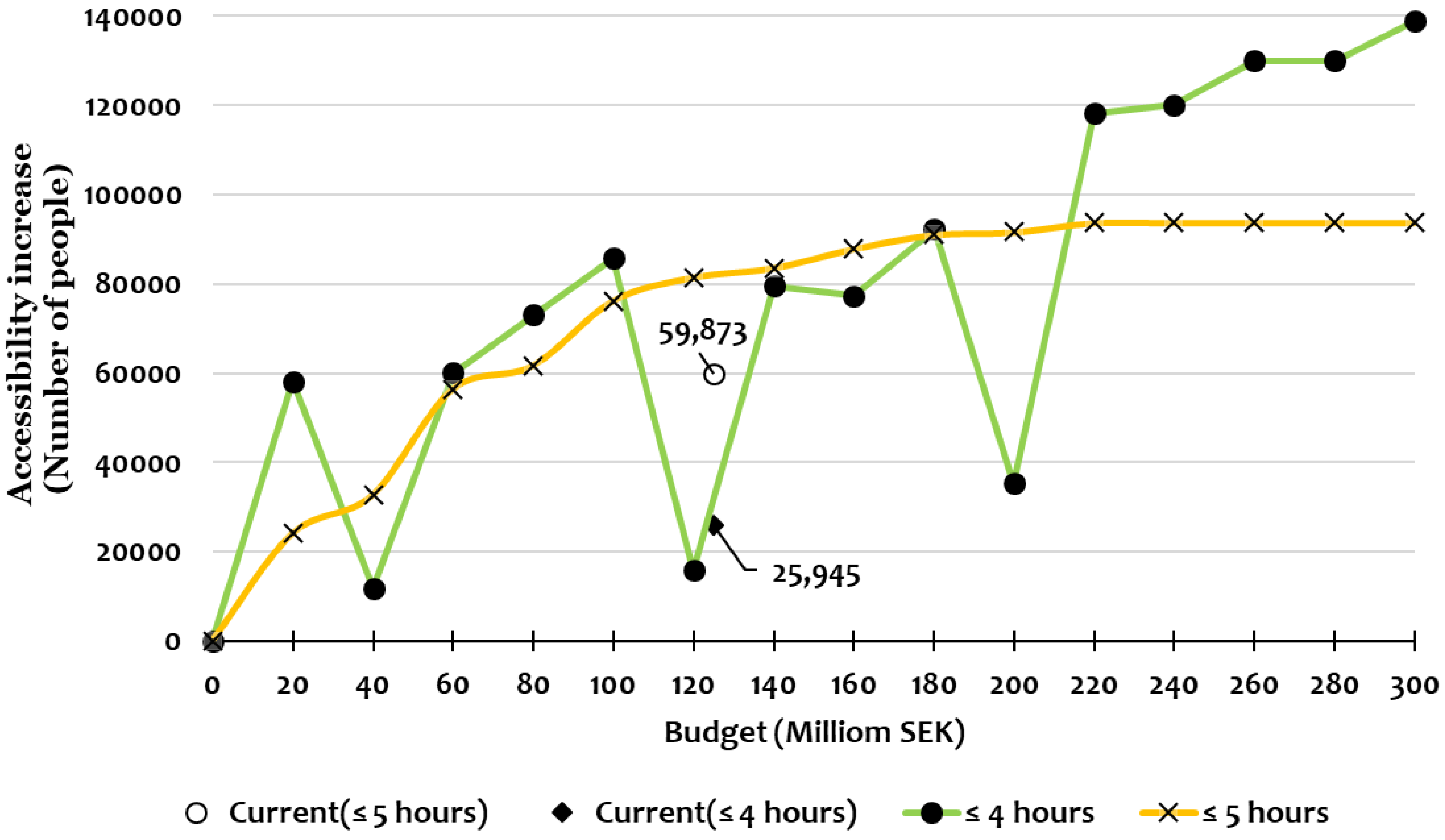
- To Stockholm within 4 and 5 hours
  - 97.04% and 99% can reach Stockholm within 4 and 5 hours respectively
  - The remaining 295,371 and 99,788 people, respectively need improved accessibility
- To an international airport within 4 hours
  - 88.71% do not need PSO routes
  - The remaining 1,126,603 people need improved accessibility
- The small communities and are a target for PSO routes

Accessibility to Stockholm within 4 and 5 hours (1/2)



Considered individually

Accessibility to Stockholm within 4 and 5 hours (2/2)

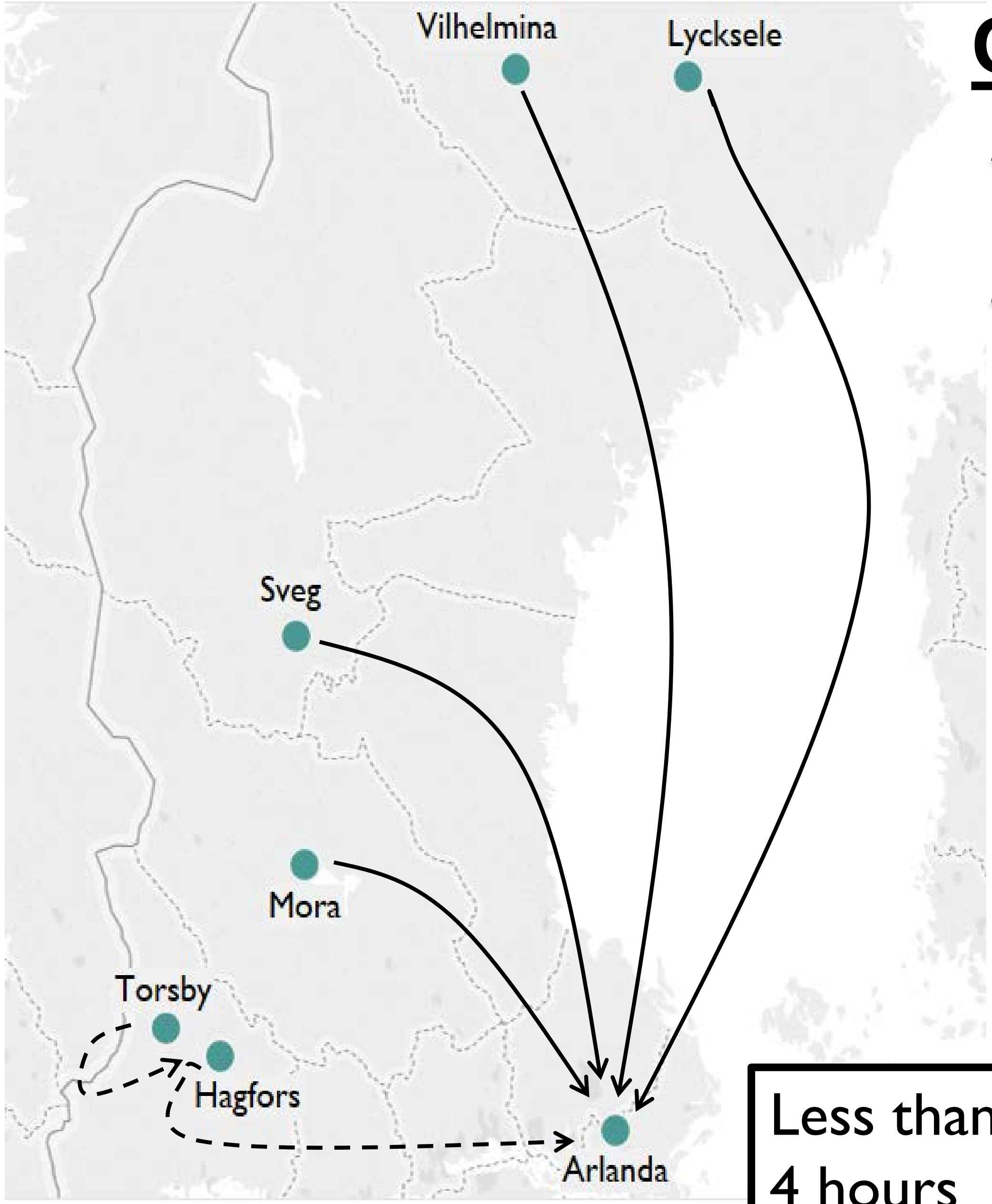


Prioritise 5 hours
over 4 hours

Optimal routes

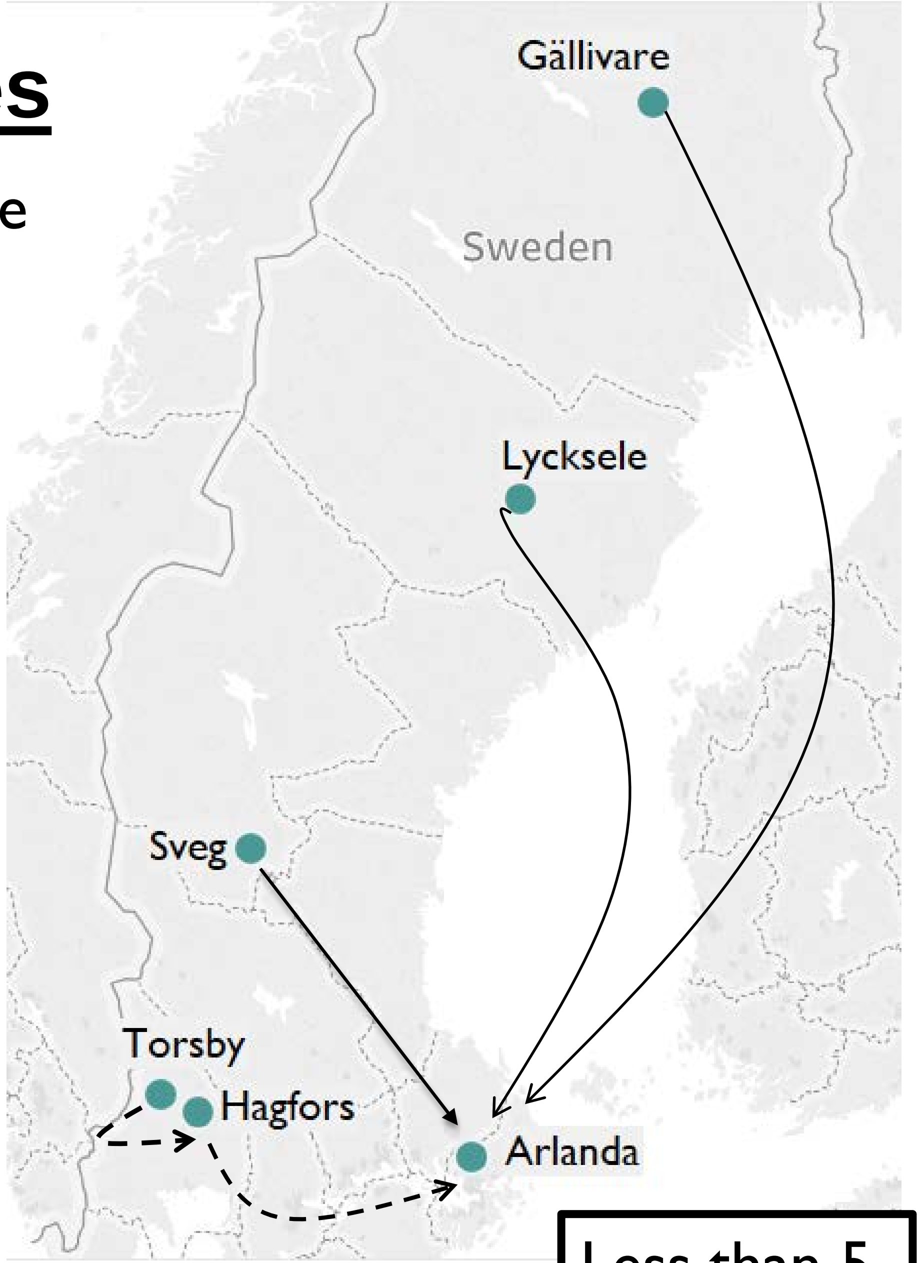
⟶ Direct route

- - - → One-stop route



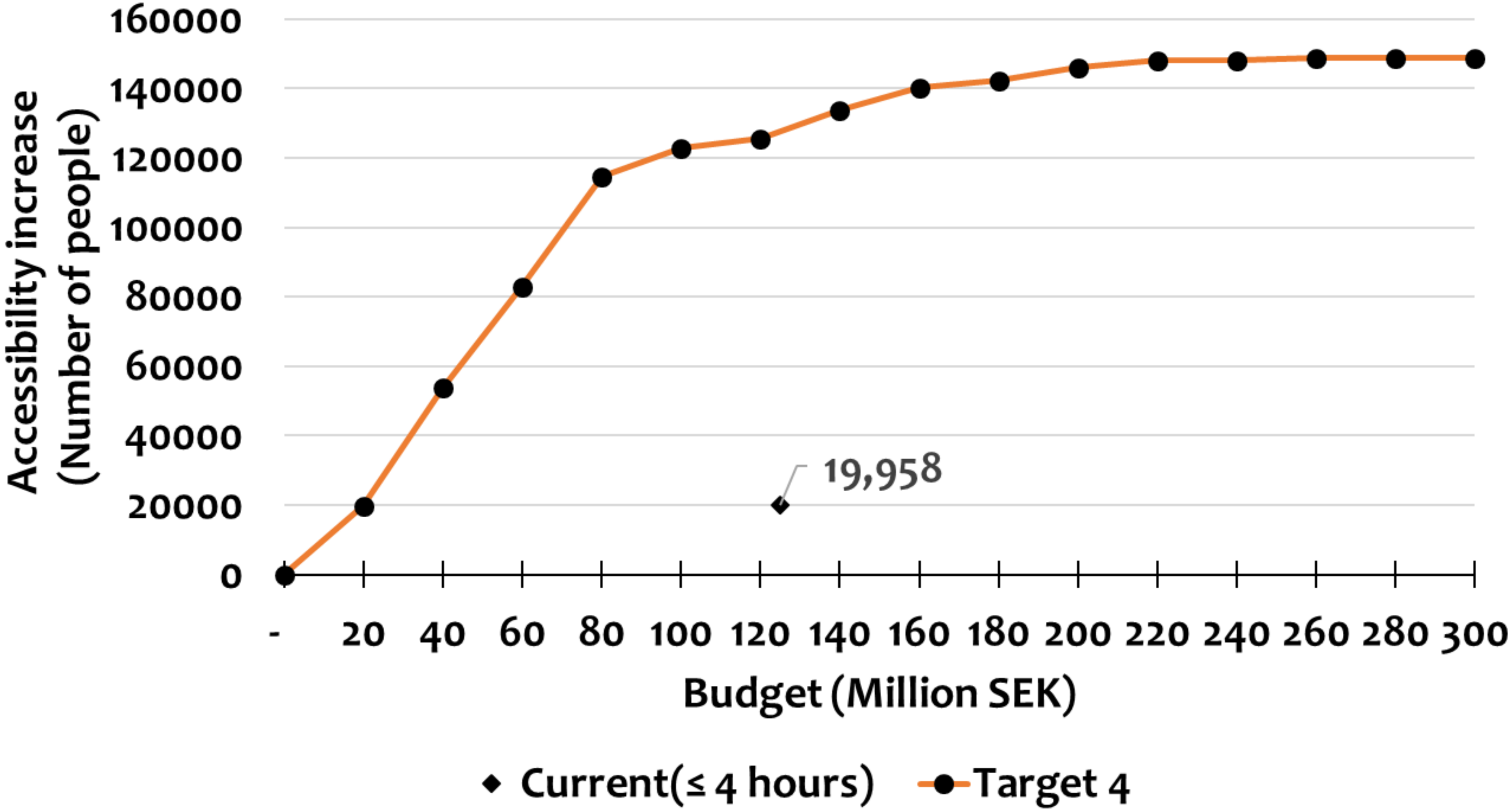
Less than 4 hours

One stop routes appear with longer target times



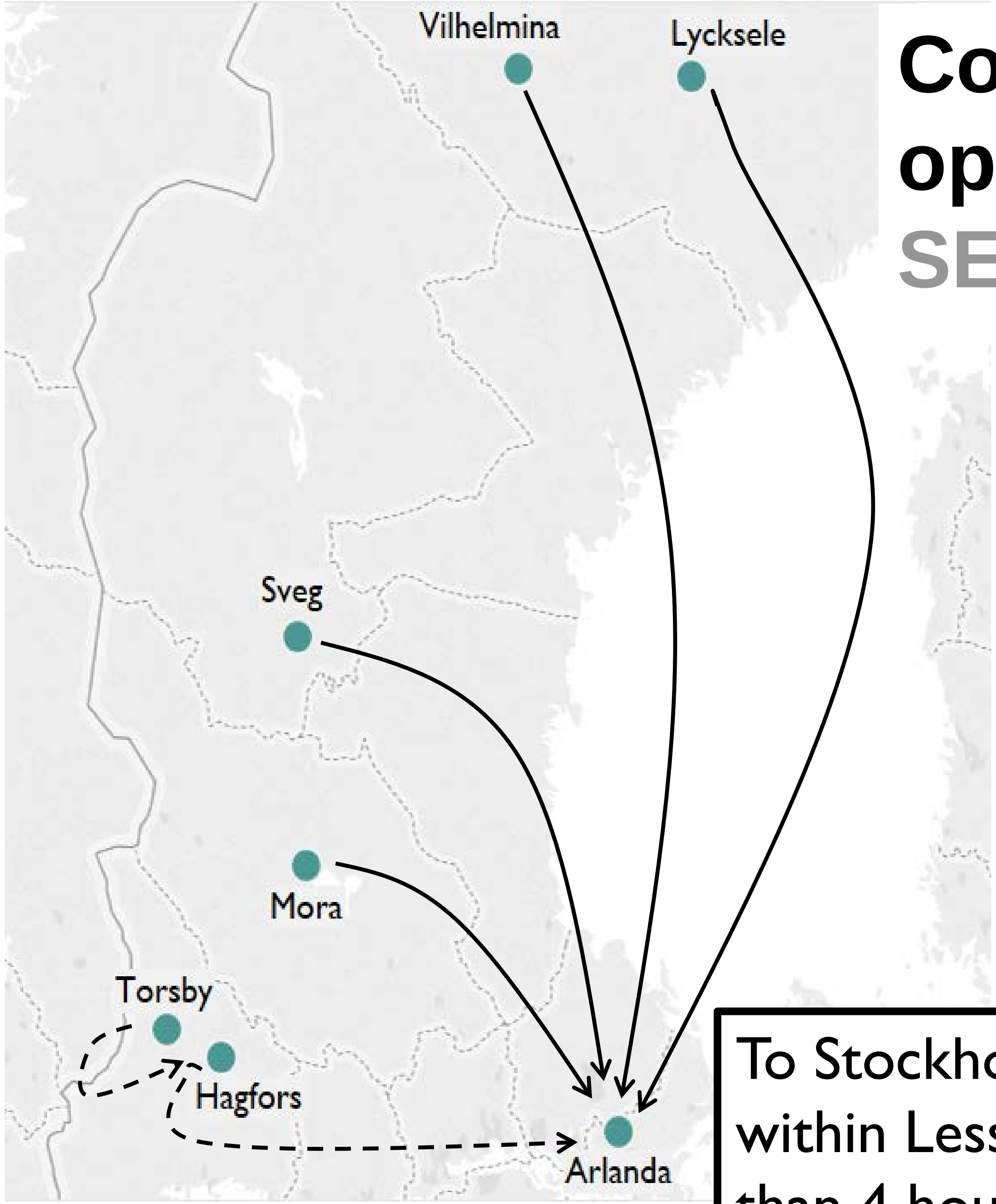
Less than 5 hours

Accessibility to an international airport within 4 hours

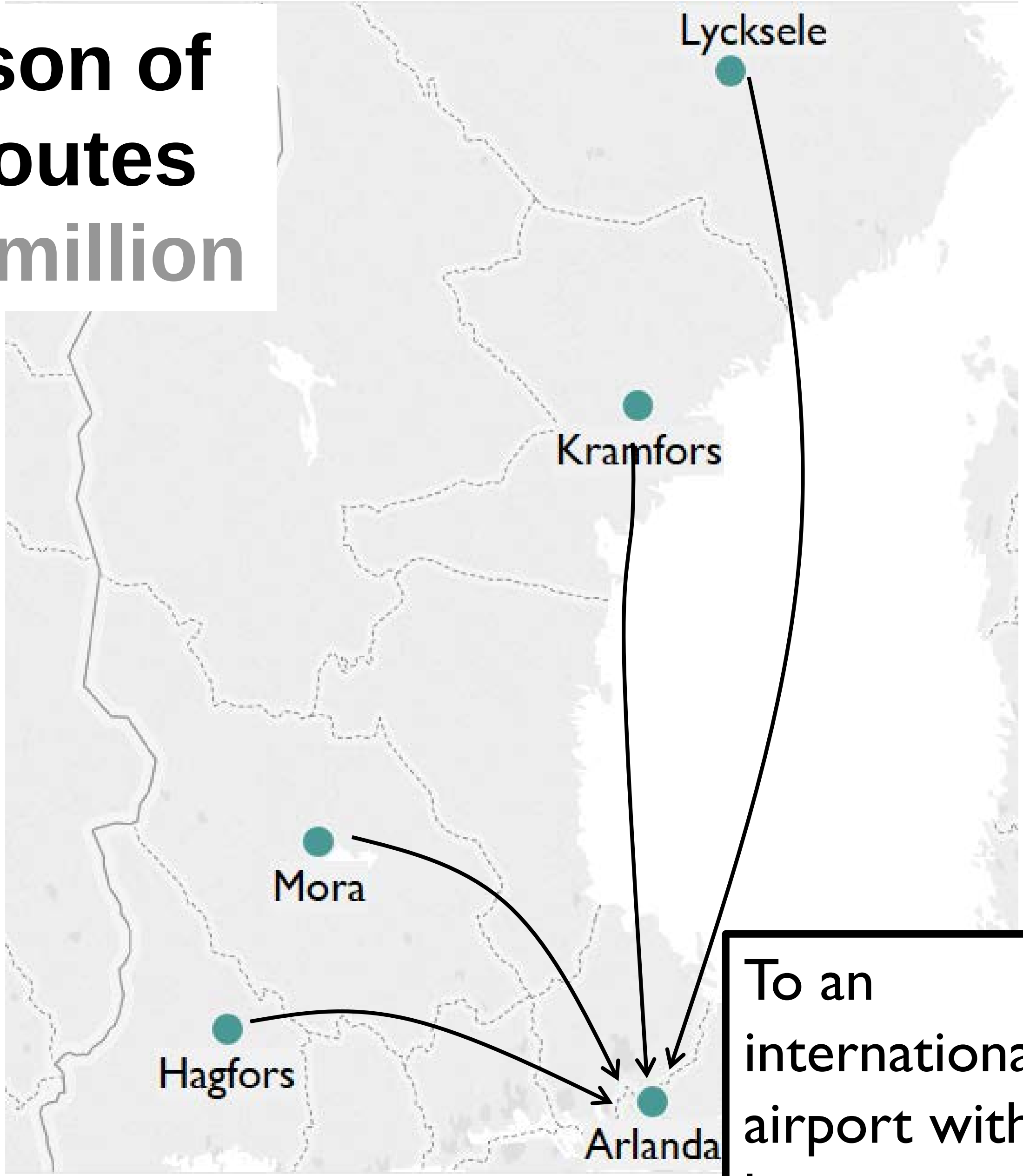


Comparison of optimal routes

SEK 120 million



To Stockholm within Less than 4 hours



To an international airport within 4 hours

Conclusion

- Accessibility without PSO route is quite good for most population centres
- Good job by Trafikverket but the results indicate room for improvement
- An optimisation-based decision support tool can be used to evaluate subsidised route networks
- Possible application to other regions/countries

Further research

- Consider
  - Additional criteria
  - Setup cost on new routes
- A detailed flight scheduling
- Explore possibilities of other air traffic networks

Questions

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