Methods for Capacity Allocation in Deregulated Railway Markets

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0. Outline

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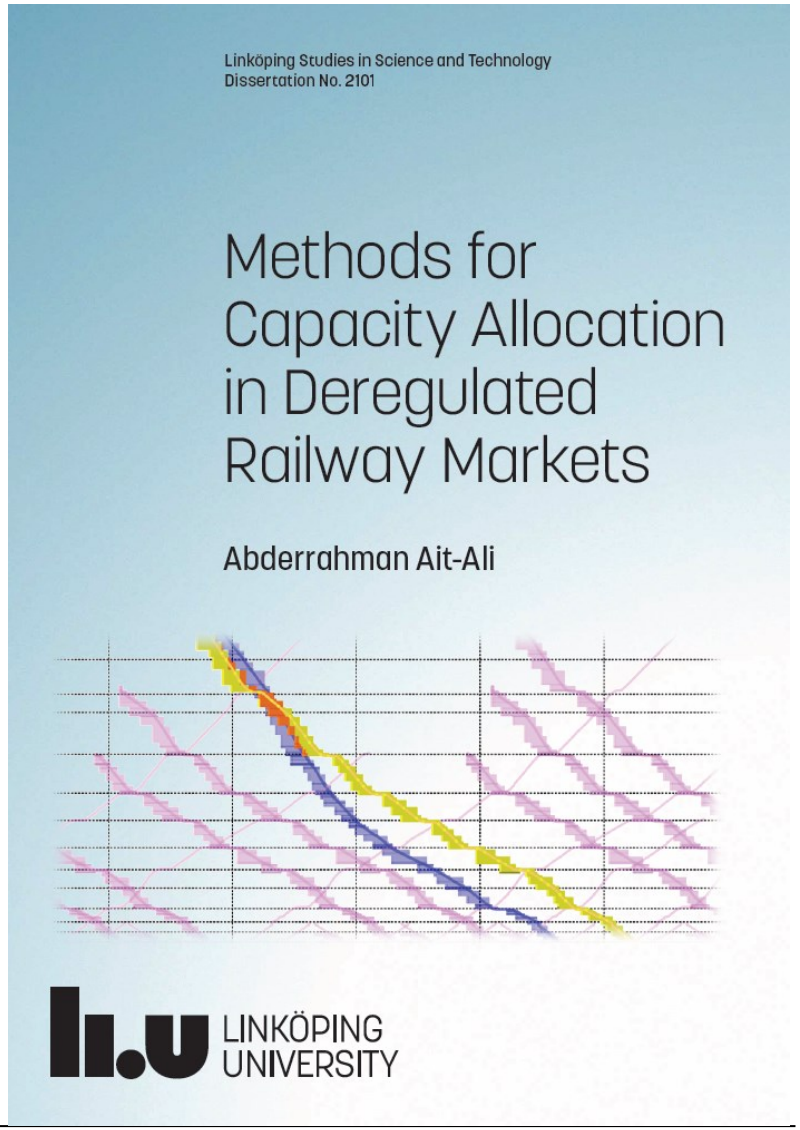


1. Research Setting

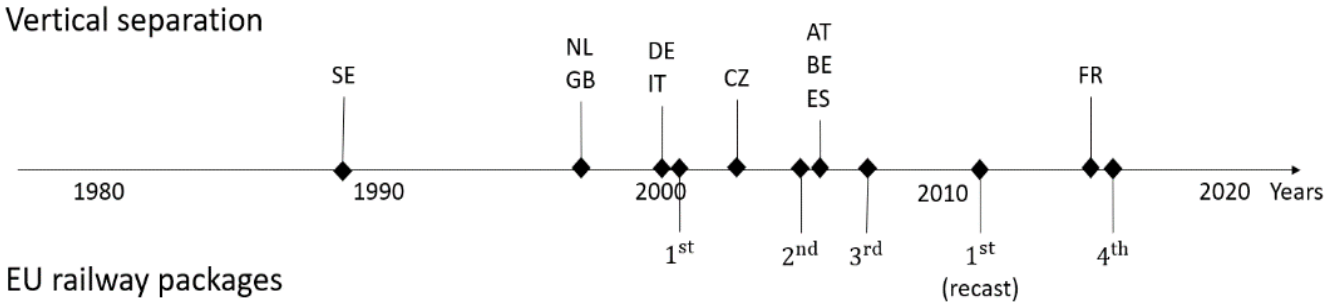
a) Background

b) Problem(s)

c) Delimitation

a) Background

- Major reforms in (European) railways
  - **Vertical separation** of rail infrastructure management from service operations
  - Followed by **deregulation**, i.e., new entrants are allowed in the railway market



b) Problem(s), before deregulation

- Before railway deregulation (or vertically separation), **capacity allocation** was
  - **internally** performed with a monopolistic company
  - (supposedly) aimed at finding **efficient timetables**

- **Efficiency** refers to
  - the goal of the monopolistic company, e.g., profit (max), cost (min) or social benefits (max)

b) Problem(s), after deregulation

- Now (after deregulation), **capacity allocation** should be
  - **transparent**, i.e., clear and fair to different (often competing) railway companies in the market
  - and (still) **efficient**
- **Efficiency** here is
  - set by the **local railway legislation**, e.g., (in Sweden)
    - (min) total costs on society, i.e., **social costs** (*samhällsekonomiska kostnader*)

c) Delimitation

- Focus on **efficiency,** with transparency in mind
- More detailed study of two important **market segments**, i.e., **publicly controlled** and **commercial** traffic
  - Detailed traffic contracts (e.g., open access, franchising) are not studied
  - Other segments (e.g., ad hoc, maintenance) are only briefly discussed
- **Real time traffic** aspects (e.g., robustness) are not considered (but can be included)

2. Literature Review

a) Railway capacity (allocation)

b) European context

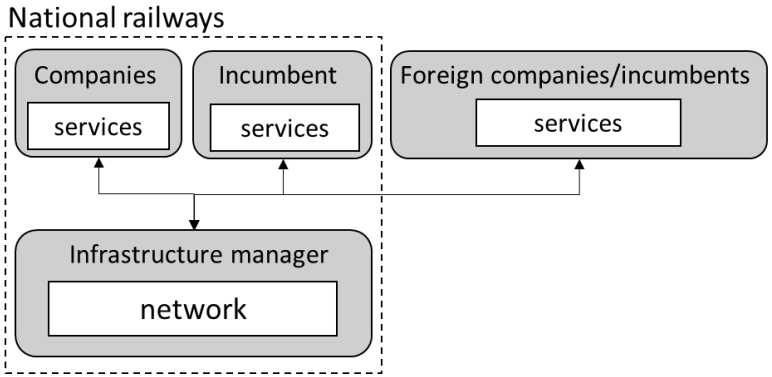
c) Capacity allocation

d) Challenges & opportunities

a) Railway capacity (allocation)

- Need for (prior) planning of railway traffic, i.e., **capacity allocation**
  - In contrast to (ad hoc) **road traffic** allocation, i.e., **queues** (congestion)
- Multiple definitions of **railway capacity**
  - E.g., **train paths** in the annual timetable
- **Network effects** and **combinatorial** nature
  - E.g., train timetable problems (TTPs) are **hard** to solve

b) European context



- Capacity allocation by an “independent” **infrastructure manager (IM)**
- Competition (for/on the track) between **railway undertakings (RUs),** incl. **incumbent**
  - IM solves **capacity conflicts**
  - RUs have **different** traffic contracts/goals, e.g., profit (max), social benefit (max).

c) Capacity allocation (1/2)

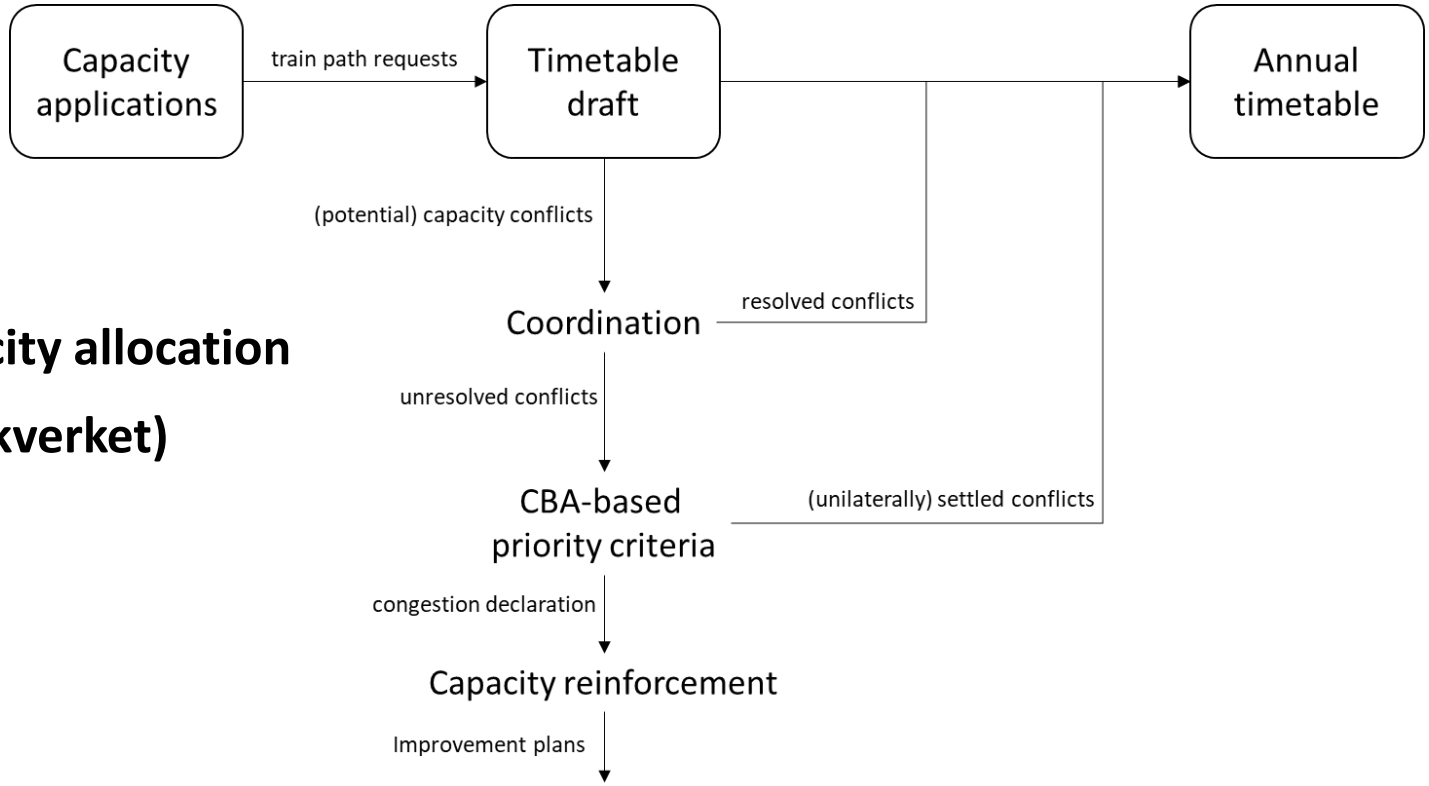
- **Yearly** process to construct the **annual timetable**
  - Efficiently (and transparently) solve capacity conflicts
- **Existing methods** for conflict settlement: model-based, priority criteria and market-based.
- **Problems**
  - Transparency, e.g., robustness model (France)
  - Efficiency, e.g., (CBA*) priority criteria (Sweden)

* Cost-benefit analysis

c) Capacity allocation (2/2)

Swedish capacity allocation

(by Trafikverket)



d) Challenges & opportunities

- Priority criteria for conflict settlement (in Sweden)
  - **Cost-benefit analysis** (CBA) for all market segments, incl. private commercial traffic (**data?**)
  - **Static** parameters/prioritization (corner solutions?)
- Opportunities
  - Available data for **publicly controlled traffic**
  - Legislation
    - market-based, e.g., **capacity pricing**

3. Conducted Research

a) Literature gaps
b) Research questions
c) Methodology
d) Successive allocation in segmented markets
e) Publicly controlled traffic
f) Commercial traffic

a) Literature gaps

- Literature of capacity/resource allocation (in deregulated markets) **is less rich** in railway than other public utilities
- Need for methods to allocate capacity in **deregulated railway markets** in a way that is
  - **efficient,** e.g., social benefits
  - **transparent**, e.g., market-based
- Research projects for **socially efficient railway capacity allocation**, e.g., SamEff (*Samhällsekonomiskt effektiv tilldelning av järnvägskapacitet*)

b) Research questions (RQs)

RQ1. What capacity allocation is used in current deregulated markets?

RQ2. How can capacity conflicts be more efficiently resolved between commercial and subsidised traffic?

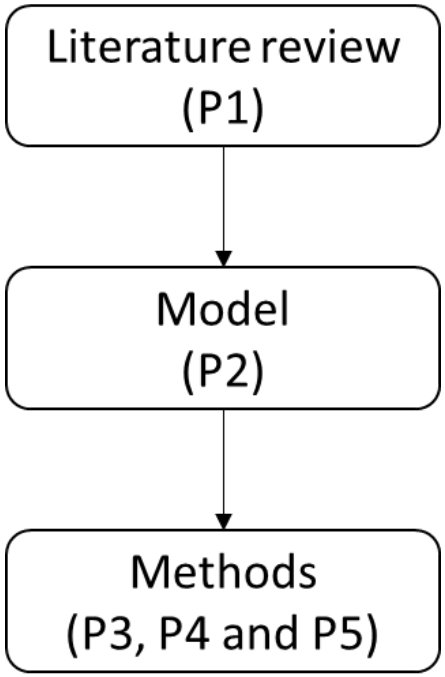
RQ3. Is subsidised traffic supply efficient according to CBA guidelines?

RQ4. How can mathematical optimisation be used to further improve the traffic supply?

RQ5. How much demand data is needed for more accurate policy decisions?

c) Methodology (1/2)

- Top-down research methodology:
  1. **Review** of (European) deregulated railway markets and their capacity allocation
  2. **Build a model** for successive capacity allocation in a segmented deregulated market
  3. **Develop methods** for the allocation model, i.e., solutions, data and parameters

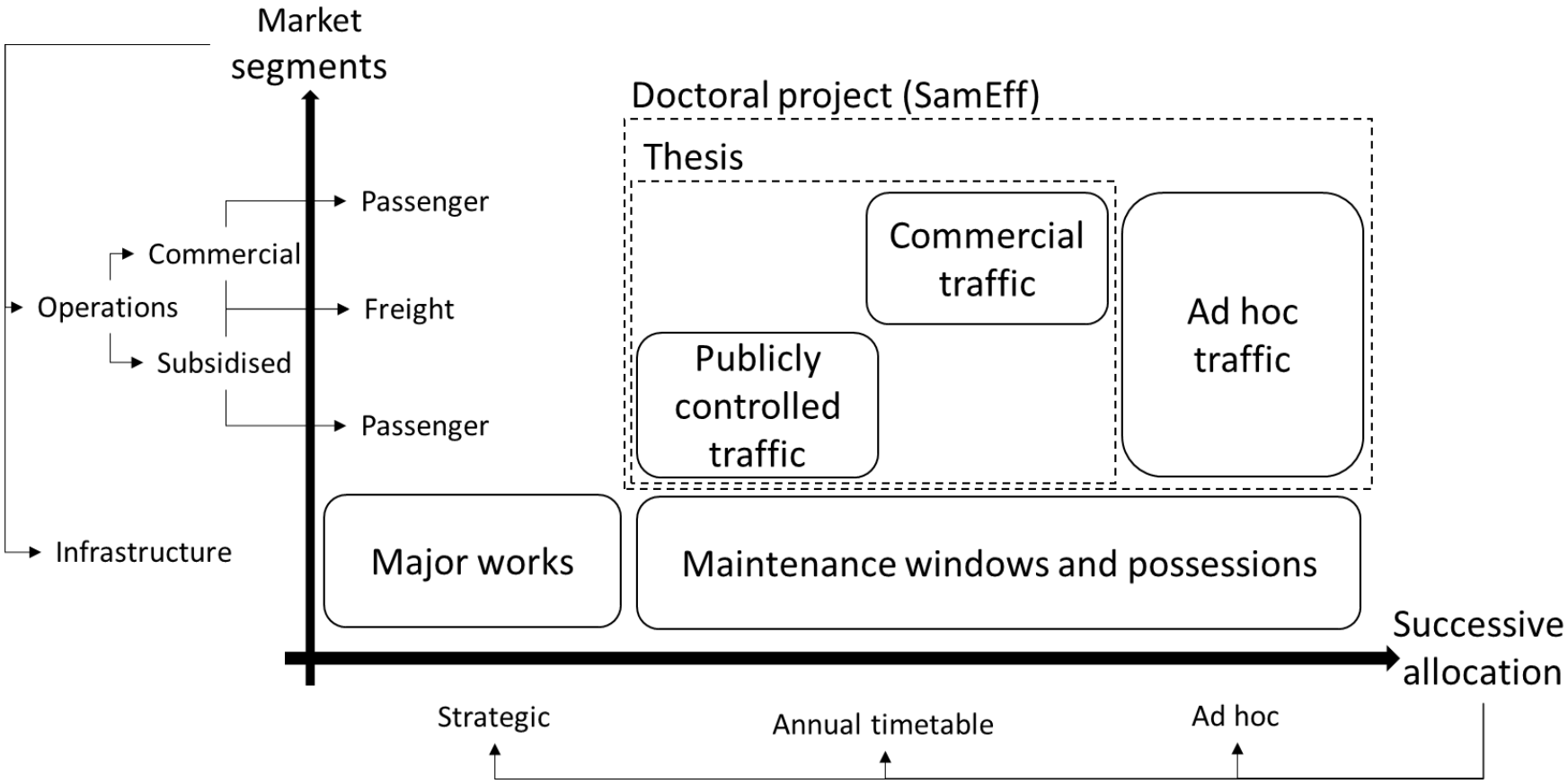


c) Methodology (2/2)

- Documented in **5 research papers**
- Based on different **research methods**

	Research methodology		
Research methods	**Literature**	**Model**	**Methods**
Qualitative text analysis	P1		
Cost benefit analysis (CBA)		P2	P3
Mathematical programming			P4 and P5
Passenger flow simulation		P2	P3 and P5
Data analysis	P1	P2	P3, P4 and P5

d) Successive allocation in segmented markets

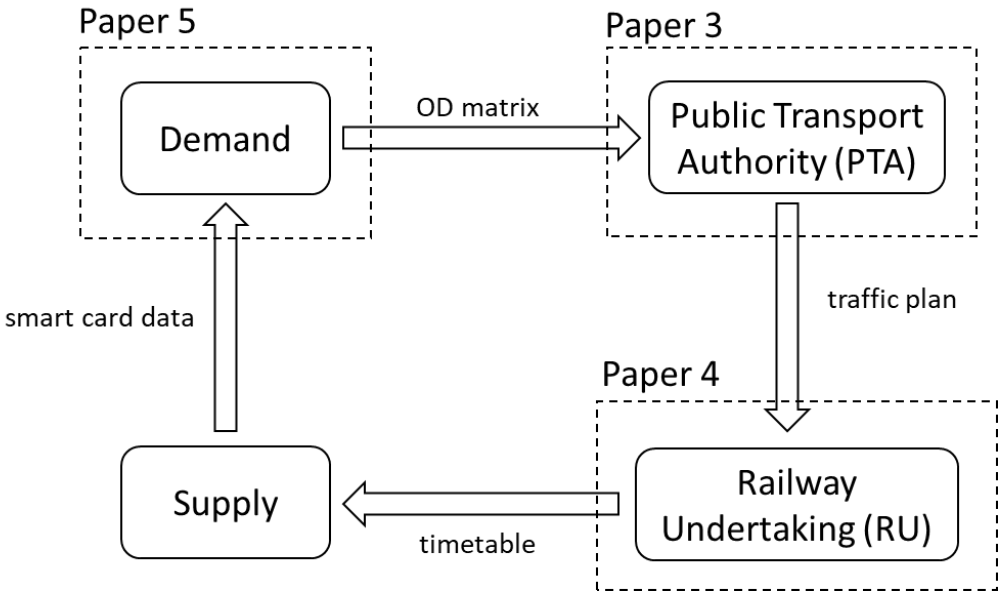


e) Publicly controlled traffic (1/2)

- Public Transport Authorities (PTAs) award Public Service Obligation (PSO) contracts to RUs
  - e.g., through **competitive tendering** (for-track competition)
- PTA specifies a traffic plan (e.g., frequency)
  - based (presumably) on total **social benefits** (max)
- RU executes the plan (e.g., timetable)
  - under operational constraints

e) Publicly controlled traffic (2/2)

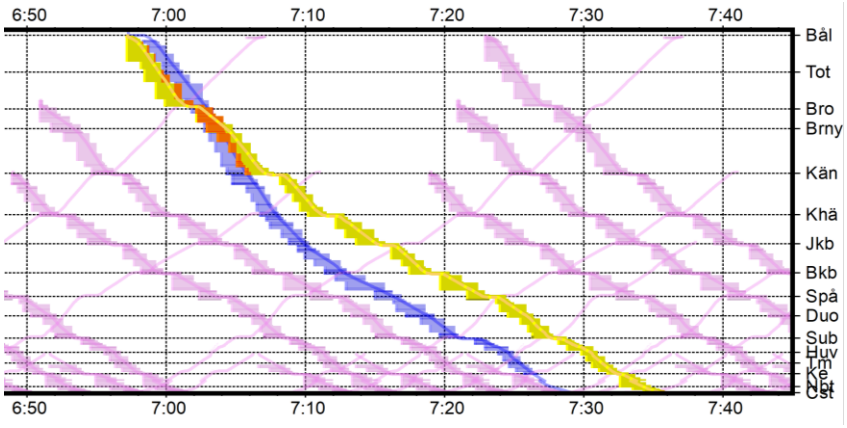
- If necessary, PTA **updates** the traffic plan
  - based on **passenger demand** (e.g., smart cards data)

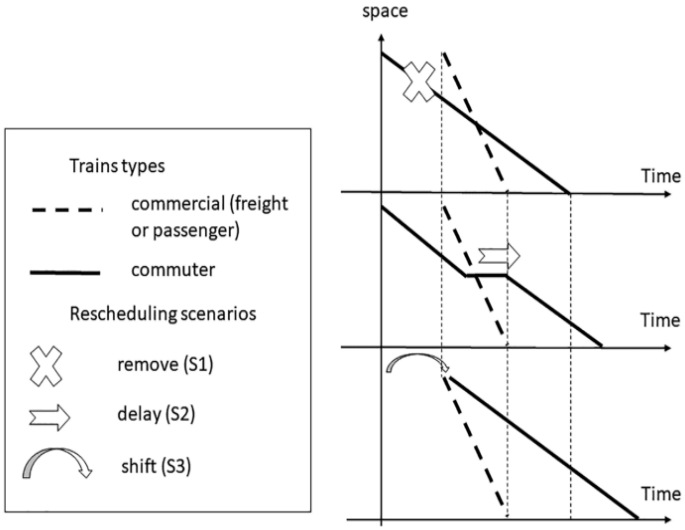


f) Commercial traffic (1/2)

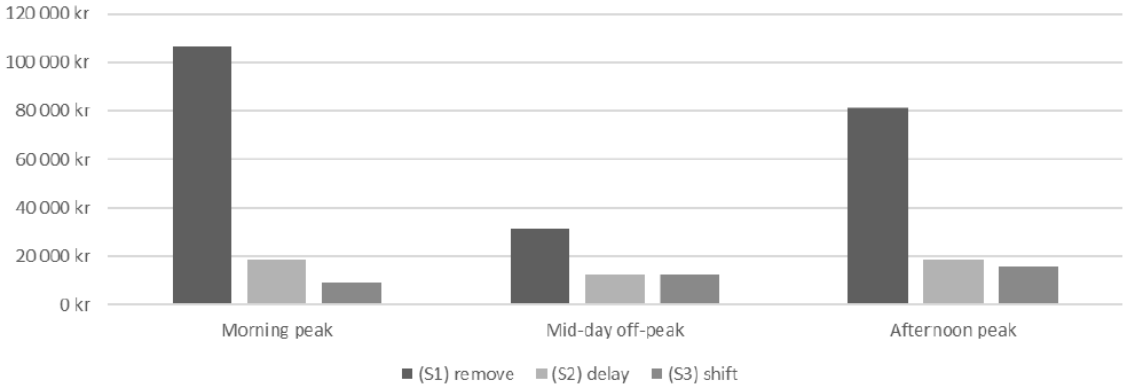
- **IM prepares** different train path scenarios (to solve capacity conflicts)

- Use of CBA to calculate marginal social costs, i.e., **reservation price**





f) Commercial traffic (2/2)



Case	Time	Consumer costs				Producer costs				Total costs
		travel	waiting	transfer	total	distance	time	fixed	total	
S1 – remove	Morning	97 499	18 835	-476	115 859	-6 370	-3 633	-900	-10 904	104 955
	Mid-day	32 433	9 482	-457	41 458	-6 370	-3 633	-900	-10 904	30 554
	Afternoon	70 817	21 298	-451	91 664	-6 370	-3 633	-900	-10 904	80 761
S2 – delay	Morning	14 059	2 038	-	16 096	-	133	12	145	16 242
	Mid-day	9 756	760	-	10 516	-	133	12	145	10 661
	Afternoon	12 138	6 920	-	19 058	-	133	12	145	19 203
S3 – shift	Morning	7 894	1 353	-	9 247	-	-	-	-	9 247
	Mid-day	9 571	1 059	-	10 630	-	-	-	-	10 630
	Afternoon	15 070	974	-	16 044	-	-	-	-	16 044

- In case of **(on-track) competition for commercial traffic**, auction starting from the reservation price

4. Research Contributions

a) Included papers

b) Main contributions

a) P1: *"A Survey of Railway Deregulation in Europe."*

RQ1. *What capacity allocation is used in current deregulated markets?*

C1. Overview of deregulated railway markets in Europe

RQ2. *How can capacity conflicts be more efficiently resolved between commercial and subsidised traffic?*

C2. Currently used ways to solve capacity conflicts

a) P2: *"Pricing Commercial Train Path Requests Based on Societal Costs."*

RQ2. How can capacity conflicts be more efficiently resolved between commercial and subsidised traffic?

C3. Pricing commercial train paths using marginal social costs

RQ3. Is subsidised traffic supply efficient according to CBA guidelines?

C4. Assessment of social costs for commuter traffic

a) P3: *"Are Commuter Train Timetables Consistent with Passengers' Valuations of Waiting Times and In-vehicle Crowding?"*

RQ3. Is subsidised traffic supply efficient according to CBA guidelines?

C5. PTA's implicit valuation for waiting time and crowding

RQ4. How can mathematical optimisation be used to further improve the traffic supply?

C6. Optimal frequencies for commuter traffic

RQ5. How much demand data is needed for more accurate policy decisions?

C9. Optimal traffic supply based on OD data

a) P4: *"Disaggregation in Bundle Methods: Application to the Train Timetabling Problem."*

RQ4. How can mathematical optimisation be used to further improve the traffic supply?

C7. Improved method to solve lagrangian-based TTP models

a) P5: *"The Value of Data for Demand Estimation in Public Transport Systems."*

RQ4. How can mathematical optimisation be used to further improve the traffic supply?

C8. EM-based estimation models for dynamic OD matrices

RQ5. How much demand data is needed for more accurate policy decisions?

C10. Value of additional data for better dynamic OD estimates

b) Main contributions

- Contributions, papers, research questions and railway stakeholders (in Sweden)

Stakeholder (Sweden)	RQ1	RQ2		RQ3		RQ4			RQ5	
	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
Regulator (Trans-portstyrelsen)	P1	P1								
IM (Trafikverket)	P1	P1	P2	P2			P4			
PTA (SL)				P2	P3	P3		P5	P3	P5
RU (SJ)							P4	P5	P3	P5
RU (Green Cargo)							P4			

5. Concluding Remarks

a) Discussion

b) Conclusions

c) Future work

a) Discussion

- **High initial investment costs** such as acquire the rolling stock
  - Traffic agreements, leasing companies
- Methods assume certain **quality of data**
  - Digitalization, cybersecurity
- Some other **challenges**
  - Acceptability**,** information asymmetry, cross-subsidisation, grandfather rights, equity, macroeconomics
- Different (but closely related) types of **congestions**
  - Capacity (on-track) vs. in-vehicle, or both (train formation)

b) Conclusions

- The **deregulation** of (European) railways brought new challenges, e.g., **capacity allocation**
- Legislation provides **opportunities** for adopting **market-based capacity allocation**
- Methods to reduce the **research gap** in the rail sector, versus other sectors

c) Future work

- **Further experimentations** to gain more insights, e.g., legislation, digitalization
- **Complementary work**, e.g., ad hoc capacity allocation, reserve capacity
- **Extensions** can be included, e.g., robustness, infrastructure maintenance

Thank you for your attention!