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Railway Timetabling Based on Cost-Benefit Analysis

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Abstract

The congestion on the tracks are increasing and to plan all requested trains on the tracks become harder. The infrastructure manager must have good methods for ruling out which operator gets its requested timetable. These methods must maximise the welfare and the decision must also be fully transparent to the operators. The aim of this paper is to develop and evaluate an optimization model for welfare cost. The welfare cost is minimised while considering the detailed constraints of the railway infrastructure. The resulting welfare cost can be used to perform a cost-benefit analysis to provide a value of possible future traffic. The cost-benefit analysis can be the base for several kinds of analyses, like finding the optimal number of departures or the best departure times, finding the economic value of a certain timetable, which are exemplified. The optimisation model is tested on a part of the Swedish railway network covering the entire area operated by the regional train operator Östgötatrafiken.

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1. Introduction

By performing an economical analysis on timetables more information about efficiency and productivity can be derived, especially when resources are scarce. In this paper, we investigate the possibility to create and evaluate a railway timetable by minimizing the welfare cost for passengers and railway operators which can form the foundation of a cost-benefit analysis. This is of interest when several railway operators are competing for the limited infrastructure capacity.

The deregulation of the Swedish railways commenced in 1988 when Banverket was created to take on the role as an infrastructure manager. The previous infrastructure manager, Statens järnvägar, had been responsible for both infrastructure and traffic on the Swedish tracks as an governmental agency but would in the following years be reorganised into a state-owned company. Banverket's main responsibilities were to maintain the railway infrastructure and organise timetables. In 2001 the railway market was opened for competition and currently multiple companies operate the Swedish railways. An increased interest from different companies to operate trains on the Swedish network along with already heavily congested tracks causes challenges to the current methods used to plan the timetable

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where the ambition is a perfect competition between the operators. Therefore, the processes and methods for railway timetabling should be enhanced in order to better handle the situation between competing companies and scarce infrastructure capacity.

1.1. Current timetabling process

The timetabling process starts over a year in advance when the Network Statement is written and published. The Network Statement contains information about larger maintenance work, details of the timetabling process, technical details of the tracks, etc. Based on the information in the Network Statement, the train operators and maintenance entrepreneurs apply for their desired train paths and maintenance work respectively. A train path is a timetable for a specific train. The infrastructure manager coordinates all requests. If two or more train paths are causing a resource conflict which cannot be resolved within reasonable adjustments, the infrastructure manager must confer with the affected operators to discuss possible changes to their desired train paths in order to fit all of them in the timetable. If no such agreements are settled, the track is declared congested and the infrastructure manager calculates an estimated value of the train paths by applying the priority criteria calculus. The priority criteria provides a value of a train path based on its transport (whether it is freight or passengers), travel time, stops, if passenger exchange occurs, etc., and rely on self declared information from the operators. When the values of the train paths are found, the train path with the lowest value loses the dispute and is excluded from the timetable. When all applications are administered and scheduled, the timetable is published, along with a list of the cancelled train paths. This point in time is also the start of the ad-hoc process, which is the planning of late applications. Many applications for train paths are submitted after the deadline and cannot participate in the annual process previously described. Some demand for train paths might not yet be apparent during the application period and the ad-hoc process should cover these late requests. The train paths in the ad-hoc process are then dealt with on a first-come-first-served basis and doesn't change any of the already planned and published train paths.

The European Union strongly advocates a fair competition on the tracks by the First Railway Directive, i.e. to let operators compete for conflicting train paths on equal and fair conditions. According to Eliasson and Aronsson (2014), there are some problems regarding the fair competition in the current timetabling process. The main issue concerns the priority criteria used to obtain a value of the train paths in disputes. The infrastructure manager is completely dependent on correct and honest information from the operators. By design, some properties may be exploited. As an example, a train travelling a longer distance has a higher value than other trains travelling shorter distances. This can be used by an operator to obtain a higher value on the requested train path by prolonging the transport a few kilometers. If two train paths in a dispute are to be operated by trains attracting similar markets, the outcome of the priority criteria cannot provide any good guidance and the consequence is a capacity allocation lacking transparency. To achieve a perfect competition, the conditions need not only be equal, but also be completely transparent to all operators.

Eliasson and Aronsson (2014) also address the problem of the different preferences of the operators. Passenger train operators must know their timetable well in advance, so they can sell tickets. Freight train operators may not know by the application deadline when or between which stations a transport should be arranged. They must then settle with submitting an application in the ad-hoc process and adjust to the already planned timetables. The subsequent sections describe a new approach addressing these issues.

1.2. Suggested timetable planning process

Eliasson and Aronsson (2014) propose a new approach for timetable planning consisting of four subprocesses. These are:

Framework agreement: A framework agreement can be concluded between the infrastructure manager and an operator. The agreement consists of a contract for operating train according to a specific departure pattern during a period (for instance having a departure each 20th minute between 7:00 and 9:00). Deviations from the departure pattern are allowed. The maximum allowed deviation is also stated in the contract. This allows some flexibility for the infrastructure manager, since there is no possibility to know how other operators want to plan their train paths. This contract is valid for a longer period of for instance five years. State-subsidised traffic is only allowed to conclude framework agreements since they are financially stronger than commercial traffic and thus should be excluded from the auctions and spot market described below. To investigate the economical aspects of capacity utilisation, the value

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