Train delays in the scenario of switch failures

A case study of Höör station

Master thesis:

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Abstract

Punctuality and delays within the railway system are of utmost concern in today's society. With an infrastructure in a dire need of maintenance and the increasing pressure for environmentally friendly transportation solutions, punctuality and accessibility within the railway system becomes crucial. With an overall punctuality rate of approximately 90%, there is much to be improved. One of the problems within infrastructure is switches and crossings (S&C). In 2017, switches accounted for 21% of all delays, costing society millions of Swedish crowns each year in socio-economic costs.

The purpose of this thesis is to examine how late trains become when a switch fails and if there are any contributing factors to these delays. This is done by analyzing delay data and creating linear and logistic regressions.

Delays can be analyzed in several different ways. One way is to measure punctuality, which shows how many trains have arrived on time at their final destination. Another way is to measure delay minutes. Delay minutes can be measured at all stations along the trains route, making this method advantageous in analyzing delays at a particular station. For this reason, the registered delay increase has been utilized in this thesis. The registered delay increase indicates the delay that has occurred between two stations.

The work is centered around Höör station and its switches. There are 7 switches at the site, 5 of which are directly connected to the Southern Main Line (Södra Stambanan). The station consists of two platforms with two tracks. The tracks lead north to Alvesta and Stockholm, and south to Malmö and the rest of Europe.

The data in this thesis comes from the Swedish Transport Administration (Trafikverket) and the Swedish Meteorological and Hydrological Institute (SMHI). Trafikverket's data comes from three different data systems: Lupp, Ofelia and BIS. Trafikverket's data provides delay minutes, information regarding the switches' location, type, and when, where and why they failed. SMHI's data consists of the location of weather stations, snow depth, temperature, and wind speed. The dataset consists of 1 732 825 observations, which have been analyzed and structured using SQL Server Management Studio. Additionally, the R-Studio program has been used to perform linear and logistic regressions.

The results demonstrate how certain switches contribute to large and more frequent delays, while others show the opposite. Even when some switches fail simultaneously, it leads to fewer and smaller delays than when there is no failure. The results also indicate that certain factors such as snow, wind speed, and low temperatures lead to more and bigger delays.

Some of the conclusions drawn include the need for further investigations into which switch faults result in the larger switch faults and their impact on the traffic. Similar investigations may also need to be conducted at larger stations where switches change positions more frequently than they do in Höör to better understand how switch failures affect the traffic.

Keywords: switches, delays, punctuality, railway, regression

Sammanfattning

Punktlighet och förseningar inom järnväg är något som står högt upp på agendan i dagens samhälle. Med en infrastruktur som är i ett stort behov av underhåll samtidigt som trycket på klimatsmarta transportlösningar bara ökar, blir punktligheten och framkomligheten inom järnvägen avgörande. Med en total punktlighet på ungefär 90% finns det mycket att göra. En av järnvägens infrastrukturproblem är spårväxlar. 2017 stod spårväxlar för 21% av alla förseningar vilket kostar samhället miljontals kronor varje år i samhällsekonomiska kostnader.

Syftet med examensarbetet är att se hur sena tåg blir när en spårväxel går sönder och om det finns några faktorer som bidrar till dess förseningar. Det görs genom att analysera förseningsdata och skapa linjära och logistiska regressioner.

Förseningar kan analysera på flera olika sätt. Ett sätt är att mäta punktligheten, vilket visar hur hur många tåg som har ankommit i tid till sin slutdestination. Ett annat sätt är att mäta förseningsminuter. Förseningsminuterna kan mätas vid alla stationer längs tågets väg vilket gör den metoden fördelaktig vid analys av förseningar vid en station. Av den anledningen är det merförseningar som har använts i detta examensarbete. Merförseningen ger den förseningen som har uppkommit mellan två stationer.

Arbetet är utformat kring stationen i Höör och dess växlar. På platsen finns det 7 växlar, varav 5 av de är direkt kopplade på Södra stambanan. Stationen består av två plattformar med två spår. Norrut leder spåren mot Alvesta och Stockholm och söderut leder spåren mot Malmö och resten av Europa.

Datan som har använts i examensarbetet kommer från Trafikverket och SMHI. Datan från Trafikverket kommer från tre olika datasystem Lupp, Ofelia, och BIS. Trafikverkets data tillhandhåller förseningsminuter, information angående växlarnas lokalisering, typ och när, var hur och varför de gick sönder. SMHI:s data består av lokalisering av väderstation, snödjup, temperatur och vindhastighet. Datamängden består av 1 732 825 observationer och med hjälp av SQL-Server Management Studio har den analyserats och strukturerats. Även programmet R-Studio har använts för att göra linjära och logistiska regressioner.

Resultatet visar på hur vissa av växlarna bidrar till större och fler förseningar medan andra växlar visar på motsatsen. Även när vissa växlar går sönder samtidigt leder det till mindre och färre förseningar än när inga växlar är trasiga. Resultatet indikerar också på att vissa faktorer som snö, vindhastighet och låga temperaturer leder till fler och högre förseningar.

Några av de slutsatser som har kunnat dras är att det behövs djupare undersökningar kring vilka växelfel det är som ger upphov till de större växelfelen och vad påverkan blir på trafiken av de. Liknande undersökningar kan även behövas göra på en större station där det finns växlar som byter läge oftare än vad de gör i Höör för att bättre kunna se hur växelfelen påverkar trafiken.

Nyckelord: spårväxlar, förseningar, punktlighet, järnväg, regression

Preface

This thesis has been produced during the spring of 2024. It has been the last part of my education within civil engineering at Lunds Tekniska Högskola. The subject has been drafted by myself and my supervisors Grace Mukunzi and Carl-William Palmqvist.

I would like to thank everyone that has helped me with the writing of this thesis. A big thank you to my main supervisor Grace Mukunzi for giving me your time and effort to guide me through different programs and writing techniques. I would also like to thank my other supervisor, Carl-William Palmqvist, for answering all my questions about the Swedish railway system and guiding me throughout the thesis. Also, a big thank you to the railway group for giving me a place to sit and compose this thesis and for making me feel like a part of your research group.

Lund, May 2024

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1. Introduction

Transportation of people and goods stands for around 5% of the European Unions (EU) total gross domestic product (GDP) and it is estimated that every household spends on average 13.2% of their budget on transport goods and services (EU, n.d.-b). Therefore, an effective transportation system benefits both the individual but also companies and countries (AASHTO, 2021). Apart from the economic benefits of an effective transport system, there are other benefits, like reduced pollution and reduced transportation time (Simons, 1992). As of 2020, road transport stood for 24% of the EU's total emissions of carbon dioxide (CO_2) (EU, 2023a). Trains on the other hand runs, for most parts in Europe, on electricity (EU, n.d.-a). Within the EU, around 39.4% of the electricity production comes from renewable sources, 21.9% from nuclear power, and 38.7% from fossil fuels (EU, 2023b). In Sweden, 71% of the electricity production comes from renewable sources and the other 29% comes from nuclear power (SCB, n.d.). The carbon footprint for trains is thereby low in Sweden compared to other modes of transportation. In a comparison between trains, cars, and planes, trains require 0.071 kWh/pkm while cars require 0.30 kWh/pkm and short haul planes require 0.60 kWh/pkm (Åkerman, 2011). Since all of Sweden's electricity production comes from non-fossil fuels, the train is the mode of transport in which the carbon footprint is the lowest. Because of the environmental benefits with train rides, the numbers of trains and the amount of train passengers has increased significantly during the last 30 years.

Between 1990 and 2017, passenger journeys with trains had increased by 102 % and the number of trains by 120%, while the capacity stayed at the same level in Sweden (Nelldal et al., 2018). With the increased number of passengers and trains, the demands for an efficient and safe railway have risen. One way to measure the efficiency of the railway is to measure the punctuality (Trafikverket, 2018). As of 2022 the punctuality was at 90,1 percent for passenger trains and 73,2 percent for freight trains in Sweden (Trafikverket, 2023a). One of the reasons to measure punctuality is to be able to set up goals to strive for. In Sweden the goal is to have a punctuality of 95% for freight trains and passenger trains (Trafikverket, 2022). The goal is set by a trade association called "Tillsammans för tåg i tid" (TTT) in which the Swedish transport administration (Trafikverket) is project leaders. In 2019, infrastructure failures stood for almost 19 percent of all the delays (Pettersson, 2020). The other 81% were caused by operation management, accidents and outside factors, railway operators, and consequential causes.

This points towards the commonly known problems with maintaining the railways standards over the last decade. In a report from the Confederation of Swedish Enterprise (Svenskt Näringsliv), the accumulated maintenance debt for road and railway was 77.5 billion Swedish crowns in 2023 (Svenskt Näringsliv, 2023). This has led to a big debate on where the money goes and with an increased interest in train travels, the advocacy for a more robust and safer railway has increased. Trafikverket owns 91% of the Swedish railway network and are the ones responsible for maintaining and keeping the railway up to date, meaning that they are mostly responsible for the infrastructure problems in Sweden (Trafikverket, 2024). In 2023, Trafikverket spent 7.2 billion Swedish crowns on maintenance on the railway system (Sundh & Canaki, 2024). In order to decrease that number, Svenskt Näringsliv predicts that the budget on maintenance needs to be increased by 31% (Svenskt Näringsliv, 2023). Even when doing so, it would take at least 11 years before the debt was settled, provided that the cost for maintenance stays on the same level. Exceptionally, back in 2009, switches and crossings (S&Cs) stood for 13% of the total maintenance cost (Nissen, 2005). With the same percentage today, it would mean that S&Cs costs about 936 million in maintenance costs every year. Moreover, when a train is delayed, it doesn't affect just one person or company. Only between

Hässleholm and Älmhult, which is 54 km long, the cost for delays connected to switch failures were about 3 billion Swedish crowns between 2013 and 2016 (Tosovic & Hua, 2017). Between 2017 and 2021, there was 48 532 incidents recorded in Sweden where a switch had failed (Mukunzi & Palmqvist, 2024). That means almost 10 000 incidents every year and since there are 10 600 switches in total in Sweden, the number of incidents per switch per year is high (Trafikverket, 2023b). With switches only standing for 5.5% of the total track length and with 13% of the maintenance cost and 10 000 incidents every year, it shows that something needs to be done (Fuqing, 2011).

With a lot of switch failures comes a lot of problems in the infrastructure. First and foremost, it costs a lot of money to keep repairing and replacing the switches, but it also causes disturbances in the traffic. During reparation, removal, or installation of a switch, the track cannot be used causing a disturbance in the traffic flow. Depending on the severity of the failure, tracks might have to be closed or the speed limit needs to be lowered over the switch before the reparation can happen. It can also make it impossible to direct trains onto their right path which is the main purpose of a railway switch. Some people, like Palmqvist (2019), argues that the number of failures and the negative effects of the traffic flow can be lowered if the total number of switches are lowered. He means that a lower number of switches will make it easier to keep the remaining switches up to date and to make sure that they are functional. The negative side of a low number of switches, is that it makes it harder to adjust and create alternative paths for the trains. The risk for there being a delay also increases since the redundancy of the system and station is compromised. With fewer alternate routes than usual, the ability to divert trains into different tracks is being reduced which causes the redundancy to be compromised.

1.1 Aims

The goal and aim of this thesis is to get an understanding of how switch failures effects delays and if they do, by how much and which factors that contributing to the failures.

1.2 Research questions

The research questions are as follows:

1. Does the failure of different railway switches impact the delays of trains?
2. Which factors are affecting the delays of trains and by how much are they affected?

Research question number 2 is used as a control to make sure that research question number 1 gives a realistic result.

1.3 Limitations

The data included in this thesis is based out of one station in southern Sweden, called Höör. The timeframe of the data collection ranges over a period between 2001-06-17 and 2020-11-01. The thesis does not look into how different switch types affects the delays or how the severity of failures affects the delays or its factors.

2. Background

Switches are important components of the infrastructure within the railway system. They are used to divert trains onto other tracks and directions. This chapter is meant to give the reader a background in what a switch is and how it connects to punctuality.

2.1 Delays and punctuality

Delays and punctuality can be defined and described in different ways. In Sweden, a train is on time to its final destination if it arrives no more than 5 minutes and 59 seconds after the scheduled arrival at their final destination (Kristoffersson, 2019). There are some voices, like Palmqvist, that argues that early trains should also be accounted as unpunctual for being early since they are not in their designated time slot, causing disturbances in the traffic flow (Palmqvist, 2019). In order to know why a train is delayed, every time a train passes a station the time is clocked and compared to what the scheduled time is. If the delay is more than 3 minutes, a code is determined. The code is divided into three different levels and each level describes what happened with a different number of details (Trafikverket, 2021a). The code, the date, the delay in minutes, which train that was delayed and the location of the delay is stored in a database called LUPP. Trafikverket are the ones who's responsible for coding and updating the database (Trafikverket, n.d.-b). However, as Palmqvist shows, most of the delays for passenger trains are small delays, under 3 minutes, and are therefore not coded (Palmqvist, 2019). When adding them up, the delay can become quite severe. This makes it hard to follow up and see what the reasons for the delays are. In Palmqvists doctoral thesis, he shows that most of these delays occurs at the station when alighting and boarding passengers happens (ibid). Infrastructure problems are not showed to have as big of an impact as the dwell delays when it comes to the small delays, but with delay increases that are over 3 minutes, infrastructure failures are a contributing factor to the delays.

Delays can be divided into primary delays and secondary delays. Primary delays are delays that occur because of a failure or incident, as described by Palmqvist, Johansson, and Sipilä (Palmqvist et al., 2023). They continue to describe how secondary delays are the delays occurring when the trains are being delayed because there is another delayed train in front of them. Another term for secondary delays is knock-on delays, i.e. delays that occur because of another delay. The authors saw that secondary delays stood for 64% of all delays and primary delays stood for 36%. This means that trying to reduce the primary delays by 1 minute would almost triple the effect because there are no secondary delays without a primary delay.

When describing how well the punctuality is, the most common method used is by calculating the number of trains that are on time and dividing them by the total number of trains (Nelldal et al., 2018). Since punctuality only measures if the train is on time at its final destination, it does not show how the train runs compared to the timetable when the train is on the line. For the passenger, the punctuality is the measurement that matters since they are only interested to arrive at their final destination on time. For them it does not matter if the train loses 1 or 2 minutes between two stations, as long as they arrive on time.

2.2 Switches and crossings

Switches and crossings are a part of the infrastructure and a big component in the railway system. They are used to connect two tracks so that the train can be guided to the right track and destination (Zwanenburg, 2008) The number of switches on a station varies from just a couple to several hundred on the biggest ones (Trafikverket, 2019). This means that when a switch fails, the impact on the railway system can be huge. Between January 2017 and October 2018 switch failures stood for 21 percent of the delay minutes connected to infrastructure failures (Kristoffersson, 2019). A study by Palmqvist et al. (2020), found that there is a quadratic relationship between punctuality and the number of switches, and by limiting the number of switches at a station, the punctuality increases disproportionately. This corresponds to a study by Malavasi & Ricci (2001), in which the authors found that a reduction in the number of switches at their studied station led to a decrease by 10% for the number of delayed trains.

Switches consists of several both big and small parts which is contributing to its complexity. Figure 1 gives an insight in how a typical switch looks like.

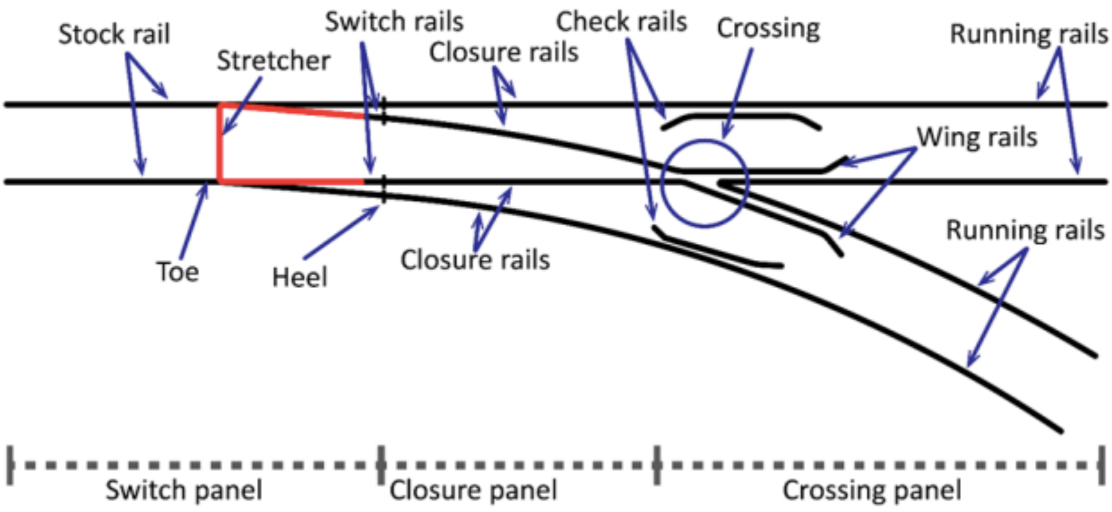

Figure 1. Layout of a typical switch. Source: Mukunzi & Palmqvist, 2023

The switch in Figure 1 consists of 3 major parts: the switch panel, the closure panel, and the crossing panel. It is the switch panel that enables the diversion between the two tracks, and it is composed of seven sub-systems, i.e. the slide baseplates, the stretcher bar, the stock rail, the ALD (Actuation, Lock & Detection) device, and the Sole/Base & Anchor plates (Mukunzi & Palmqvist, 2023). The closure panel connects the switch panel and the crossing panel with the closure rails. The crossing panel consist mainly of the crossing components. Other parts that are including in the buildup of a switch is: the track support (slab/ballast), the fastening system, and sleepers/bearers. Evidently, these components that are being described are for a typical switch but there are multiple types that has different components and design. Some of the parts in a switch are more likely to fail than others and some are harder to repairer than others. More than half of all switch failures is caused by the stretcher or the squats (Grossoni et al., 2021). A squat is a metal fatigue which causes surface defects on the rail. Furthermore, 80% of all the switch failures are caused by 6 different failure types. A big reason for why switches are subject to failing, is the high number of interlinking mechanical and electrical components (Litherland & Andrews, 2023). Litherland and Andrews also concluded that the bigger the switch is by size, the higher the turnout was for failures. Another study by Rama and Andrews, showed that ineffective maintenance had a big impact on early life failures for switches (Rama & Andrews, 2013).

When deciding which kind of switch to use at a station, the speed of which the trains should be able to have over the switch is an important factor. With a higher allowance of speed for the switches, the higher the risk is for switch failures (Hamadache et al., 2019). With a higher speed allowance, the bigger the radius and length of the switch is needed which causes the switch to be more prominent to breakdowns. In Sweden, there are about 11 different types of switches being used, with each type having different lengths and radiuses (Trafikverket, 2021b). They are divided into categories depending on their design and function. There are simple switches, cross switches, symmetrical switches, and more. The radius of a switch depends on which types of trains that are supposed to pass the switch and their speed. The bigger the radius is, the higher speed over the switch can be allowed for the trains. In Sweden, the railway tracks that are being used are for most parts used by all different kinds of train, both different passenger trains with different speeds and freight trains. For this reason, when deciding what kind of switch to use and with which radius, it is the landscaping and the design of the track that are the primary factors in Sweden.

3. Case description

Höör was selected as the target of the case study because of its location and amount of traffic passing the station. The station is located on the "Södra stambanan" which is one of the major train lines in Sweden. With mixed traffic (both freight and passenger trains) passing the station, it made a good fit for the study. Södra stambanan is one of the four most important routes within the Swedish railway system and connects Stockholm with Scania and southern Europe (Honauer & Ödeen, 2022; Sköld & Solinen, 2018).

Höör is located in the region of Scania, in the southern part of Sweden. The station in Höör was opened in 1858 and the first train arrived on the 4th of October (Höör kommun, n.d.). Since Höör is located in the center of Scania, it was suitable location to place a train station on the Södra stambana with its connection to the rest of Sweden and Europe. Höörs connection to Scania, Sweden and the rest of Europe is showed in Figure 2.

Figure 2. A map over Scania with all railway routes. Source: Trafikverket.

In Figure 2 Höör is located in the middle, between Stehag and Tjörnarp, along the Södra stambana. Höör as a city is also linked to road route 13 that connects Ystad with Ängelholm, and route 23 that connects Europe road E22 north of Lund and Linköping.

The layout of the tracks at Höör is showed in Figure 3.

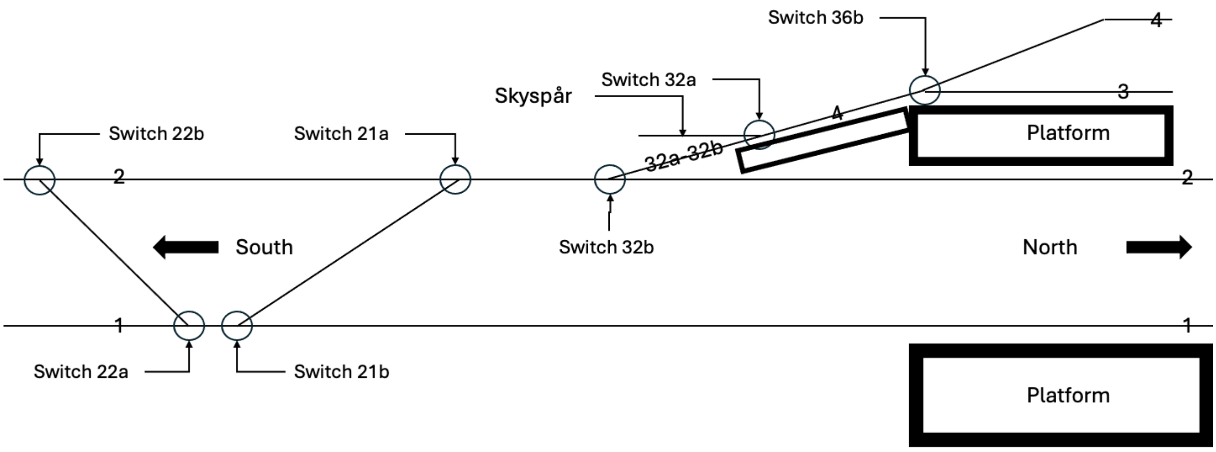

Figure 3. Track layout at Höör (figure is not to scale).

Switch 21a, 21b, 22a, 22b and 32b is connected to the two main tracks, numbered 1 and 2. Track number 1 is for trains heading south and track number 2 is for trains heading north. Switch 36b is connected to track 3 and 4 and switch 32a is connected to track 4 and a track called "skyspår". Track 3 is used for trains that has Höör as their end station or start station. In rush hour, trains has Höör as their start station once every hour. The same goes for the trains that has Höör as their end station. These trains are local commuting trains called Pågatåg, and stops at most stations. The timetable for passenger trains that are starting or ending in Höör can be found in the attachment. Track 4 and skyspår is a sidetrack used to divert trains if necessary. The switches at Höör are the type of EV, shortened for "Enkel Växel" which is translated to *simple switch*. The switch type for each switch at Höör is presented in Table 1.

Table 1. Switch names for all switches at Höör. Source: NJDB (Nationell järnvägsdatabas), Trafikverket.

Switch number	Switch name
21a	EV-60E-1200-1:18,5 rak
21b	EV-60E-1200-1:18,5 rak
22a	EV-60E-1200-1:18,5 rak
22b	EV-60E-1200-1:18,5 rak
32a	EV-BV50-225/190-1:9
32b	EV-UIC60-300-1:9
36b	EV-SJ50-11-1:9

Switch 21a, 21b, 22a, and 22b all have the same switch type as presented in Table 1. EV stands for simple switch, 60E says that the switch is of a newer type of simple switch and that it is a 60-kilo rail (weight per meter), 1200 is the radius of the switch, and 1:18,5 rak is the angle and "rak" means straight in Swedish (Ebelin & Elmström, 2014). UIC60 is an older switch type but of a 60-kilo rail. BV50 is also an older switch type but with a 50-kilo rail instead and so is the SJ50 switch.

4. Overview of data

This chapter provides an overview of the data and the different factors that are being analyzed in this thesis. The data comes from four separate systems provided by Trafikverket and the Swedish Meteorological and Hydrological Institute (SMHI). The dataset consists of 1,732,825 data points during the specified time frame, in which one point represents one train over the time frame of the thesis.

4.1 Lupp

Lupp is a database that stores traffic and facility information (Trafikverket, n.d.-b). It’s used to extract statistics about punctuality, different disturbances, and information about the facilities conditions on the Swedish railway network. Every time a train passes a station, the time is noted and compared to the time of the timetable. If the train is more than 3 minutes delayed, a code will be issued, explaining what’s causing the delay (Hedman & Svensson, 2020). In this thesis, the data used from Lupp consists of the points showed in Figure 4 and Figure 5. Even though both these figures come from Lupp, they are saved separately in SQL and needs to be put together which is why they are showed like this.

Results | Messages

	Date_started	Sch_time	Act_time	Delay	Train_id	Station_name	Station_signature	Registered_delay_increase
1	2020-01-13	2020-01-13 12:03:00.000	2020-01-13 12:01:00.000	-2	8190	Kopparberg	Kpg	0
2	2020-01-13	2020-01-13 13:55:00.000	2020-01-13 13:54:00.000	-1	8192	Kopparberg	Kpg	0
3	2020-01-13	2020-01-13 14:00:00.000	2020-01-13 14:00:00.000	0	8192	Kopparberg	Kpg	0
4	2020-01-13	2020-01-13 19:22:00.000	2020-01-13 19:22:00.000	0	8174	Forsbacka	Fb	0
5	2020-01-13	2020-01-13 19:33:00.000	2020-01-13 19:31:00.000	-2	8174	Gävle c	Gä	0
6	2020-01-13	2020-01-13 17:46:00.000	2020-01-13 17:47:00.000	1	8174	Rämshyttan	Rmh	0
7	2020-01-13	2020-01-13 17:59:00.000	2020-01-13 17:59:00.000	0	8174	Sellnäs	Slnä	0
8	2020-01-13	2020-01-13 20:24:00.000	2020-01-13 20:30:00.000	6	8176	Forsbacka	Fb	0

Figure 4. Raw data from Lupp.

The headline in Figure 4, “Date_started”, is the date when a certain train ran and passed a specific station.
“Sch_time” is when the train was scheduled to arrive at a specific station.
“Act_time” is the actual time that the train passed a specific station.
“Delay” is the deviation in minutes between the actual time and the scheduled time.
“Train_id” is the number the train is given for each specific day.
“Station_name” is the name of the specific station that the train passes.
“Station_signature” is the shortening of the station name.
“Registered_delay_increase” is how many more minutes the train is delayed when passing a specific station.

The first row in Figure 4 is interpreted as: train id 8190 passes a station called Kopparberg on 2020-01-13. The train was scheduled to pass the station at 12:03 but the actual time it passed was at 12:01, indicating that the delay is -2 minutes. The registered delay increase was 0 minutes, meaning that the train didn’t lose any time between the station before Kopparberg and Kopparberg station.

Results | Messages

	Date_started	Train_id	Train_type	Train_subtype
1	2009-11-24	9782	Godståg	FJÄRR
2	2009-11-30	5655	Godståg	FJÄRR
3	2008-12-23	87564	Tjänstetåg	-
4	2009-09-23	4004	Godståg	FJÄRR
5	2009-01-19	41690	Godståg	FJÄRR
6	2009-10-18	1443	Resandetåg	PENDEL

Figure 5. Raw data from Lupp.

The headline in Figure 5, “Date_started”, is the date when a certain train ran and passed a specific station.
“Train_id” is the number the train is given for each specific day.
“Train_type” describes what sort of train that is connected to the train id. The different train types are: “Godståg” = freight train, “Tjänstetåg” = empty train, “Resandetåg” = passenger train, “Växlingsrörelse” = when the engine has to move from one side of the train to other, also called shunting trains in english, and “vagnuttagning” = when a train leaves a station and goes out on the line but then returns to the same station.
“Train_subtype” describes how far the train travels. The different train subtypes are: “Fjärr” = long distance, “Pendel” = commuter train, “System” = systematic trains, “Flyg” = direct trains between airports and major city, “Combi” = are freight carts that can be transported on trucks and trains “Gods” = freight, “Post” = mail trains, “Region” = regional trains, “Snabb” = high speed train, and “Övr” = other types.

The fourth row in Figure 5 is interpreted as: train id 4004 on the 23rd of September is a long-distance freight train.

4.2 Ofelia

Ofelia is a data system that collects all the failures, disturbances or incidents within the infrastructure (Trafikverket, n.d.-c). It is used to analyze length, causes, actions and severity of failures and disturbances within the network. In this thesis, the data used from Ofelia consists of the points showed in Figure 6.

Results | Messages

	Anmält_FR	Anläggningsindivid_FR	Anläggningstyp_BVS	Anläggningsdel_BVS	Platsnamn_från_G	Platsnamn_till_G	Avslutat_FR
1	2016-01-10 23:04:00.000	810	Spårväxel	Växelvärme	Garsås	Garsås	2016-01-12 07:49:00.000
2	2016-01-10 23:07:00.000	323a	Spårväxel	Tunganordning	Huvudsta	Huvudsta	2016-01-11 00:02:00.000
3	2016-01-10 23:20:00.000	-	Djur i spår	Djur i spår	Säter	Gustafs	2016-01-19 06:51:00.000
4	2016-01-10 23:19:00.000	M 61 Kur 7	Balisgrupp	Balis	Stockaryd	Stockaryd	2016-02-01 14:17:00.000
5	2016-01-10 23:36:00.000	323a	Spårväxel	Växelvärme	Huvudsta	Huvudsta	2016-01-11 10:31:00.000
6	2016-01-10 23:39:00.000	-	Djur i spår	Djur i spår	Kalixfors	Råtsi	2016-01-11 10:10:00.000
7	2016-01-11 00:00:00.000	M 161	Signal	Signallampa	Varberg	Varberg	2016-01-11 07:58:00.000
8	2016-01-11 00:02:00.000	105	Spårväxel	Omläggningsanordning	Katrineholms c	Katrineholms c	2016-01-11 01:17:00.000
9	2016-01-11 00:06:00.000	322, 326	Spår	Spår	Stockholm C	Stockholm C	2016-01-11 05:24:00.000

Figure 6. Raw data from Ofelia

The headline in Figure 6, “Anmält_FR”, is when a failure or disturbance in the infrastructure is reported.

“Anläggninsgindivid_FR” is the individual name or number of the facility.
“Anläggninsgtyp_BVS” describes what facility type that has failed or is being disturbed within the infrastructure.
“Anläggningsdel_BVS” describes which part of the facility type that has failed or is being disturbed.
“Platsnamn_från_G” is from which station the failure or disturbance is being noticed.
“Platsnamn_till_G” is to which station the failure or disturbance is being noticed.
“Avslutat_FR” is when the case is reported as finished.

The first row in Figure 6 is interpreted as: on 2016-01-20 at 23:04 a failure at switch number 810 was reported. It’s the exchange heater on the switch that failed. The switch is located in Garsås and it was fixed on 2016-01-11 at 03:34 and its individual number is 810.

4.3 BIS

BIS is a data base that describes where different parts and sections of the infrastructure is located (Trafikverket, n.d.-a). It is used to extract information about the infrastructures different section and parts and where on the track they are located. In this thesis, the data used from BIS consists of the points showed in Figure 7.

Results | Messages

	spår	Växelnr	Växeltyp	placefrom	placeto
1	z1,z10	i10	3V-SJ50-5,9-1:10/1:9 fram	Västerås norra	Västerås norra
2	z100,z103	i1	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
3	z100,z104	i3	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
4	z104,z105	i4	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
5	z105,z109	i6	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
6	z105,z106	i8	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
7	z106,z108	i10	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central
8	z106,z107	i11	EV-XX00-OKÄND TYP	Borlänge central	Borlänge central

Figure 7. Raw data from BIS.

The headline in Figure 7, “spår”, is the track numbers that the switch connects.
“Växelnr” is the number of the switch.
“Växeltyp” is the name of the switch type.
“placefrom” is from which station the switch starts.
“placeto” is the station name of where the switch ends.

The first row in Figure 7 is interpreted as: switch number i10 is of the type 3V-SJ50-5,9-1:10/1:9 fram and it’s located in Västerås norra on between track z1 and z10.

4.4 Weather

The weather data comes from SMHI which is a data system that describes different weather situations on the Swedish railway track. In this thesis, the data taken from SMHI consist of the points showed in Figure 8, Figure 9, Figure 10, and Figure 11. The different types of weather data are used as a control of the result. Temperature, snow and strong winds are proved to impact delays in a negative way and they can therefore give a good indication whether the result is valid or not.

	Station_name	Station_number	Date	temp_avg	temp_max	temp_min
1	Barkåkra	62180	2002-08-08	18,6	24,4	12,5
2	Hörby A	53530	2017-08-01	18,1	23,8	14
3	Sturup	53300	2020-09-11	11,9	17,1	5,8
4	Helsingborg A	62040	2012-09-27	12,3	14,8	11,2
5	Hörby A	53530	2012-11-30	-1,2	-0,1	-4,7
6	Skillinge A	54290	2002-02-08	5,8	8,3	3,7

Figure 8. Temperatures at each weather station.

The headline in Figure 8, "Station_name", is the name of the weather station.
"Station_number" is a unique number for a specific weather station.
"Date" is the date of when the temperature was recorded.
"temp_avg" is the average temperature in Celsius during the specific day.
"temp_max" is the maximum temperature in Celsius recorded for that specific day.
"temp_min" is the minimum temperature in Celsius recorded for that specific day.

The first row in Figure 8 is interpreted as: At Barkåkra station, with station number 62180, on the 8th of August 2002, the average temperature was 18.6 °C with a maximum temperature of 24,4 °C and a minimum temperature of 12.5 °C.

	weather_station_id	datum	snowdepth
1	72080	2000-01-21	0,02
2	72080	2000-01-22	0,02
3	72080	2000-01-23	0,02
4	72080	2000-01-24	0,03
5	72080	2000-01-25	0,03
6	72080	2000-01-26	0,02

Figure 9. Snow depth at each weather station.

The headline in Figure 9, "weather_station_id" is the given number for a specific weather station.
"datum" is the date of when the snow depth was recorded.
"snowdepth" is the snow depth in meters at the specific weather station.

The first row in Figure 9 is interpreted as: At station number 72080, on the 21st of January 2000, the snow depth was 0.02 meters, or 2 centimeters.

The closest weather station to Höör which measures snow depth did not record every day during the time frame that is being investigated, resulting in the need of Figure 10, where the train station is connected to a weather station.

	lupp_station	relevant_day	weather_station	distance_km	weather_station_id
1	Korpklev	2000-01-01	Vimmerby	32,3461954208063	75400
2	Korpklev	2000-01-02	Vimmerby	32,3461954208063	75400
3	Korpklev	2000-01-03	Vimmerby	32,3461954208063	75400
4	Korpklev	2000-01-04	Vimmerby	32,3461954208063	75400
5	Korpklev	2000-01-05	Vimmerby	32,3461954208063	75400
6	Korpklev	2000-01-06	Vimmerby	32,3461954208063	75400

Figure 10. Weather stations that measure snow depth.

The headline in Figure 10, "lupp_station", is the train station.
"relevant_day" is the date of when the snow depth was recorded.
"weather_station" is the name of the weather station.
"distance_km" is the distance from the weather station to the train station.
"weather_station_id" is the given number for a specific weather station.

The first row in Figure 10 is interpreted as: On the 1st of January 2000, there was a measurement of snow depth at the weather station in Vimmerby, with the station number 75400. The weather station was located 32.35 km from a train station called Korpklev.

	Station_name	Station_number	Date	wind_avg	wind_max
1	Skillinge A	54290	2015-06-13	2,2	5,9
2	Skillinge A	54290	2015-09-15	6,4	9,6
3	Hästveda Mo	63160	2015-04-07	4,2	6
4	Hästveda Mo	63160	2016-09-29	4,5	7
5	Helsingborg A	62040	2016-07-16	3,8	5,5
6	Skillinge A	54290	2016-04-10	3,6	5,2

Figure 11. Wind speeds at each weather station.

The headline in Figure 11, "station_name" is the name of the weather station.
"Station_number" is the given number for a specific weather station.
"Date" is the date of when the wind speed was recorded.
"wind_avg" is the average wind speed in m/s during the specific day.
"temp_max" is the maximum wind speed in m/s recorded for that specific day.

The first row in Figure 11 is interpreted as: at Skillinge A, with the station number 54290, on the 13th of June 2015, the average wind was 2.2 m/s with a maximum speed of 5.9 m/s.

4.5 Frequency of switch failures

Table 2 shows the number of times each switch has failed during the time frame of the thesis.

Table 2. Number of failures per switch.

Switch number	Frequency
21a	114
21b	34
22a	46
22b	11
32a	18
32b	29
36b	3
Sum	255

In Table 2, one can see that switch number 21a is the switch with the highest frequency of failures and switch number 36b is the switch with the lowest frequency of failures. Switch 21b, 22a, and 32b also has a high frequency of failures and switch 22b, and 32a are in the lower range. The five switches with the highest frequency are all directly connected to the main tracks according to Figure 3. With a sum of 255 failures, the average frequency of failures every year is more than 13 over the 19.5 years that the time frame for the thesis is. In Table 3, different scenarios are shown for if the switches have failed by themselves or if multiple switches have failed during the same time.

Table 3. The frequency of when two switches are broken simultaneously.

Broken switches	Frequency
21a + 21b	2
21a + 22a	2
21b + 22a	4
22a + 22b	2
22a + 32a	2
22a + 32b	1
22b + 32a	1

Table 3 shows how it is not very common that two switches are broken at the same time, but it still happens enough times or the length of the failures were long enough for an analysis to be made. The limitations on whether combination is counted for in the analysis is depending on how many trains that are passing the station during the failures. Therefore, the longer the failures occur, the more trains will pass, and more data will be created selected to that combination of failures. Combinations of failures in which there 3 or more failures simultaneously and other combinations of 2 simultaneously failures are not showed in Table 3 since they do not happen during the time frame of the thesis. The frequency of a single failure is not showing either since when there are two switches failing simultaneously, at least one of the switches are broken by itself at some point. If, for example, switch 21a fails on the 26th of August, 2008, at 07:00 and is fixed on the 28th of August, 2008, at 15:00, and switch 22a fails on the 27th of August, 2008, at 20:00, and is fixed on the 28th of August, 2008, at 23:00, both switches are at some point broken at the same time but they are also broken by their self at some point. There can also be cases when only one of the switches are broken by themselves at some point, which is the case if the other switch breaks and can be fixed before the first failure is being fixed.

4.6 Delays in Höör

Out of the 1,732,825 data points, 1,202,096 trains did not get a delay increase. That means that 530,279 trains did get a delay increase, or 30.6% of all trains. Figure 12 shows the frequency cumulative delay distribution for all the trains. The delays vary from 0 minutes to 740 minutes at most but after 6 minutes, the increase in percentage is too low to be visualized which is why the figure ends at the 6-minute mark. The data is of such that negative delay increases are counted as a 0 which is why the graph starts at almost 69.4%.

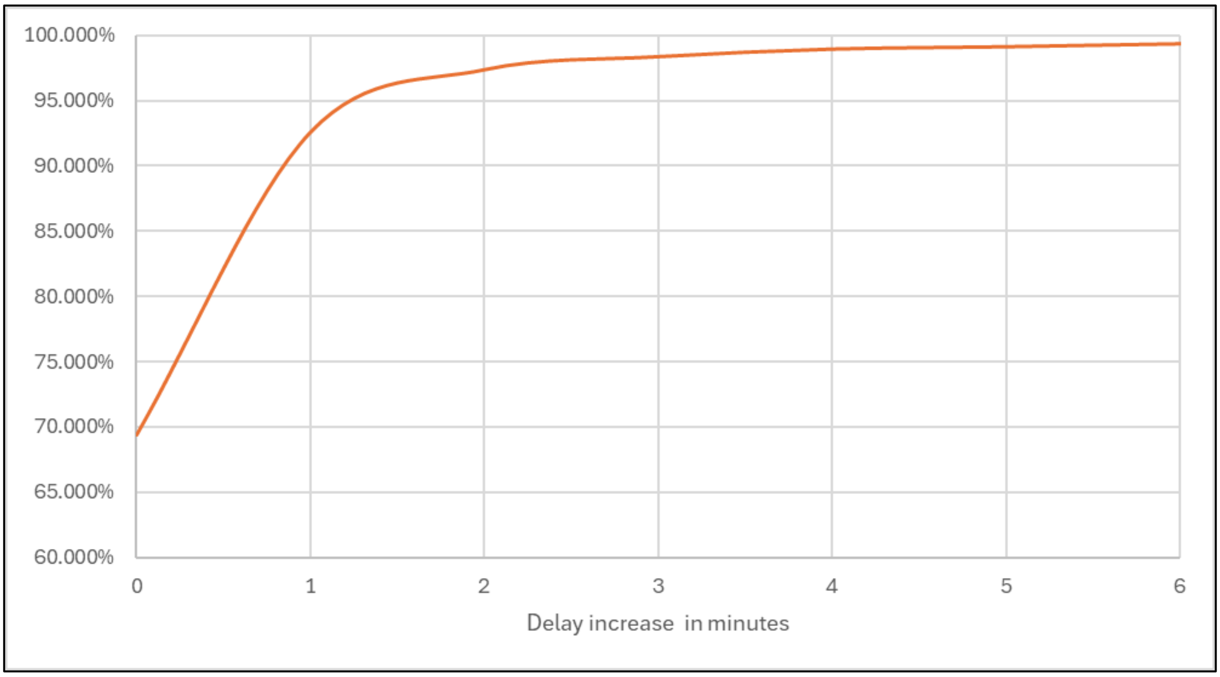

Figure 12. Shows the frequency of cumulative delay distribution for all trains passing Höör.

As can be seen from Figure 12, most delay increases are under 2 minutes which corresponds to what previous research says. Delays that are under 2 minutes stands for 91.4% of all the delays at Höör which shows how important it is to investigate those delays. Even though the delays that are under 2 minutes stands for the majority of the delays, they are not as dominate when you count the number of minutes that each delay minute has caused. To get the result of the sum of each delay minute, the delay minute is multiplied with how many times that specific delay minute has occurred. The result is showed in Figure 13.

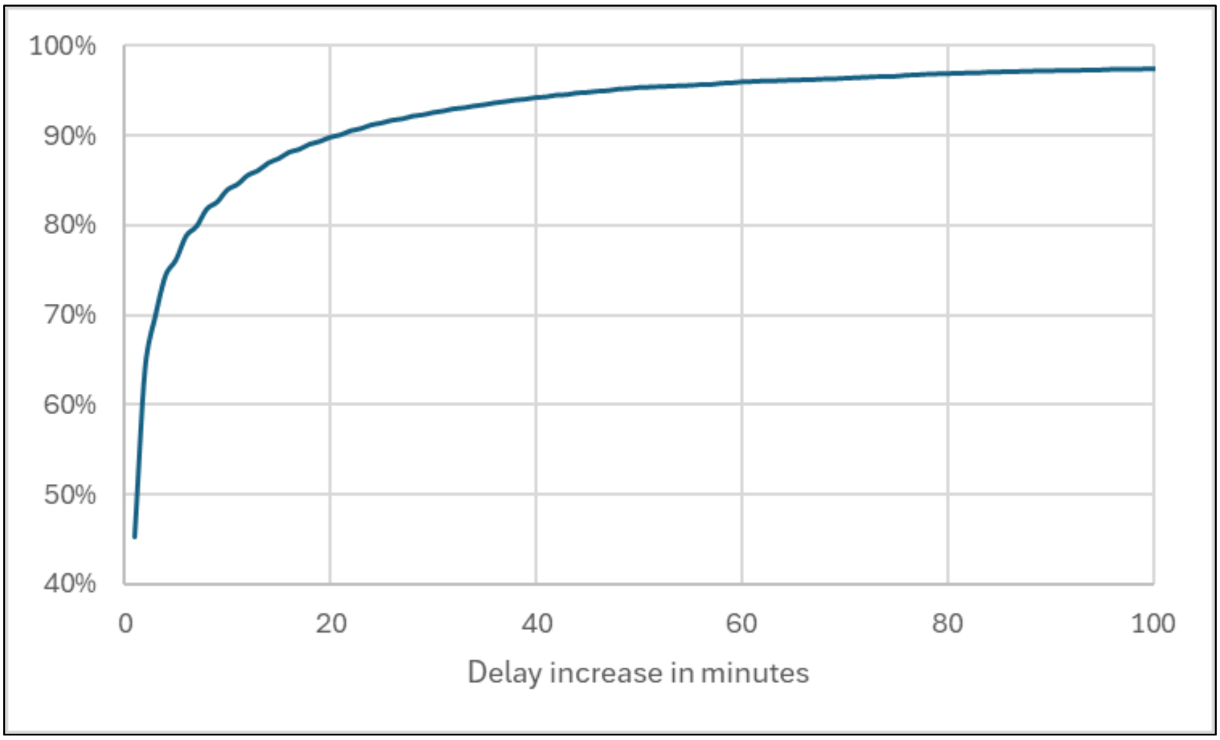

Figure 13. The cumulative delay minutes for all trains in Höör.

In Figure 13, delay minute 1 to 100 is showed which represent 97.5% of the sum of all delay minutes. Compared to Figure 12, the bigger delay minutes has a bigger impact here with delays that are over 100 minutes representing 2.5% of all delay minutes. Delay minutes 1 and 2 are still a vast majority of all the delays with 64.1% of the delay minutes.

Out of the 1,732,825 data points, 1,646,614 of them are linked to when there was no switch failure present at the station and 86,211 of them were linked to either 1 or 2 switch failures simultaneously. Percentage wise, that is 95% of all the trains that has passed Höör station without there being a switch failure and 5% when there has been a switch failure.

4.7 Weather variables

This chapter provides information about the frequency and values of the different variables that are being investigated in this thesis.

4.7.1 Snow

Figure 14 shows how often there is snow present at the weather station and how large the snow depth is.

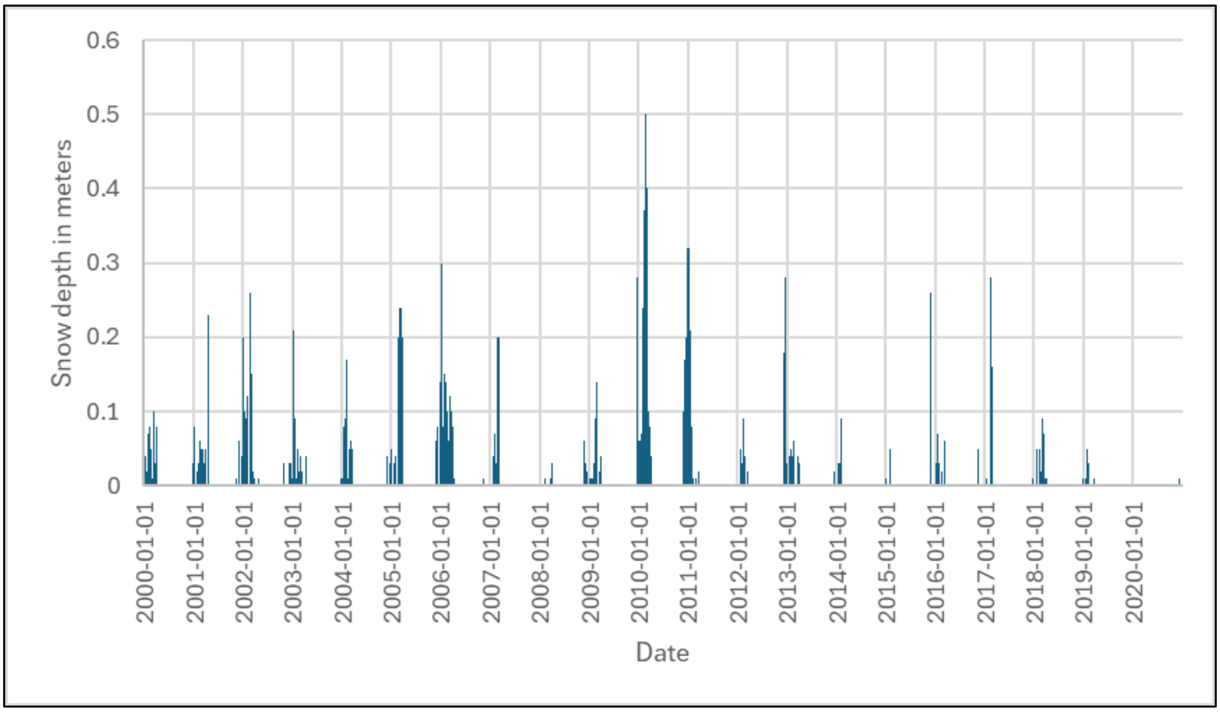

Figure 14. Measured snow depth in meters.

The time frame of the snow data ranges between 01-01-2000 and 30-12-2020. High peaks are noted during the wintertime, with a maximum depth of 50 cm on February the 20th, 2010. The low peaks are naturally recorded during the summertime when it is too warm for snow to exist. The issue with the snow data is that the closest weather station does not measure the snow depth every day, so it is the closest measured snow depth, on the relevant day, that is being used. The furthest distance was recorded on July 24th, 2006. On that the day, the closest weather station that recorded the snow depth was in Rörsbo, which is located 143 km from Höör station. Since it was in the summertime, the snow depth is most likely also 0 meters in Höör but the problem comes when it is a long distance during the wintertime, since the snow depth can differ quite a bit from place to place. The average distance over the time frame for the snow data was 46.7 km.

4.7.2 Temperature

Figure 15 shows how the average temperature differs over the time frame of the thesis.

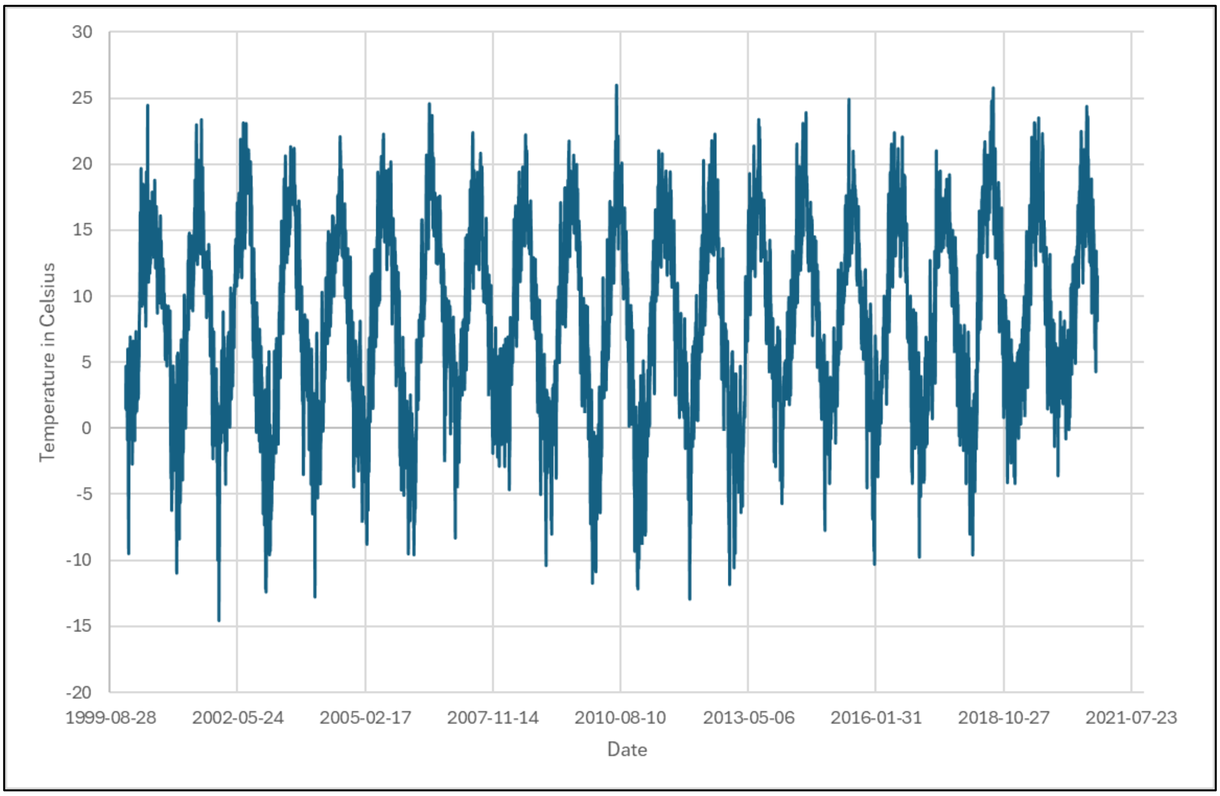

Figure 15. Average temperature at Hörby weather station.

The time frame of the temperature data ranges between 01-01-2000 and 01-11-2020. As can be seen in Figure 15, the temperature follows the seasons with high peaks in the summer times and low peaks in the winter times. The highest average temperature recorded was on July 10th, 2007, with an average temperature of 26°C. The lowest average temperature recorded was on December 31st, 2001, with an average temperature of -14.5°C.

4.7.3 Wind speed

Figure 16 shows how the wind speed differs over the time frame of the thesis.

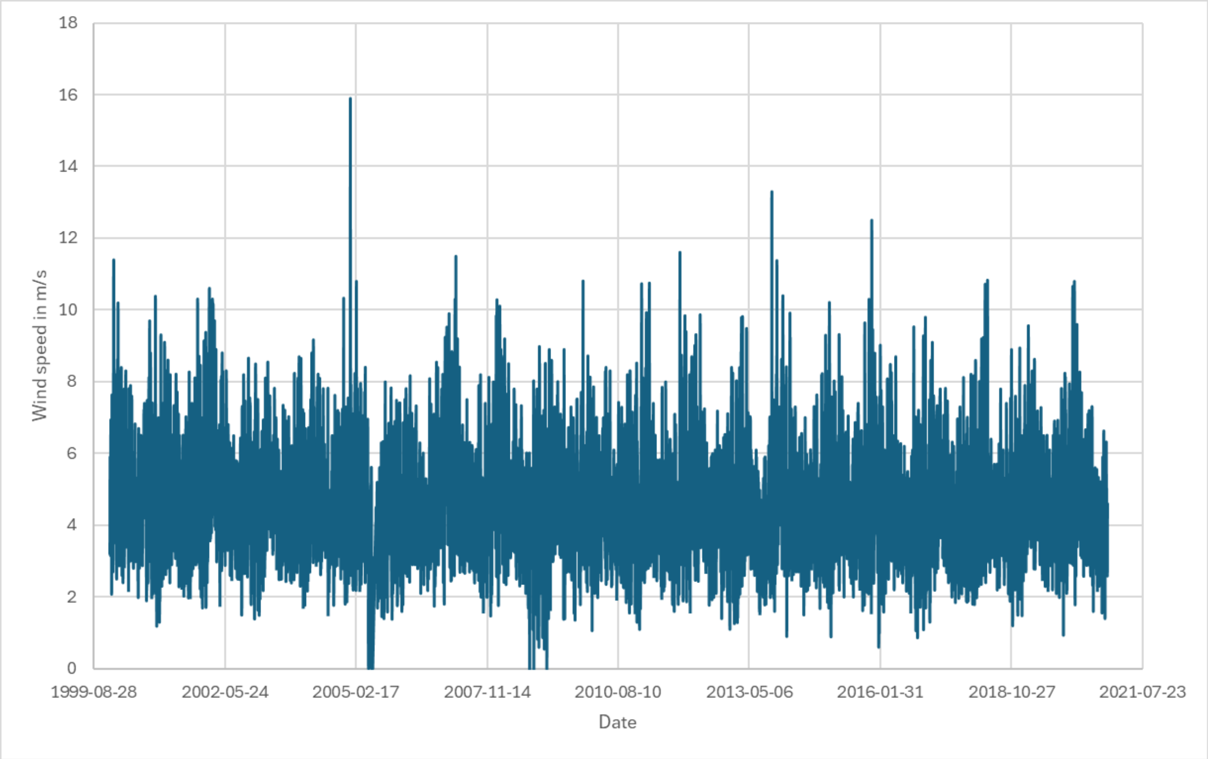

Figure 16. The maximum wind speed recorded every day at Hörby.

The time frame of the wind data ranges between 01-01-2000 and 01-11-2020. The wind speed does not have clear seasons like the temperature but the majority of the highest peaks are recorded during the wintertime. The highest wind speed recorded was on the 8th of January 2005, with a maximum speed of 15.9 m/s. On 10 different days, the maximum speed being recorded, was 0 m/s, being the lowest maximum speed over the day recorded.

5. Theory

This chapter is meant to give the reader a theoretical background to the statistical methods that are being used in the thesis. The statistical methods in this thesis consists mostly of a linear and a logistic regression. Linear and logistic regressions can predict and foresee a quantitative response. The linear regression predicts a value Y for a single predictor variable X, while the logistic regression predicts the probability for a value Y to happen to a certain X (James et al., 2021).

5.1 Linear regression

There are two majors approaches when doing a linear regression. The first approach is a simple linear regression. It uses equation 1 as a base and assumes there's an approximately linear relationship between X and Y.

$$Y = \beta_0 + \beta_1 X + \varepsilon \tag{1}$$

Here, the Y stands for the quantitative response, β_0 and β_1 are coefficients or unknown constants, X is the single predictor variable, and ε is an error term. The two unknown constants, β_0 and β_1, represents the intercept and slope of the linear model. The intercept is value of Y when X is 0 and the slope is the average increase in Y with a one-unit increase in X. The error term, ε, is used since the relationship between X and Y is most likely not exactly linear and there might be a need to add a term that catches all the misses with a simple model. The term is assumed to be independent from X. Since β_0 and β_1 is unknown, they need to be estimated and in order to do that, a data set is needed. The data set will estimate $\hat{\beta}_0$ and $\hat{\beta}_1$ by computing equation 2

$$\hat{y} = \widehat{\beta_0} + \widehat{\beta_1} x + \varepsilon \tag{2}$$

where ŷ indicates a prediction of Y on the ground of $X = x$. The hat symbol, ˆ, represents the estimated value of a parameter or coefficient, or represents the estimated value of the response. When estimating β_0 and β_1, the most common approach is the least square approach and to be able to one, a set of data is needed. Let

$$(x_1, y_1), (x_2, y_2), \dots, (x_n, y_n)$$

represent n observation pairs, in which each pair consists of a measurement of X and a measurement of Y. The goal is to get $\hat{\beta}_0$ and $\hat{\beta}_1$ to represent the data set the best way possible so that $\widehat{y_i} = \widehat{\beta_0} + \widehat{\beta_1} x_i + \varepsilon$ for $i = 1, \dots, n$. If $\widehat{y_i} = \widehat{\beta_0} + \widehat{\beta_1} x_i + \varepsilon$ is the prediction of Y based on the ith value of X, then $e_i = y_i - \widehat{y_i}$ denotes the ith residual. The residual sum of squares (RSS) can be defined as equation 3.

$$RSS = e_1^2 + e_2^2 + \cdots + e_n^2 \tag{3}$$

Which is equal to equation 4.

$$RSS = \left(y_1 - \widehat{\beta_0} - \widehat{\beta_1} x_1\right)^2 + \left(y_2 - \widehat{\beta_0} - \widehat{\beta_1} x_2\right)^2 + \cdots + \left(y_n - \widehat{\beta_0} - \widehat{\beta_1} x_n\right)^2 \tag{4}$$

In the least square approach, $\hat{\beta}_0$ and $\hat{\beta}_1$ minimizes the RSS. By doing some calculus, the minimizers can be defined as in equation 5 and 6.

$$\widehat{\beta_1} = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{5}$$

$$\widehat{\beta_0} = \bar{y} - \widehat{\beta_1}x \tag{6}$$

$\bar{y}$ and $\bar{x}$ are defined in equation 7 and 8.

$$\bar{y} \equiv \frac{1}{n}\sum_{i=1}^{n} y_i \tag{7}$$

$$\bar{x} \equiv \frac{1}{n}\sum_{i=1}^{n} x_i \tag{8}$$

In order to see if the predictor has a relationship with the response, a probability called the p-value can be determined. The p-value shows the probability that $\beta_1 = 0$, mening that if the p-value is 1, then $\beta_1 = 0$ with 100% certainty, and if the p-value is 0, then β_1 has a value that makes the relationship between X and Y a 100% correct.

The second approach, which is the one that's going to be used in this thesis, is the multiple linear regression. It uses equation 9 as a base and accommodates multiple predictors directly instead of just a single one, like the one in equation 1.

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_p X_p + \varepsilon \tag{9}$$

Here, X_j represents the jth predictor and β_j specifies the connection between that variable and the response. β_j can be interpreted as the average effect on Y with a one unit increase of X_j, when all the other predictors are fixed. β_0 is the intercept, just like in equation 1, and it is equal to the value of Y when all the X:s are 0. Here it is not only β_0 and β_1 that are unknown but β_0, β_1, …, β_p is also unknown. When given the estimates $\hat{\beta}_0$, $\hat{\beta}_1$, …, $\hat{\beta}_p$ predictions can be made using equation 10.

$$\hat{y} = \widehat{\beta_0} + \widehat{\beta_1}x_1 + \widehat{\beta_2}x_2 + \cdots + \widehat{\beta_p}x_p + \varepsilon \tag{10}$$

The least square approach can also be used in a multiple linear regression, which suggest that we can choose $\hat{\beta}_0$, $\hat{\beta}_1$, …, $\hat{\beta}_p$ to minimize the sum of squared residuals with equation 11.

$$RSS = \sum_{i=1}^{n}(y_i - \hat{y}_i)^2 = \sum_{i=1}^{n}\left(y_i - \widehat{\beta_0} - \widehat{\beta_1}x_1 - \widehat{\beta_2}x_2 - \cdots - \widehat{\beta_p}x_{ip}\right)^2 \tag{11}$$

In the multiple linear regression, unlike in the simple linear regression, the coefficients estimates need complex algebra using matrixes which is why it won't be shown in this thesis, but the result is the same with an estimated coefficients for all the predictors used in the regression. Just like in the simple linear regression, the p-value for each estimate can be used to see if the predictor has a relationship with the response. If the p-value is close to one for one of the estimates, then that predictor should probably be taken out of the regression since it doesn't correspond to the response in a significant way.

5.2 Logistic regression

The advantage of a logistic regression is that it can give a qualitative response instead of just a quantitative response. Just like in the linear regression, there are two approaches when doing a logistic regression. There is a simple approach or a multiple approach. In this thesis, the multiple logistic regression will be used to predict whether there will be a delay or not when a switch has failed. For simplification, the response will be a generic 0/1 binary response. In the response for the thesis, a 1 will indicate there is a delay and a 0 indicates there is no delay. The end response will estimate the probability of a delay.

When doing a simple logistic regression, the first step is to clarify how to model the relation between p(X) and X which is showed in equation 12.

$$p(X) = \Pr(Y = 1|X) \tag{12}$$

It is possible to represent the probability using a linear regression model like in equation 13.

$$p(X) = \beta_0 + \beta_1 X \tag{13}$$

The problem with using equation 13 to calculate the probability is that when the predictor is low, the response might be lower than 0 and if the predictor is big, the response might be over 1 which is not possible when it comes to probabilities and are therefore not suitable for calculating probabilities. To avoid this problem, a logistic function that only gives outputs between 0 and 1 can be used. The logistic function is showed in equation 14.

$$p(X) = \frac{e^{\beta_0 + \beta_1 X}}{1 + e^{\beta_0 + \beta_1 X}} \tag{14}$$

Equation 14 can be transformed into equation 15.

$$\frac{p(X)}{1 - p(X)} = e^{\beta_0 + \beta_1 X} \tag{15}$$

If we take the logarithm on each side from equation 15 we get equation 16

$$\log\left(\frac{p(X)}{1 - p(X)}\right) = \beta_0 + \beta_1 X \tag{16}$$

in which the left side is called log odds or logit. When it comes to a logistic regression, changing X with a one-unit increase changes the log odds by β_1. The problem here is that with a one-unit increase in X, β_1 does not correspond to the change in p(X) since the relationship between p(X) and X is not a straight line. The value that increases of p(X) with a one-unit increase of X depends on the current value of X. No matter what the current X is, if β_1 is positive, there will be an increasing p(X) with a one-unit increase of X and if β_1 is negative, there will be a decreasing p(X) with a one-unit increase of X. It is possible to use a non-linear least square approach when estimating β_0 and β_1 but it is preferable to use a maximum likelihood approach instead since it has better statistical properties. The idea with the maximum likelihood approach is to seek estimates for β_0 and β_1 so that when $\hat{\beta}_0$ and $\hat{\beta}_1$ is estimated, they will yield a number close to one for all individuals who defaulted when plugged in to the model for p(X), given in equation 14. $\hat{\beta}_0$ and $\hat{\beta}_1$ would yield a number close to zero for all individuals who did not default. This idea can be formalized into one equation called a likelihood function, which is being showed in equation 17.

$$l(\beta_0, \beta_1) = \prod_{i:y_i=1} p(x_i) \prod_{i':y_{i'}=0} \left(1 - p(x_{i'})\right) \tag{17}$$

Just like for the linear regression, the p-value can be used to determine how significant β_0 and β_1 is to the response.

When doing a multiple logistic regression, the steps are quite similar. Equation 14 can be generalized into equation 18 with the help of the analogy from chapter 6.1.1 that explains the transformation from simple to multiple predictors in a linear regression.

$$\log\left(\frac{p(X)}{1 - p(X)}\right) = \beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p \tag{18}$$

Where $X = (X_1, \ldots, X_p)$ are p predictors. Equation 18 can be rewritten into equation 19.

$$p(x) = \frac{e^{\beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p}}{1 + e^{\beta_0 + \beta_1 X_1 + \cdots + \beta_p X_p}} \tag{19}$$

Just like in the simple logistic regression, the maximum likelihood approach can be used to estimate $\beta_0, \beta_1, \ldots, \beta_p$. The p-value can also be used here to determine the signification of $\beta_0, \beta_1, \ldots, \beta_p$ and to see which predicators who are altering the response and which that are not.

6. Method

The method being used in this thesis is of a quantitative nature. The workflow bcan be split into 5 different steps as showed in Figure 17.

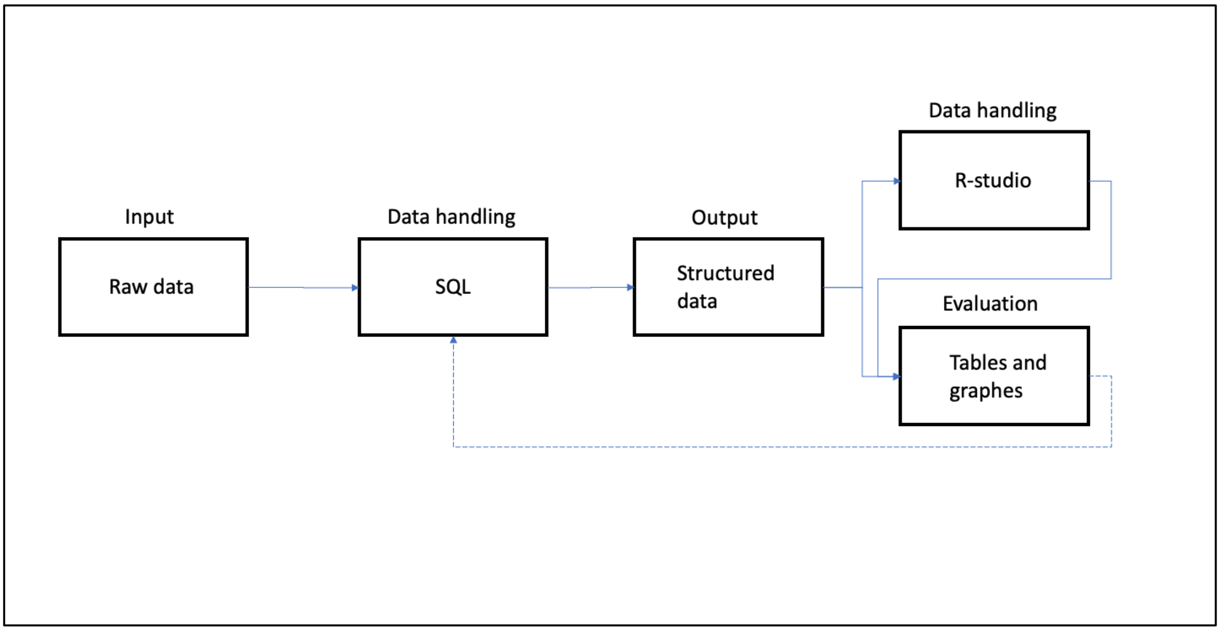

Figure 17. Schematic illustration of the thesis method.

6.1 Handling of Data

The data is sorted and analyzed through two different programs, SQL and R studio.

6.1.1 SQL

In SQL, the three different data systems, LUPP, Ofelia, and BIS are connected and combined into one table with the result showed in Figure 18.

Results | Messages

	Date_started	train_id	delay_increase	sch_time	Act_time	Train_type	Train_subtype	21a	21b	22a	22b	32a	32b	36b
1	2001-06-17	49823	0	2001-06-17 15:41:00.000	2001-06-17 14:29:00.000	Godståg	FJÄRR	0	0	0	0	0	0	0
2	2001-06-17	40742	0	2001-06-17 17:26:00.000	2001-06-17 17:21:00.000	Godståg	FJÄRR	0	0	0	0	0	0	0
3	2001-06-17	42166	0	2001-06-17 19:28:00.000	2001-06-17 18:21:00.000	Godståg	COMBI	0	0	0	0	0	0	0
4	2001-06-17	333	1	2001-06-17 07:54:00.000	2001-06-17 07:55:00.000	Resandetåg	FJÄRR	0	0	0	0	0	0	0
5	2001-06-17	311	1	2001-06-17 17:19:00.000	2001-06-17 17:29:00.000	Resandetåg	FJÄRR	0	0	0	0	0	0	0
6	2001-06-17	342	1	2001-06-17 12:04:00.000	2001-06-17 12:06:00.000	Resandetåg	FJÄRR	0	0	0	0	0	0	0
7	2001-06-17	42164	0	2001-06-17 18:39:00.000	2001-06-17 18:16:00.000	Godståg	COMBI	0	0	0	0	0	0	0
8	2001-06-17	42160	8	2001-06-17 15:29:00.000	2001-06-17 15:31:00.000	Godståg	COMBI	0	0	0	0	0	0	0

Figure 18. Result output from SQL.

In order to get to Figure 18, several steps were taken. The first step was to combine Ofelia and BIS in order to get the track number and switch number to the failures. That was done by linking the two systems by the column “Växelnr” and “Anläggningsindivid_FR”. In this step, the “Anläggningsdel_BVS” was sorted to only show switches and “Platsnamn_från_G” and “Platsnamn_till_G” was sorted to only show Höör as the station. Since both those columns showed the same thing, one of them could be taken out of the table. The result of the combination is showed in Figure 19.

	Anmält_FR	Anläggningstyp_BVS	Anläggningsdel_BVS	Anläggningsindivid_FR	Platsnamn_till_G	Avhjälpt_FR	Avslutat_FR	Datum_DT	Växelnr	spår
1	2017-12-14 08:58:00.000	Spårväxel	Växelvärme	32a	Höör	2017-12-16 07:00:00.000	2017-12-18 06:34:00.000	2017-12-14	32a	4,32a-32b,sky.spår
2	2002-05-15 09:05:00.000	Spårväxel	Omläggningsanordning	32A	Höör	2002-05-15 13:55:00.000	NULL	2002-05-15	32a	4,32a-32b,sky.spår
3	2002-05-18 09:55:00.000	Spårväxel	Omläggningsanordning	32A	Höör	2002-05-18 12:25:00.000	NULL	2002-05-18	32a	4,32a-32b,sky.spår
4	2002-05-23 10:42:00.000	Spårväxel	Omläggningsanordning	32A	Höör	2002-05-23 13:30:00.000	NULL	2002-05-23	32a	4,32a-32b,sky.spår
5	2011-03-16 07:50:00.000	Spårväxel	Spårväxel	32A	Höör	2011-03-16 09:11:00.000	2011-03-22 08:34:00.000	2011-03-16	32a	4,32a-32b,sky.spår
6	2017-02-08 20:23:00.000	Spårväxel	Spårväxel	32a	Höör	2017-02-09 04:00:00.000	2017-02-09 08:44:00.000	2017-02-08	32a	4,32a-32b,sky.spår
7	2003-01-17 13:28:00.000	Spårväxel	Omläggningsanordning	32A	Höör	2003-01-17 16:00:00.000	NULL	2003-01-17	32a	4,32a-32b,sky.spår

Figure 19. Result after combining Ofelia and BIS.

When looking into the table from Figure 19, it was discovered that one of the reported failures was reported on 2014-12-27 and wasn't fixed until 2016-05-20. The failure was reported when another report of a switch failure was wrongfully closed, and a new report number was created. The other report with the real failure was fixed after almost a day but the new report number was not fixed for almost 17 months without anything being wrong, causing the data set to be faulty. It would have showed a failure for one of the switches for 17 months, causing all the trains within that time frame to pass a faulty switch even though that was not the case. By taking away the new report number, the problem was fixed.

The next step started with sorting out Höör from the Lupp data. The column called "Delay" was taken away since it's the registered delay increase that is interesting. The "Delay" column doesn't show if the delay is increasing or decreasing from previous station but the "registered_delay_increase" does, which is why that column is being analyzed. After taking away the "Delay" column, it was decided which trains were to be included in the data and which were to be excluded. Because of the lay out of the station and the location of the switches (as showed in Figure 3), all trains arriving from north and who had Höör as their final destination were excluded from the data since the switches are located south of the station and are therefore not affected directly by a switch failure. This was done by taking away the trains that had "sista" as their dwell type and an odd number as train id, since all odd train id:s in Sweden has a south direction as a rule. The same was done with all the trains starting in Höör and going north but it was done by taking away the trains with "första" as their dwell type and an even number as their train id. At the same time, Figure 4 and Figure 5 were combined into one table, using train id and the date started as common attributes with the result showed in Figure 20.

	Date_started	train_id	delay_increase	sch_time	Act_time	Train_type	Train_subtype
1	2009-12-14	11096	1	2009-12-14 21:21:00.000	2009-12-14 21:21:00.000	Resandetåg	REGION
2	2008-08-17	1256	0	2008-08-17 19:37:00.000	2008-08-17 19:35:00.000	Resandetåg	PENDEL
3	2004-05-09	1208	0	2004-05-09 07:33:00.000	2004-05-09 07:32:00.000	Resandetåg	PENDEL
4	2004-02-08	6106	0	2004-02-08 18:59:00.000	2004-02-08 18:58:00.000	Godståg	ÖVR
5	2005-07-17	4148	0	2005-07-17 18:41:00.000	2005-07-17 18:43:00.000	Godståg	FJÄRR

Figure 20. Combination of the two data sets from Lupp.

The third step was to combine the already combined Ofelia and BIS data with the Lupp and weather data. This started with creating a column for each individual switch at Höör. The cells under each column were given either a 0 or a 1. A 0 indicated that there were no failures on that particular switch when a specific train passed it. A 1 indicated that there was a failure on that particular switch when a specific train passed it or were scheduled to pass it. When combining Figure 19 and Figure 20 with the new columns, the sch_time, Act_time, Avhjälpt_FR and Avslutat_FR were used in the combining. It was decided that the trains who were affected by the switch failure were does trains who either passed within the time frame of the failure or were scheduled to pass within the time frame because some trains might have had to wait for the failure to be fixed before passing the station. To get the weather data into the table, the dates were used for the combining. Before the combining could happen, it was decided which weather scenarios that were assumed to be problematic for the switches and punctuality. New columns were created, and the cells were either given a 1 or a 0. 1 indicated that the weather scenario could be problematic and a 0 indicated that it should not be a problem. For the temperature, a 1 were given if the average temperature were below 0°C or above or equal to 20°C. For the snow depth, a 1 were given if the snow depth was above 0 meters. For the wind speed, a 1 were given if the maximum wind speed during the day was above or equal to 10 m/s. In all other scenarios, a 0 was given for all the different criteria. The range of the criteria's are based on a study on the impacts of weather on railway infrastructure in Sweden (Ochsner et al., 2024). The study shows how the fault rates for switches increase with temperatures below 0°C and above 20°C. It also shows how the snow depth effects the fault rate. Wind speed shows a slight increase in fault rate when the speed exceeds 10 m/s but not as much as the previous factors. The effect of precipitation showed to be none existing for switches which is why it is not included in this thesis.

In order to create a cumulative distribution of the registered delay increase, a table for each combination of switch failure and one were all switches worked were created. The table included the delay increase and how many times each delay increase has happened for that specific table. Figure 21 shows how one of the combinations can look like.

	delay_increase	21a	21b	22a	22b	32a	32b	36b	n
1	0	1	0	0	0	0	0	0	21795
2	1	1	0	0	0	0	0	0	5182
3	2	1	0	0	0	0	0	0	696
4	3	1	0	0	0	0	0	0	256

Figure 21. Table used for cumulative distribution of delay increase.

The first row in Figure 21 is interpreted as: 21795 trains got 0 more minutes delayed compared to the scheduled time when switch 21a was broken. All the different table for each combination was put into an excel sheet where a figure of the cumulative distribution could be made.

6.1.2 R Studio

To answer research question 1: Does the failure of a railway switch impact the delays of trains?, two different regressions, in R Studio, are being made. One logistic regression and one on linear. The logistic regression focuses on the prediction of a delay and the linear regression focuses on the delay minutes. For the logistic regression, a new column was created called "increase". Each cell was given either a 0 or a 1, where a 0 indicated that there was no delay increase and a 1 indicated that there was a delay increase no matter how big the increase was. By doing this, a logistic regression focused on the whether there will be a delay or not could be made and with the "delay_increase" column, a linear regression could be made. In the logistic regression, the different train types and subtypes, the two different temperature factors, the snow factor, and the wind factor were put in as different independable variables. The regression used the increase column as the dependable variable and therefore the response gives a prediction on whether there will be a delay or not. In the linear regression, the independable variables were the same as for the logistic regression. The dependable variable on the other hand were instead of the increase column, the "delay_increase" column. By doing that, the response predicts how big each delay would be for every variable. The input table looked like Figure 22

	delay_increase	21a	21b	22a	22b	32a	32b	36b	train_type	train_subtype	temp_freezing	temp_warm	snow	wind_high	increase
1	0	0	0	0	0	0	0	0	Godståg	FJÄRR	0	0	0	0	0
2	0	0	0	0	0	0	0	0	Godståg	FJÄRR	0	0	0	0	0
3	0	0	0	0	0	0	0	0	Godståg	FJÄRR	0	0	0	0	0
4	3	0	0	0	0	0	0	0	Resandetåg	PENDEL	0	0	0	0	1
5	1	0	0	0	0	0	0	0	Resandetåg	PENDEL	0	0	0	0	1
6	0	0	0	0	0	0	0	0	Resandetåg	FJÄRR	0	0	0	0	0

Figure 22. Input data to R Studio.

The 4th row in Figure 22 is interpreted as: When all switches worked, there was a train which did got 3 minutes further delayed meaning there was a delay increase. The temperature was somewhere between 0 and 20 °C since both "temp_freezing" and "temp_warm are showing 0:s. There was also no snow on that day and the maximum wind speed was under 10 m/s.

7. Results

The results are shown in three sections. The first section is describing how many switch failures for each switch that has occurred during the time frame. The second section reports the result from the linear regression and the third section from the logistic regression.

7.1 Cumulative delay distribution

The output from excel with the cumulative distribution of the registered delay increase is showed in Figure 23.

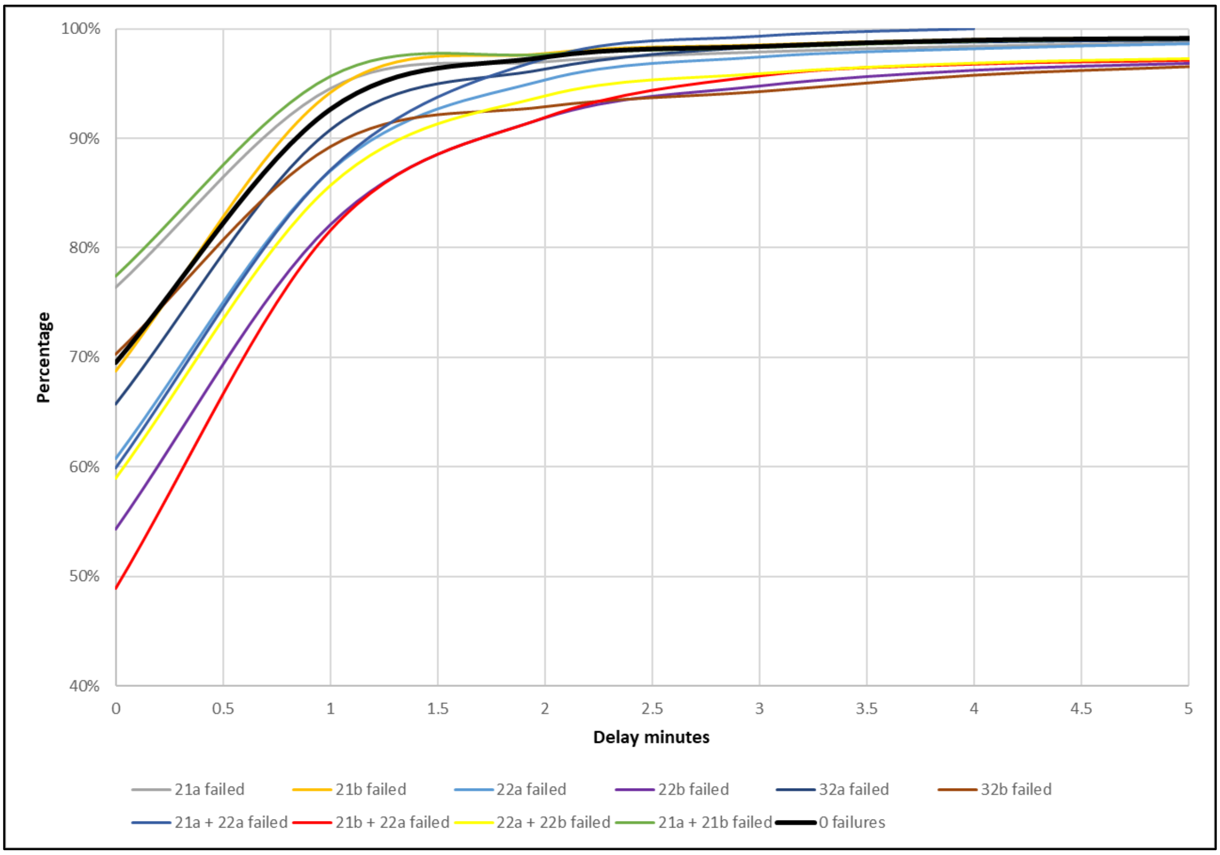

Figure 23. Shows the cumulative distribution for every combination of failure and non-failure.

The thickened, black line represent how the delay distribution is on a "normal" day where all the switches work. Almost 70% of the trains doesn't have a delay increase from their timetable and 97% has 2 minutes or less delay increase. The orange, grey and green line are all above the black line. Before the 2-minute mark, all three of those lines have a higher percentage, meaning the trains that have passed those switches when they are broken have not been getting more delayed then when they work. The rest of the lines are underneath the blackline, indicating the opposite. The dark blue line ends at the 4-minute mark, meaning that there were no trains that got 5 or more minutes delayed. Switch 36b is not included since it did not break often enough to get enough statistical data for this part. There were only 89 trains that passed Höör when that switch was broken which makes it hard to make any conclusions. The same goes with the other combinations of failures that could be made and are not showed in Figure 23 and in which most of them never even happened.

7.2 Linear regression

The output from the linear regression is presented in Table 4.

Table 4. Result from the first linear regression that was being made.

Coefficients:					
	Estimate (β)	Std. Error	t value	P-value	
Intercept	0.466806	1.112782	0.419	0.675	
21a	0.007118	0.014889	0.478	0.633	
21b	0.046073	0.018553	2.483	0.013	*
22a	0.216416	0.019969	10.837	2,00E-16	***
22b	0.531774	0.032413	16.406	2,00E-16	***
32a	0.366379	0.046699	7.846	4.31e-15	***
32b	0.510495	0.060961	8.374	2,00E-16	***
36b	2.835458	0.263817	10.748	2,00E-16	***
Freight trains	0.084004	1.112790	0.075	0.940	
Passenger trains	0.012898	1.112783	0.012	0.991	
Service trains	-0.162689	1.112856	-0.146	0.884	
Shunting trains	-0.474867	1.506672	-0.315	0.753	
Snow	0.107107	0.008147	13.146	2,00E-16	***
Temperature > 0°C	0.003903	0.010762	0.363	0.717	
Temperature < 0°C	0.048369	0.007327	6.601	4.08e-11	***
Wind speed > 10 m/s	0.350052	0.029842	11.730	2,00E-16	***
21a + 21b	-0.133233	0.033178	-4.016	5.93e-05	***
22a + 32b	2.084773	0.341572	6.103	1.04e-09	***
22a + 22b	-0.400345	0.099596	-4.020	5.83e-05	***
21b + 22a	0.076421	0.090192	0.847	0.397	
21a + 22a	-0.180801	0.206712	-0.875	0.382	

The stars next to the P-value represents the significance level of the P-value. Three stars indicates that the P-value is less than 0.001 and because of the big data set, it is considered to be the only acceptable significance in order to be able to count on the factor to make an impact on the response. Table 4 shows that snow, low temperatures and a high wind speed is significant for the response of the linear regression. Factors who do not show a significant P-value were taken out one by one, starting with the train type. After the second regression, snow, low temperatures, and high wind speeds are still the significant factors to the response. The next factor to be taken away is the warm temperature since it does not show any significance to the response. The result from the third linear regression, without train type and warm temperature as a factor, is shown in Table 5.

Table 5. Result from the third linear regression.

Coefficients:					
	Estimate (β)	Std. Error	t value	P-value	
Intercept	0,488294	0,002083	234,406	2,00E-16	***
21a	0,005101	0,014889	0,343	0,7319	
21b	0,046521	0,018551	2,508	0,0122	*
22a	0,214297	0,019969	10,732	2,00E-16	***
22b	0,529211	0,032414	16,327	2,00E-16	***
32a	0,364524	0,046702	7,805	5,94E-15	***
32b	0,509593	0,060963	8,359	2,00E-16	***
36b	2,827558	0,263847	10,717	2,00E-16	***
21a + 21b	-0,133362	0,033134	-4,025	5,70E-05	***
22a + 32b	2,076761	0,34161	6,079	1,21E-09	***
22a + 22b	-0,398342	0,099606	-3,999	6,36E-05	***
21b + 22a	0,074616	0,0902	0,827	0,4081	
21a + 22a	-0,178099	0,206736	-0,861	0,389	
Snow	0,107987	0,008146	13,257	2,00E-16	***
Temperature < 0°C	0,04807	0,007323	6,565	5,21E-11	***
Wind speed > 10 m/s	0,350782	0,029843	11,754	2,00E-16	***

The estimates in Table 5 are the coefficients that is being described in chapter 5.1. If the estimate has a positive result, it indicates that the response will be greater than what the intercept says, meaning that the delay has increased. In the case of one switch being broken, the estimates show an increase in delays for every switch. When switch number 22a and 32b is broken simultaneously and when switch number 21b and 22a is broken simultaneously, the estimate gives an increased delay. When switch number 21a and 21b is broken at the same time, when switch number 22a and 22b is simultaneously, and when switch number 21a and 22a is broken at the same time, the estimate gives a decreased delay. The intercept, switch number 22a, 22b, 32a, 32b, and 36b are significant to the response. They have a low standard deviation compared to the estimate and are therefore a good fit to the response. The same goes for when switch 21a and 21b, 22a and 32b, and 22a and 22b is broken simultaneously. Switch number 21a and 21b are not significant to the response. They have a high standard deviation compared to the estimate and are therefore not a good fit to the response. The same goes with when switch number 21b and 22a, and 21a and 22a is broken at the same time. The other factors, beside the switches, who are significant enough to affect the response are the wind speed, whether there is snow present at the station and if the temperature is below 0 degrees Celsius. All three of them has estimates that increases the delays.

7.3 Logistic regression

The output from the logistic regression is presented in Table 6.

Table 6. Result from the first logistic regression that was being made.

Coefficients:					
	Estimate (β)	Std. Error	z value	P-value	
Intercept	-0.445421	0.914545	-0.487	0.626229	
21a	-0.407181	0.014221	-28.633	2,00E-16	***
21b	0.025952	0.016342	1.588	0.112272	
22a	0.323816	0.016757	19.325	2,00E-16	***
22b	0.653132	0.026716	24.447	2,00E-16	***
32a	0.136022	0.040063	3.395	0.000686	***
32b	-0.077203	0.054411	-1.419	0.155932	
36b	0.900533	0.220317	4.087	4.36e-05	***
Freight trains	-1.441338	0.914560	-1.576	0.115028	
Passenger trains	-0.210350	0.914546	-0.230	0.818088	
Service trains	-1.674287	0.914695	-1.830	0.067185	.
Shunting trains	-7.127353	10.923535	-0.652	0.514094	
Snow	0.225760	0.007093	31.830	2,00E-16	***
Temperature > 0°C	-0.014528	0.009619	-1.510	0.130953	
Temperature < 0°C	0.044861	0.006440	6.966	3.27e-12	***
Wind speed > 10 m/s	0.283232	0.025663	11.036	2,00E-16	***
21a + 21b	-0.080711	0.031174	-2.589	0.009623	**
22a + 32b	1.536886	0.308042	4.989	6.06e-07	***
22a + 22b	-0.551835	0.082892	-6.657	2.79e-11	***
21b + 22a	0.232299	0.074293	3.127	0.001767	**
21a + 22a	0.434357	0.172975	2.511	0.012036	*

The stars next to the P-value represents the same significance of the P-value as for the linear regression. Therefore, the same consideration to the factors will be made. Table 6 shows that snow, low temperatures and a high wind speed is significant for the response of the linear regression. Factors who do not show a significant P-value were taken out one by one for the logistic regression as well, starting with the train type. After the second regression, snow, low temperatures and high wind speeds are still the significant factors to the response in. The next factor to be taken away is the warm temperature since it does not show any significance to the response. The result from the third linear regression, without the train type and warm temperature as a factor, is showed in Table 7.

Table 7. Result from the third logistic regression.

Coefficients:					
	Estimate (β)	Std. Error	z value	P-value	
Intercept	-0,845213	0,001825	-463,154	2,00E-16	***
21a	-0,351098	0,014071	-24,951	2,00E-16	***
21b	0,051115	0,016087	3,177	1,49E-03	**
22a	0,358497	0,016458	21,783	2,00E-16	***
22b	0,669889	0,026159	25,609	2,00E-16	***
32a	0,179037	0,039505	4,532	5,84E-06	***
32b	-0,044167	0,053627	-0,824	0,41017	
36b	0,943467	0,215144	4,385	1,16E-05	***
21a + 21b	-0,086774	0,030804	-2,817	0,00485	**
22a + 32b	1,33188	0,297146	4,482	7,39E-06	***
22a + 22b	-0,583732	0,081307	-7,179	7,00E-13	***
21b + 22a	0,238721	0,072868	3,276	0,00105	**
21a + 22a	0,382767	0,169852	2,254	2,42E-02	*
Snow	0,192861	0,006944	27,775	2,00E-16	***
Temperature < 0°C	0,04921	0,006315	7,793	6,54E-15	***
Wind speed > 10 m/s	0,257827	0,025137	10,257	2,00E-16	***

The estimates in Table 7 are the coefficients that is being described in chapter 5.2. If the estimate has a positive result, it indicates that the response will be greater than what the intercept says, meaning that the chances of a delay has increased. If the estimate is negative, the response will be less than what the intercept says, meaning that the chances of a delay has decreased. Switch number 21b, 22a, 22b, 32a, and 36b has positive estimates. Switch number 21a and 32b has negative estimates. When switch number 21a and 21b, 22a and 22b are both broken simultaneously, the estimates are negative. When switch number 22a and 32b, 21b and 22a, and 21a and 22a are broken at the same time, the estimates are positive. The three other factors called snow, temp_freezing, and wind_high, all have positive estimates, meaning that when these factors are present, the prediction of whether there is a delay or not increases. The P-value for when switch number 21a, 22a, 22b, 32a, and 36b are broken is low, indicating a high significance. Switch number 21b and 32b has a low P-value, indicating a low significance to the response. To be able to interpret and understand the output from Table 7 equation 19 from section 5.2, was used to create Table 8.

Table 8. Result from the third logistic regression with equation 19.

Coefficients:						
	Estimate (β)	Std. Error	P-value		$B_0 + B_1X_1 + \ldots + B_pX_p$	P(X)
Intercept	-0,845213	0,001825	2,00E-16	***	-0,845213	0,3004
21a	-0,351098	0,014071	2,00E-16	***	-1,196311	0,2321
21b	0,051115	0,016087	1,49E-03	**	-0,794098	0,3113
22a	0,358497	0,016458	2,00E-16	***	-0,486716	0,3807
22b	0,669889	0,026159	2,00E-16	***	-0,175324	0,4563
32a	0,179037	0,039505	5,84E-06	***	-0,666176	0,3394
32b	-0,044167	0,053627	0,41017		-0,88938	0,2912
36b	0,943467	0,215144	1,16E-05	***	0,098254	0,5245
21a + 21b	-0,086774	0,030804	0,00485	**	-0,931987	0,2825
22a + 32b	1,33188	0,297146	7,39E-06	***	0,486667	0,6193
22a + 22b	-0,583732	0,081307	7,00E-13	***	-1,428945	0,1933
21b + 22a	0,238721	0,072868	0,00105	**	-0,931987	0,2825
21a + 22a	0,382767	0,169852	2,42E-02	*	0,486667	0,6193
Snow	0,192861	0,006944	2,00E-16	***	-1,428945	0,3425
Temperature < 0°C	0,04921	0,006315	6,54E-15	***	-0,606492	0,3109
Wind speed > 10 m/s	0,257827	0,025137	2,00E-16	***	-0,462446	0,3572

The probability column (P(X)) shows an estimation of the probability on how many trains that has had a delay increase during the different scenarios and factors. It shows that the highest probability of a delay increase occurs when switch number 22a and 32b, and 21a and 22a are broken simultaneously. The probability of a delay increase in those two scenarios are almost 62%. For the combination when 21a and 22a are broken at the same time, the standard deviation is high compared to estimate and the P-value is high which makes the estimates uncertain. For the combination of 22a and 32b being broken simultaneously, the P-value is low which makes the estimate and probability significant to the response. The probability column (P(X)) also shows that the lowest probability of a delay increase occurs when switch number 22a and 22b are broken at the same time. The probability of a delay increase in that scenario is close to 19%.

8. Discussion

The short answer to research question number 1: Does the failure of a railway switch impact the delays of trains?, is no. By looking at Figure 23 and the cumulative distribution of the registered delay increase, there seems to be that when some of the switches are broke, the trains are not as delayed as when all the switches work. If it would be one case in which that scenario happened, it would not be anything out of the ordinary since they are many combinations that are being studied. But when three different combinations of failures have a less effect on train delays, it looks strange. Especially when one of the scenarios, the failure of switch 21a and all of the other switches working, is the combination with the most failures and biggest set of data. A possible explanation for this is that the P-value in the linear regression is quite high, causing the estimate to be unsignificant to the response. It also has a high standard deviation that makes the estimate uncertain. The standard deviation shows the variance in the data, which means that a large value indicates that the data has a high spread, and it is not conclusive. With switch 21a, even though the amount data is bigger than for the other switches, the variance is a lot bigger than the estimate which makes the estimate uncertain. It also answers why the estimate from Table 5 is positive when Figure 23 clearly shows that the delay increase is smaller when the switch is broken than when all the switches work.

The answer to research question number 2: Which factors are affecting the delays and by how much are they affected?, is that some of the studied factors have an impact on the delays in Höör and some does not. The result shows an increase in the delay minute and the prediction of whether there will be a delay or not when there is snow present at the station, when the temperature is below 0 °C, and when the maximum wind speed of the day exceeds 10 m/s. For most cases, when snow is present at the station, the temperature is also below 0 °C which makes the two factors connected. According to the linear and logistic regressions presented in Table 5 and Table 8, the wind speed seems to be the factor that affects the delays the most, followed by the snow depth and the freezing temperature. With a wind speed of at least 10 m/s, the delay increases by 0.35 minutes and the prediction of whether there will be a delay or not goes from 30.0% to 35.7% which is an increase by 19.0%. Previous research shows that wind speed does not affect the fault rate of switches, but it does show an impact on delays which corresponds to the results (Ochsner et al., 2024; Lorenz et al., 2021). A higher wind speed tends to impact the railway in other ways than on the switches. For example, extreme winds often lead to trees falling, damaging the electrical wires and the track. It could technically fall on a switch and damage it but the odds for that happening are very low which is the reason for why it is not being regarded as a problem for switches. With snow present at the closest weather station, the delay increases by 0.11 minutes and the prediction of whether there will be a delay or not goes from 30.0% to 34.3% which is an increase by 14.3%. This corresponds to previous research with snow getting stuck in-between different components of the switch and causing it to malfunction (Baranowska & Öman, 2012). With temperatures under 0°C, the delay increases by 0.05 minutes and the prediction of whether there will be a delay or goes from 30.0% to 31.1% which is an increase by 3.7%. The temperature does not have as big of an impact as the other two weather factors, but it still shows a low P-value, meaning that it is still significant to the result. In the study by Ochsner et al. (2024), the fault rate for switches increases exponentially under 0°C and are at its peak at -30°C. With a lowest average of -14.5°C, those extreme kinds of temperatures do not exist at Höör, but the lower the temperature is the higher the chances are there for snow being present. This corresponds to that the snow depth has a higher impact on the delays sense the temperatures probably has a lower average when there is snow present then for just under 0°C.

The hard part about analyzing the weather data is the location of the weather station. In this case, most of the data is collected at the weather station in Hörby which is located close to 10 km from the train station in Höör. Even though the weather is for most parts the same in both Höör and Hörby, there could be a difference, altering the results. This is the case for the weather data that includes the temperature and wind speed. When it comes to the snow depth, the distance is even greater. With an average distance of 46.7 km between a weather station and the train station in Höör, the snow depth can be quite different between the different stations. As described in section 4.7.1, this is not a problem for most of the days during the year since the temperature in Scania is for most part over 0°C, meaning that there will not be any snow present. The issues arises when a weather station that is far away from Höör records a small snow depth. When that is the case, the likelihood for there being snow at Höör are being decreased. The regressions have handled the snow depth as being present or not being present and they are not considering the size of the depth. This means that a 1-centimeter snow depth are being recognized with the same magnitude as a 50-centimeter snow depth. That by itself can be problematic and misleading in the data but if the small snow depths are being recorded far away from here, there might not even be snow represented at Höör which leads to a faulty data set.

A reason for why some of the switches shows a better punctuality and a smaller delay increase even though they are broken could be connected to how the station is build and the design of the tracks. The station has two platforms and the tracks on which passengers can board and alight the trains. Unlike other, bigger stations, the switches at Höör are not used at the same extent to direct trains to different platforms. They are also not used to divert trains onto another direction since two out of three tracks follow each other. This results in a smaller usage of the switches. If there is a failure that causes the switches to be unable to move, it would not affect the delays as much if they are not being used, as long as the failure does not cause trains to have to stop or slow down while passing it. The switches that are being used in a higher extent than the others are switch 21a, 21b, and 32b. All three of them are used when trains that has Höör as their first station, is leaving from track 3 which is once every hour. Switch 32b is used for trains that has Höör as their last station which also is once every hour at most. The other switches are not used, unless there is some kind of extra ordinary event that leads to trains having to change which track they are going on.

The hardest result to try to explain is the logistic and linear regression estimates of switch number 36b. From Table 2, it is presented that switch number 36b only broke down 3 times during the time frame. It is also presented that only 89 trains passed Höör during these three failures which is in the context, not a lot of data to analyze. If we add the location of the switch and the timetable, which is presented in Figure 3 and in the attachments, it is not many trains that passes the switch. Most of the trains goes on the two main tracks and not on the sidetrack. The trains that pass switch 36b only do it in direction, which means that the switch never has to change position and the delays might not be affected if the failure of the switch is minor. During the three failures, only 89 trains passed Höör and if they did not pass the switch, it should not have been affected by the failure as much as it did, and especially not with a low P-value. One explanation could be that there was some other failures or incidents at the time of this switch failures which caused the delay increases. That it happened to happen three different times might be unusual, but it is not impossible making it a possible explanation.

Even though Höör is a busy station with a lot of traffic, the data set might have been too small to make the results valid. With 95% of all the datapoints coming from when there was no switch failure, the dataset for when the switches had failed might have been too small. With only 5%

of the data linked to switch failures, it could be hard to make assumptions on how much the delays differs from when there is a switch failure and when it is not. The data that consists of zero switch failures can contain a lot of different failures and reasons for why the trains are being delayed that have not happened in the rest of the data set. To get a bigger dataset for when there is a switch failure, it could be needed to look at several different stations at the same time. By looking at several stations, the number of switch failures and trains passing the failure would increase and give more data to the delays.

9. Conclusion

The results are a bit inconclusive, making it hard to make any assumptions on whether switch failures affect the delays or not. Some of the switches shows tendencies towards an increase in the number of delays and the size of the delays while other switches show the opposite. In order to make conclusions about the delays and their size, the severity of the failure needs to be studied more deeply. Switch failures that are less severe might not be a problem and if they are a majority of the failures, it would affect the data. An argument could be made that even though the failure is not severe, it would still cost money and time to fix it and therefore are those failures also important. That is true, but when looking at if switch failures cause train delays, the small failures might not be affecting the delays more than any other reason. Depending on the severity of the failure, some trains might even be cancelled and would therefore not be showed in the data even though they are affected by the failure.

There is also a need for similar studies on a bigger station than Höör. As described in section 8, the switches in Höör are not used as much as other switches because of the design and layout of the station. In a bigger station, in which switches need to change position more frequently, the consequences of a switch failure would probably show a bigger effect than at Höör. Looking at a bigger station would create other problems and it would be more difficult to determine what's supposed to be included or not, but it would give a better picture of how, especially small failures, affects the delays.

To summarize, results of the thesis does not show a clear trend between failures of switches and an increase in delays. There are factors who contribute to the delays but without further research it is difficult to determine if most switch failures cause a delay increase at smaller stations.

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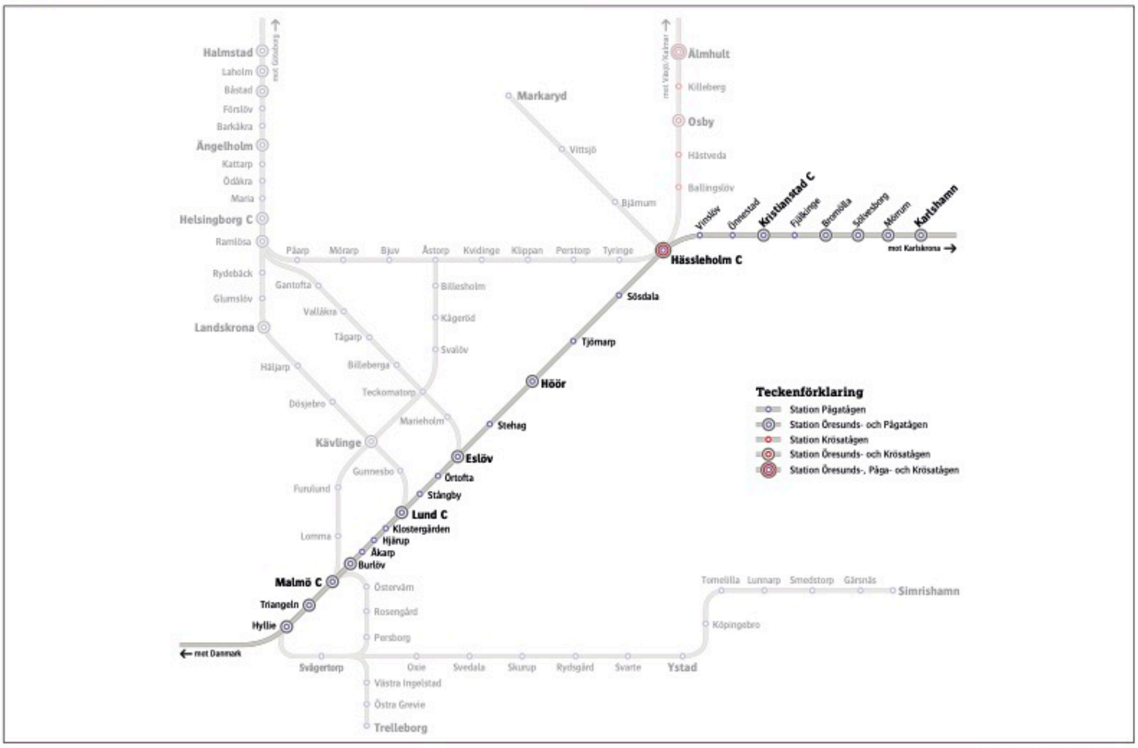
11. Attachments

4B Karlskrona–Kristianstad–Malmö–Köpenhamn



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	1203	1257	1205	11901	1021	1259	1855	1025	1025	1207	11903	1029	1029	1261	1857	1033	1033	1955	1209
	M-F		M-F	M-F			M-F	M-F	L,S		M-F	M-F	L,S	M-F	M-F	M-F	L,S	M-F	
Karlskrona												04.48							
Bergåsa												04.51							
Ronneby												05.09							
Bräkne-Hoby												05.20							
Karlshamn												05.36						06.05	
Mörrum												05.44						06.12	
Sölvesborg												05.58						06.26	
Bromölla												06.05						06.34	
Fjälkinge												|						06.44	
Kristianstad												06.20						06.53	
Kristianstad	04.04		05.04		05.26		05.43			06.04		06.26	06.26		06.43				07.04
Önnestad	04.10		05.10		|		05.49			06.10		|	|		06.49				07.10
Vinslöv	04.16		05.16		|		05.55			06.16		|	|		06.55				07.16
Hässleholm C	04.26		05.26		05.45		06.05			06.26		06.45	06.45		07.05				07.26
Hässleholm C	04.32	05.04	05.28	05.41	05.47			06.16	06.16	06.28	06.41	06.47	06.47			07.16	07.16		07.28
Sösdala	04.40	05.12	05.36	|	|			|	|	06.36	|	|	|			|	|		07.36
Tjörnarp	04.44	|	05.40	|	|			|	|	06.40	|	|	|			|	|		07.40
Tjörnarp	04.44	05.16	05.40	|	|			|	|	06.40	|	|	|			|	|		07.40
Höör	04.49	05.21	05.45	05.54	|	06.21		06.29	06.29	06.45	06.54	|	|	07.21		07.29	07.29		07.45
Stehag	04.56	05.28	05.52	|	|	06.28		|	|	06.52	|	|	|	07.28		|	|		07.52
Eslöv	05.02	05.34	05.58	|	|	06.34		|	|	06.58	|	|	|	07.34		|	|		07.58
Eslöv	05.02	05.34	05.58	06.05	|	06.34		06.40	06.40	06.58	07.05	|	|	07.34		07.40	07.40		07.58
Örtofta	05.08	05.39	06.04	|	|	06.39		|	|	07.04	|	|	|	07.39		|	|		08.04
Stångby	05.12	05.42	06.08	|	|	06.42		|	|	07.08	|	|	|	07.42		|	|		08.08
Lund C	05.16	05.47	06.12	06.15	06.19	06.47		06.51	06.51	07.12	07.15	07.19	07.19	07.47		07.51	07.51		08.12
Lund C	05.19	05.49	06.19	06.17	06.21	06.49		06.53	06.53	07.19	07.17	07.21	07.21	07.49		07.53	07.53		08.19
Klostergården	05.21	05.51	06.21	|	|	06.51		|	|	07.21	|	|	|	07.51		|	|		08.21
Hjärup	05.24	05.54	06.24	|	|	06.54		|	|	07.24	|	|	|	07.54		|	|		08.24
Åkarp	05.27	05.57	06.27	|	|	06.57		|	|	07.27	|	|	|	07.57		|	|		08.27
Burlöv	05.30	06.00	06.30	06.23	06.27	07.00		|	|	07.30	07.23	07.27	07.27	08.00		|	|		08.30
Malmö C	05.36	06.06	06.36	06.29	06.33	07.06		07.03	07.03	07.36	07.29	07.33	07.33	08.06		08.03	08.03		08.36
Malmö C	05.38	06.08	06.38	06.32	06.35	07.08		07.05	07.05	07.38	07.32	07.35	07.35	08.08		08.05	08.05		08.38
Triangeln	05.41	06.11	06.41	06.35	06.38	07.11		07.08	07.08	07.41	07.35	07.38	07.38	08.11		08.08	08.08		08.41
Hyllie	05.45	|	06.45	06.39	06.42	|		07.12	07.12	07.45	07.39	07.42	07.42	|		08.12	08.12		08.45
Hyllie		06.15			06.44	07.15		07.14	07.14			07.44	07.44	08.15		08.14	08.14		
CPH Airport					07.00			07.30	07.30			08.00	08.00			08.30	08.30		
Tårnby					07.04			07.34	07.34			08.04	08.04			08.34	08.34		
Ørestad					07.07			07.37	07.37			08.07	08.07			08.37	08.37		
København H					07.15			07.45	07.45			08.15	08.15			08.45	08.45		

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Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	11905	1037	1037	1263	1263	1263	1263	1859	1041	1041	1041	1957	1211	1045	1045	1265	1861	1049	11993
	M-F	M-L	S	M	M	Ti,O	Ti-F	M-F	M-F	L	S	M-F		M-L	S	M-F	M-F		M-F
Karlskrona		05.48												06.48					
Bergåsa		05.51												06.51					
Ronneby		06.09												07.09					
Bräkne-Hoby		06.20												07.20					
Karlshamn		06.36										07.05		07.36					
Mörrum		06.44										07.12		07.44					
Sölvesborg		06.58										07.26		07.58					
Bromölla		07.05										07.34		08.05					
Fjälkinge		|										07.44		|					
Kristianstad		07.20										07.53		08.20					
Kristianstad		07.26	07.26					07.43					08.04	08.26	08.26		08.43		
Önnestad		|	|					07.49					08.10	|	|		08.49		
Vinslöv		|	|					07.55					08.16	|	|		08.55		
Hässleholm C		07.45	07.45					08.05					08.26	08.45	08.45		09.05		09.17
Hässleholm C	07.41	07.47	07.47						08.16	08.16	08.16		08.32	08.47	08.47			09.16	
Sösdala	|	|	|						|	|	|		08.40	|	|			|	
Tjörnarp	|	|	|						|	|	|		08.44	|	|			|	
Tjörnarp	|	|	|						|	|	|		08.44	|	|			|	
Höör	07.54	|	|	08.21	08.17	08.17	08.21		08.29	08.29	08.29		08.49	|	|	09.17		09.29	
Stehag	|	|	|	08.28	08.24	08.24	08.28		|	|	|		08.56	|	|	09.24		|	
Eslöv	|	|	|	08.34	08.30	08.30	08.34		|	|	|		09.02	|	|	09.30		|	
Eslöv	08.05	|	|	08.34	08.34	08.34	08.34		08.40	08.40	08.40		09.02	|	|	09.33		09.40	
Örtofta	|	|	|	08.39	08.39	08.39	08.39		|	|	|		09.08	|	|	09.39		|	
Stångby	|	|	|	08.43	08.43	08.43	08.43		|	|	|		09.12	|	|	09.43		|	
Lund C	08.15	08.19	08.19	08.47	08.47	08.47	08.47		08.51	08.51	08.51		09.16	09.19	09.19	09.47		09.51	
Lund C	08.17	08.21	08.21	08.49	08.49	08.49	08.49		08.53	08.53	08.53		09.19	09.21	09.21	09.49		09.53	
Klostergården	|	|	|	08.51	08.51	08.51	08.51		|	|	|		09.21	|	|	09.51		|	
Hjärup	|	|	|	08.54	08.54	08.54	08.54		|	|	|		09.24	|	|	09.54		|	
Åkarp	|	|	|	08.57	08.57	08.57	08.57		|	|	|		09.27	|	|	09.57		|	
Burlöv	08.23	08.27	08.27	09.00	09.00	09.00	09.00		|	|	|		09.30	09.27	09.27	10.00		|	
Malmö C	08.29	08.33	08.33	09.06	09.06	09.06	09.06		09.03	09.03	09.03		09.36	09.33	09.33	10.06		10.03	
Malmö C	08.32	08.35	08.35	09.08	09.08	09.08	09.08		09.05	09.05	09.05		09.38	09.35	09.35	10.08		10.05	
Triangeln	08.35	08.38	08.38	09.11	09.11	09.11	09.11		09.08	09.08	09.08		09.41	09.38	09.38	10.11		10.08	
Hyllie	08.39	08.42	08.42	|	|	|	|		09.12	09.12	09.12		09.45	09.42	09.42	|		10.12	
Hyllie		08.44	08.44	09.15	09.15	09.15	09.15		09.14	09.14	09.14			09.44	09.44	10.15		10.14	
CPH Airport		09.00	09.00						09.30	09.30	09.30			10.00	10.00			10.30	
Tårnby		09.04	09.04						09.34	09.34	09.34			10.04	10.04			10.34	
Ørestad		09.07	09.07						09.37	09.37	09.37			10.07	10.07			10.37	
København H		09.15	09.15						09.45	09.45	09.45			10.15	10.15			10.45	
				g	f	i	h												

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg Express
- 0000 Öresundståg
- 0000 Pågatåg
- L Endast lördag
- M Endast måndag
- M-F Endast måndag-fredag
- M-L Endast måndag-lördag
- S Endast söndag
- Ti,O Endast tisdag,onsdag
- Ti-F Endast tisdag-fredag
- f Kör ej 17 juni - 12 augusti.
- g Kör endast 17 juni - 12 augusti.
- h Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
- i Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Karlskrona–Kristianstad–Malmö–Köpenhamn

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1959	1959	1213	1053	1267	1895	1057	1057	1057	1961	1215	1061	1269	1065	1963	1217	1069	1271	1073
	M-F	L,S			M-F	M-F	M-F	L	S	M-F			M-F					M-F	M-F
Karlskrona				07.48								08.48					09.48		
Bergåsa				07.51								08.51					09.51		
Ronneby				08.09								09.09					10.09		
Bräkne-Hoby				08.20								09.20					10.20		
Karlshamn	08.05			08.36						09.05		09.36					10.36		
Mörrum	08.12			08.44						09.12		09.44					10.44		
Sölvesborg	08.26			08.58						09.26		09.58					10.58		
Bromölla	08.34	08.34		09.05						09.34		10.05			10.34		11.05		
Fjälkinge	08.44	08.44		|						09.44		|			10.44		|		
Kristianstad	08.53	08.53		09.20						09.53		10.20			10.53		11.20		
Kristianstad			09.04	09.26		09.43					10.04	10.26				11.04	11.26		
Önnestad			09.10	|		09.49					10.10	|				11.10	|		
Vinslöv			09.16	|		09.55					10.16	|				11.16	|		
Hässleholm C			09.26	09.45		10.05					10.26	10.45				11.26	11.45		
Hässleholm C			09.32	09.47			10.16	10.16	10.16		10.32	10.47		11.16		11.32	11.47		12.16
Sösdala			09.40	|			|	|	|		10.40	|		|		11.40	|		|
Tjörnarp			09.44	|			|	|	|		10.44	|		|		11.44	|		|
Tjörnarp			09.44	|			|	|	|		10.44	|		|		11.44	|		|
Höör			09.49	|	10.17		10.29	10.29	10.29		10.49	|	11.17	11.29		11.49	|	12.17	12.29
Stehag			09.56	|	10.24		|	|	|		10.56	|	11.24	|		11.56	|	12.24	|
Eslöv			10.02	|	10.30		|	|	|		11.02	|	11.30	|		12.02	|	12.30	|
Eslöv			10.02	|	10.33		10.40	10.40	10.40		11.02	|	11.33	11.40		12.02	|	12.33	12.40
Örtofta			10.08	|	10.39		|	|	|		11.08	|	11.39	|		12.08	|	12.39	|
Stångby			10.12	|	10.43		|	|	|		11.12	|	11.43	|		12.12	|	12.43	|
Lund C			10.16	10.19	10.47		10.51	10.51	10.51		11.16	11.19	11.47	11.51		12.16	12.19	12.47	12.51
Lund C			10.19	10.21	10.49		10.53	10.53	10.53		11.19	11.21	11.49	11.53		12.19	12.21	12.49	12.53
Klostergården			10.21	|	10.51		|	|	|		11.21	|	11.51	|		12.21	|	12.51	|
Hjärup			10.24	|	10.54		|	|	|		11.24	|	11.54	|		12.24	|	12.54	|
Åkarp			10.27	|	10.57		|	|	|		11.27	|	11.57	|		12.27	|	12.57	|
Burlöv			10.30	10.27	11.00		|	|	|		11.30	11.27	12.00	|		12.30	12.27	13.00	|
Malmö C			10.36	10.33	11.06		11.03	11.03	11.03		11.36	11.33	12.06	12.03		12.36	12.33	13.06	13.03
Malmö C			10.38	10.35	11.08		11.05	11.05	11.05		11.38	11.35	12.08	12.05		12.38	12.35	13.08	13.05
Triangeln			10.41	10.38	11.11		11.08	11.08	11.08		11.41	11.38	12.11	12.08		12.41	12.38	13.11	13.08
Hyllie			10.45	10.42	|		11.12	11.12	11.12		11.45	11.42	|	12.12		12.45	12.42	|	13.12
Hyllie				10.44	11.15		11.14	11.14	11.14			11.44	12.15	12.14			12.44	13.15	13.14
CPH Airport				11.00			11.30	11.30	11.30			12.00		12.30			13.00		13.30
Tårnby				11.04			11.34	11.34	11.34			12.04		12.34			13.04		13.34
Ørestad				11.07			11.37	11.37	11.37			12.07		12.37			13.07		13.37
København H				11.15			11.45	11.45	11.45			12.15		12.45			13.15		13.45

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg
- 0000 Öresundståg
- L Endast lördag
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag
- S Endast söndag
- f Kör ej 17 juni - 12 augusti.
- g Kör endast 17 juni - 12 augusti.
- h Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
- i Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Karlskrona–Kristianstad–Malmö–Köpenhamn

	1073	1073	1219	1077	1273	1081	1967	1221	1085	1275	1089	1089	1223	11919	1093	1277	1873	1097	1971
	L	S			M-F					M-F	M-F	L,S		M-F		M-F	M-F		L,S
Karlskrona				10.48					11.48						12.48				
Bergåsa				10.51					11.51						12.51				
Ronneby				11.09					12.09						13.09				
Bräkne-Hoby				11.20					12.20						13.20				
Karlshamn				11.36					12.36						13.36				
Mörrum				11.44					12.44						13.44				
Sölvesborg				11.58					12.58						13.58				
Bromölla				12.05			12.34		13.05						14.05				14.34
Fjälkinge				|			12.44		|						|				14.44
Kristianstad				12.20			12.53		13.20						14.20				14.53
Kristianstad			12.04	12.26				13.04	13.26				14.04		14.26		14.43		
Önnestad			12.10	|				13.10	|				14.10		|		14.49		
Vinslöv			12.16	|				13.16	|				14.16		|		14.55		
Hässleholm C			12.26	12.45				13.26	13.45				14.26		14.45		15.05		
Hässleholm C	12.16	12.16	12.32	12.47		13.16		13.28	13.47		14.16	14.16	14.28	14.41	14.47			15.16	
Sösdala	|	|	12.40	|		|		13.36	|		|	|	14.36	|	|			|	
Tjörnarp	|	|	12.44	|		|		13.40	|		|	|	14.40	|	|			|	
Tjörnarp	|	|	12.44	|		|		13.44	|		|	|	14.40	|	|			|	
Höör	12.29	12.29	12.49	|	13.17	13.29		13.49	|	14.17	14.29	14.29	14.45	14.54	|	15.17		15.29	
Stehag	|	|	12.56	|	13.24	|		13.56	|	14.24	|	|	14.52	|	|	15.24		|	
Eslöv	|	|	13.02	|	13.30	|		14.02	|	14.30	|	|	14.58	|	|	15.30		|	
Eslöv	12.40	12.40	13.02	|	13.33	13.40		14.02	|	14.33	14.40	14.40	14.58	15.05	|	15.33		15.40	
Örtofta	|	|	13.08	|	13.39	|		14.08	|	14.39	|	|	15.04	|	|	15.39		|	
Stångby	|	|	13.12	|	13.43	|		14.12	|	14.43	|	|	15.08	|	|	15.43		|	
Lund C	12.51	12.51	13.16	13.19	13.47	13.51		14.16	14.19	14.47	14.51	14.51	15.12	15.15	15.19	15.47		15.51	
Lund C	12.53	12.53	13.19	13.21	13.49	13.53		14.19	14.21	14.49	14.53	14.53	15.19	15.17	15.21	15.49		15.53	
Klostergården	|	|	13.21	|	13.51	|		14.21	|	14.51	|	|	15.21	|	|	15.51		|	
Hjärup	|	|	13.24	|	13.54	|		14.24	|	14.54	|	|	15.24	|	|	15.54		|	
Åkarp	|	|	13.27	|	13.57	|		14.27	|	14.57	|	|	15.27	|	|	15.57		|	
Burlöv	|	|	13.30	13.27	14.00	|		14.30	14.27	15.00	|	|	15.30	15.23	15.27	16.00		|	
Malmö C	13.03	13.03	13.36	13.33	14.06	14.03		14.36	14.33	15.06	15.03	15.03	15.36	15.29	15.33	16.06		16.03	
Malmö C	13.05	13.05	13.38	13.35	14.08	14.05		14.38	14.35	15.08	15.05	15.05	15.38	15.32	15.35	16.08		16.05	
Triangeln	13.08	13.08	13.41	13.38	14.11	14.08		14.41	14.38	15.11	15.08	15.08	15.41	15.35	15.38	16.11		16.08	
Hyllie	13.12	13.12	13.45	13.42	|	14.12		14.45	14.42	|	15.12	15.12	15.45	15.39	15.42	|		16.12	
Hyllie	13.14	13.14		13.44	14.15	14.14			14.44	15.15	15.14	15.14			15.44	16.15		16.14	
CPH Airport	13.30	13.30		14.00		14.30			15.00		15.30	15.30			16.00			16.30	
Tårnby	13.34	13.34		14.04		14.34			15.04		15.34	15.34			16.04			16.34	
Ørestad	13.37	13.37		14.07		14.37			15.07		15.37	15.37			16.07			16.37	
København H	13.45	13.45		14.15		14.45			15.15		15.45	15.45			16.15			16.45	

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

TECKENFÖRKLARING

0000	Öresundståg
0000	Pågatåg
0000	Pågatåg Express
L	Endast lördag
L,S	Endast lördag,söndag
M-F	Endast måndag-fredag
S	Endast söndag
f	Kör ej 17 juni - 12 augusti.
g	Kör endast 17 juni - 12 augusti.
h	Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
i	Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Karlskrona–Kristianstad–Malmö–Köpenhamn

	1225	11921	1101	1279	1875	1105	1105	1105	1973	1227	11923	1109	1281	1877	1113	1975	1975	1229	1117
		M-F		M-F	M-F	M-F	L	S	M-F		M-F		M-F	M-F		M-F	L,S		
Karlskrona			13.48									14.48							15.48
Bergåsa			13.51									14.51							15.51
Ronneby			14.09									15.09							16.09
Bräkne-Hoby			14.20									15.20							16.20
Karlshamn			14.36						15.05			15.36				16.05			16.36
Mörrum			14.44						15.12			15.44				16.12			16.44
Sölvesborg			14.58						15.26			15.58				16.26			16.58
Bromölla			15.05						15.34			16.05				16.34	16.34		17.05
Fjälkinge			|						15.44			|				16.44	16.44		|
Kristianstad			15.20						15.53			16.20				16.53	16.53		17.20
Kristianstad	15.04		15.26		15.43					16.04		16.26		16.43				17.04	17.26
Önnestad	15.10		|		15.49					16.10		|		16.49				17.10	|
Vinslöv	15.16		|		15.55					16.16		|		16.55				17.16	|
Hässleholm C	15.26		15.45		16.05					16.26		16.45		17.05				17.26	17.45
Hässleholm C	15.28	15.41	15.47			16.16	16.16	16.16		16.28	16.41	16.47			17.16			17.32	17.47
Sösdala	15.36	|	|			|	|	|		16.36	|	|			|			17.40	|
Tjörnarp	15.40	|	|			|	|	|		16.40	|	|			|			17.44	|
Tjörnarp	15.40	|	|			|	|	|		16.40	|	|			|			17.44	|
Höör	15.45	15.54	|	16.17		16.29	16.29	16.29		16.45	16.54	|	17.17		17.29			17.49	|
Stehag	15.52	|	|	16.24		|	|	|		16.52	|	|	17.24		|			17.56	|
Eslöv	15.58	|	|	16.30		|	|	|		16.58	|	|	17.30		|			18.02	|
Eslöv	15.58	16.05	|	16.33		16.40	16.40	16.40		16.58	17.05	|	17.33		17.40			18.02	|
Örtofta	16.04	|	|	16.39		|	|	|		17.04	|	|	17.39		|			18.08	|
Stångby	16.08	|	|	16.43		|	|	|		17.08	|	|	17.43		|			18.12	|
Lund C	16.12	16.15	16.19	16.47		16.51	16.51	16.51		17.12	17.15	17.19	17.47		17.51			18.16	18.19
Lund C	16.19	16.17	16.21	16.49		16.53	16.53	16.53		17.19	17.17	17.21	17.49		17.53			18.19	18.21
Klostergården	16.21	|	|	16.51		|	|	|		17.21	|	|	17.51		|			18.21	|
Hjärup	16.24	|	|	16.54		|	|	|		17.24	|	|	17.54		|			18.24	|
Åkarp	16.27	|	|	16.57		|	|	|		17.27	|	|	17.57		|			18.27	|
Burlöv	16.30	16.23	16.27	17.00		|	|	|		17.30	17.23	17.27	18.00		|			18.30	18.27
Malmö C	16.36	16.29	16.33	17.06		17.03	17.03	17.03		17.36	17.29	17.33	18.06		18.03			18.36	18.33
Malmö C	16.38	16.32	16.35	17.08		17.05	17.05	17.05		17.38	17.32	17.35	18.08		18.05			18.38	18.35
Triangeln	16.41	16.35	16.38	17.11		17.08	17.08	17.08		17.41	17.35	17.38	18.11		18.08			18.41	18.38
Hyllie	16.45	16.39	16.42	|		17.12	17.12	17.12		17.45	17.39	17.42	|		18.12			18.45	18.42
Hyllie			16.44	17.15		17.14	17.14	17.14				17.44	18.15		18.14				18.44
CPH Airport			17.00			17.30	17.30	17.30				18.00			18.30				19.00
Tårnby			17.04			17.34	17.34	17.34				18.04			18.34				19.04
Ørestad			17.07			17.37	17.37	17.37				18.07			18.37				19.07
København H			17.15			17.45	17.45	17.45				18.15			18.45				19.15

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

TECKENFÖRKLARING

0000	Pågatåg
0000	Pågatåg Express
0000	Öresundståg
L	Endast lördag
L,S	Endast lördag,söndag
M-F	Endast måndag-fredag
S	Endast söndag
f	Kör ej 17 juni - 12 augusti.
g	Kör endast 17 juni - 12 augusti.
h	Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
i	Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Karlskrona–Kristianstad–Malmö–Köpenhamn

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1283	1879	1121	1121	1977	1231	1125	1285	1897	1129	1979	1979	1233	1133	1287	1137	1137	1137	1981
	M-F	M-F	M-F	L,S	M-F			M-F	M-F		M-F	L,S			M-F	M-F	L	S	M-F
Karlskrona							16.48							17.48					
Bergåsa							16.51							17.51					
Ronneby							17.09							18.09					
Bräkne-Hoby							17.20							18.20					
Karlshamn					17.05		17.36				18.05			18.36					
Mörrum					17.12		17.44				18.12			18.44					
Sölvesborg					17.26		17.58				18.26			18.58					
Bromölla					17.34		18.05				18.34	18.34		19.05					19.34
Fjälkinge					17.44		|				18.44	18.44		|					19.44
Kristianstad					17.53		18.20				18.53	18.53		19.20					19.53
Kristianstad		17.43				18.04	18.26		18.43				19.04	19.26					
Önnestad		17.49				18.10	|		18.49				19.10	|					
Vinslöv		17.55				18.16	|		18.55				19.16	|					
Hässleholm C		18.05				18.26	18.45		19.05				19.26	19.45					
Hässleholm C			18.16	18.16		18.32	18.47			19.16			19.32	19.47		20.16	20.16	20.16	
Sösdala			|	|		18.40	|			|			19.40	|		|	|	|	
Tjörnarp			|	|		18.44	|			|			19.44	|		|	|	|	
Tjörnarp			|	|		18.44	|			|			19.44	|		|	|	|	
Höör	18.17		18.29	18.29		18.49	|	19.17		19.29			19.49	|	20.17	20.29	20.29	20.29	
Stehag	18.24		|	|		18.56	|	19.24		|			19.56	|	20.24	|	|	|	
Eslöv	18.30		|	|		19.02	|	19.30		|			20.02	|	20.30	|	|	|	
Eslöv	18.33		18.40	18.40		19.02	|	19.33		19.40			20.02	|	20.33	20.40	20.40	20.40	
Örtofta	18.39		|	|		19.08	|	19.39		|			20.08	|	20.39	|	|	|	
Stångby	18.43		|	|		19.12	|	19.43		|			20.12	|	20.43	|	|	|	
Lund C	18.47		18.51	18.51		19.16	19.19	19.47		19.51			20.16	20.19	20.47	20.51	20.51	20.51	
Lund C	18.49		18.53	18.53		19.19	19.21	19.49		19.53			20.19	20.21	20.49	20.53	20.53	20.53	
Klostergården	18.51		|	|		19.21	|	19.51		|			20.21	|	20.51	|	|	|	
Hjärup	18.54		|	|		19.24	|	19.54		|			20.24	|	20.54	|	|	|	
Åkarp	18.57		|	|		19.27	|	19.57		|			20.27	|	20.57	|	|	|	
Burlöv	19.00		|	|		19.30	19.27	20.00		|			20.30	20.27	21.00	|	|	|	
Malmö C	19.06		19.03	19.03		19.36	19.33	20.06		20.03			20.36	20.33	21.06	21.03	21.03	21.03	
Malmö C	19.08		19.05	19.05		19.38	19.35	20.08		20.05			20.38	20.35	21.08	21.05	21.05	21.05	
Triangeln	19.11		19.08	19.08		19.41	19.38	20.11		20.08			20.41	20.38	21.11	21.08	21.08	21.08	
Hyllie	|		19.12	19.12		19.45	19.42	|		20.12			20.45	20.42	|	21.12	21.12	21.12	
Hyllie	19.15		19.14	19.14			19.44	20.15		20.14				20.44	21.15	21.14	21.14	21.14	
CPH Airport			19.30	19.30			20.00			20.30				21.00		21.30	21.30	21.30	
Tårnby			19.34	19.34			20.04			20.34				21.04		21.34	21.34	21.34	
Ørestad			19.37	19.37			20.07			20.37				21.07		21.37	21.37	21.37	
København H			19.45	19.45			20.15			20.45				21.15		21.45	21.45	21.45	

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg
- 0000 Öresundståg
- L Endast lördag
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag
- S Endast söndag
- f Kör ej 17 juni - 12 augusti.
- g Kör endast 17 juni - 12 augusti.
- h Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
- i Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Karlskrona–Kristianstad–Malmö–Köpenhamn

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1235	1141	1145	1983	1237	1149	1153	1153	1899	1153	1239	1157	1241	1241	1165	1243	1243
							M-F	L		S			M-L	S		M-L	S
Karlskrona		18.48				19.48						20.48			21.48		
Bergåsa		18.51				19.51						20.51			21.51		
Ronneby		19.09				20.09						21.09			22.09		
Bräkne-Hoby		19.20				20.20						21.20			22.20		
Karlshamn		19.36				20.36						21.36			22.36		
Mörrum		19.44				20.44						21.44			22.44		
Sölvesborg		19.58				20.58						21.58			22.58		
Bromölla		20.05		20.34		21.05						22.05			23.05		
Fjälkinge		|		20.44		|						|			|		
Kristianstad		20.20		20.53		21.20						22.20			23.20		
Kristianstad	20.04	20.26			21.04	21.26			21.43		22.04	22.26	23.04	23.04	23.26	00.04	00.04
Önnestad	20.10	|			21.10	|			21.49		22.10	|	23.10	23.10	|	00.10	00.10
Vinslöv	20.16	|			21.16	|			21.55		22.16	|	23.16	23.16	|	00.16	00.16
Hässleholm C	20.26	20.45			21.26	21.45			22.05		22.26	22.45	23.26	23.26	23.45	00.26	00.26
Hässleholm C	20.28	20.47	21.16		21.32	21.47	22.16	22.16		22.16	22.32	22.47	23.32	23.32	23.47	00.32	
Sösdala	20.36	|	|		21.40	|	|	|		|	22.40	|	23.40	23.40	|	00.40	
Tjörnarp	20.40	|	|		21.44	|	|	|		|	22.44	|	23.44	23.44	|	00.44	
Tjörnarp	20.44	|	|		21.44	|	|	|		|	22.44	|	23.44	23.44	|	00.44	
Höör	20.49	|	21.29		21.49	|	22.29	22.29		22.29	22.49	|	23.49	23.49	|	00.49	
Stehag	20.55	|	|		21.56	|	|	|		|	22.56	|	23.56	23.56	|	00.56	
Eslöv	21.01	|	|		22.02	|	|	|		|	23.02	|	00.02	00.02	|	01.02	
Eslöv	21.04	|	21.40		22.02	|	22.40	22.40		22.40	23.02	|	00.02	00.02	|	01.02	
Örtofta	21.10	|	|		22.08	|	|	|		|	23.08	|	00.08	00.08	|	01.08	
Stångby	21.13	|	|		22.12	|	|	|		|	23.12	|	00.12	00.12	|	01.12	
Lund C	21.17	21.19	21.51		22.16	22.19	22.51	22.51		22.51	23.16	23.19	00.16	00.16	00.19	01.16	
Lund C	21.19	21.21	21.53		22.19	22.21	22.53	22.53		22.53	23.19	23.21	00.19	00.23	00.21	01.19	
Klostergården	21.21	|	|		22.21	|	|	|		|	23.21	|	00.21	00.25	|	01.21	
Hjärup	21.24	|	|		22.24	|	|	|		|	23.24	|	00.24	00.28	|	01.24	
Åkarp	21.27	|	|		22.27	|	|	|		|	23.27	|	00.27	00.31	|	01.27	
Burlöv	21.30	21.27	|		22.30	22.27	|	|		|	23.30	23.27	00.30	00.34	00.27	01.30	
Malmö C	21.36	21.33	22.03		22.36	22.33	23.03	23.03		23.03	23.36	23.33	00.36	00.40	00.33	01.36	
Malmö C	21.38	21.35	22.05		22.38	22.35	23.05	23.05		23.05	23.38	23.35	00.38	00.42	00.35	01.38	
Triangeln	21.41	21.38	22.08		22.41	22.38	23.08	23.08		23.08	23.41	23.38	00.41	00.45	00.38	01.41	
Hyllie	21.45	21.42	22.12		22.45	22.42	23.12	23.12		23.12	23.45	23.42	00.45	00.48	00.42	01.45	
Hyllie		21.44	22.14			22.44	23.14	23.14		23.14		23.44			00.44		
CPH Airport		22.00	22.30			23.00	23.30	23.30		23.30		00.00			01.00		
Tårnby		22.04	22.34			23.04	23.34	23.34		23.34		00.04			01.04		
Ørestad		22.07	22.37			23.07	23.37	23.37		23.37		00.07			01.07		
København H		22.15	22.45			23.15	23.47	23.47		23.47		00.17			01.15		

TECKENFÖRKLARING

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- f Kör ej 17 juni - 12 augusti.
- g Kör endast 17 juni - 12 augusti.
- h Kör ej 27 december 2023, samt 2 januari och 2 april 2024.
- i Kör endast 27 december 2023, samt 2 januari och 2 april 2024.

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1952	1892	11000	1202	1954	1854	1894	1252	1252	1004	1204	1956	1254	1008	1856	1896	1012	1012	11900	1206	1958
	M-F	M-F	M-F	M-F	M-F	M-F	L,S	M-F	L,S	M-F	M-F	M-F	M-F	M-F	M-F	L,S	M-L	S	M-F		M-F
København H										04.44				05.14			05.44	05.44			
Ørestad										04.51				05.21			05.51	05.51			
Tårnby										04.54				05.24			05.54	05.54			
CPH Airport										04.59				05.29			05.59	05.59			
Hyllie										05.12				05.42			06.12	06.12			
Hyllie				04.15					04.45	05.18	05.15		05.45	05.48			06.18	06.18	06.22	06.15	
Triangeln				04.18					04.48	05.21	05.18		05.48	05.51			06.21	06.21	06.25	06.18	
Malmö C				04.22					04.52	05.25	05.22		05.52	05.55			06.25	06.25	06.29	06.22	
Malmö C				04.26				04.54	04.54	05.27	05.24		05.54	05.57			06.27	06.27	06.31	06.24	
Burlöv				04.31				04.59	04.59	05.32	05.29		05.59	|			06.32	06.32	06.36	06.29	
Åkarp				04.34				05.02	05.02	|	05.32		06.02	|			|	|	|	06.32	
Hjärup				04.37				05.05	05.05	|	05.35		06.05	|			|	|	|	06.35	
Klostergården				04.40				05.08	05.08	|	05.38		06.08	|			|	|	|	06.38	
Lund C				04.43				05.11	05.11	05.39	05.41		06.11	06.07			06.39	06.39	06.43	06.41	
Lund C				04.44				05.13	05.13	05.41	05.44		06.13	06.09			06.41	06.41	06.45	06.48	
Stångby				04.48				05.17	05.17	|	05.48		06.17	|			|	|	|	06.52	
Örtofta				04.51				05.20	05.20	|	05.51		06.20	|			|	|	|	06.55	
Eslöv				|				05.25	05.25	|	|		06.25	|			|	|	|	|	
Eslöv				04.57				05.30	05.30	|	05.57		06.30	06.18			|	|	06.54	07.00	
Stehag				05.03				05.37	05.37	|	06.03		06.37	|			|	|	|	07.06	
Höör				05.09				05.43	05.43	|	06.09		06.43	06.29			|	|	07.04	07.12	
Tjörnarp				05.15						|	06.15			|			|	|	|	07.18	
Sösdala				05.19						|	06.19			|			|	|	|	07.22	
Hässleholm C				05.27						|	06.27			06.43			|	|	07.19	07.30	
Hässleholm C		04.55	05.11	05.34		05.55	05.55			06.11	06.34				06.55	06.55	07.11	07.11	07.21	07.34	
Vinslöv		05.04	|	05.44		06.04	06.04			|	06.44				07.04	07.04	|	|		07.44	
Önnestad		05.10	|	05.50		06.10	06.10			|	06.50				07.10	07.10	|	|		07.50	
Kristianstad		05.16	05.33	05.56		06.16	06.16			06.33	06.56				07.16	07.16	07.33	07.33		07.56	
Kristianstad	05.02		05.39		06.02					06.39		07.02					07.39				08.02
Fjälkinge	05.11		|		06.11					|		07.11					|				08.11
Bromölla	05.19		05.52		06.19					06.52		07.19					07.52				08.19
Sölvesborg	05.26		05.59		06.26					06.59		07.26					07.59				08.26
Mörrum	|		06.13		|					07.13		|				08.13				|
Mörrum	05.43		06.14		06.43					07.14		07.43					08.14				08.43
Karlshamn	05.51		06.21		06.51					07.21		07.51					08.21				08.51
Bräkne-Hoby			06.37							07.37							08.37				
Ronneby			06.49							07.49							08.49				
Bergåsa			07.08							08.08							09.08				
Karlskrona			07.12							08.12							09.12				

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

0000	Pågatåg
0000	Öresundståg
0000	Pågatåg Express
L,S	Endast lördag,söndag
M-F	Endast måndag-fredag
M-L	Endast måndag-lördag
S	Endast söndag

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1958	1256	1016	1016	1858	1020	11902	1208	1860	1258	1024	1028	1210	11904	1260	1962	1032	1032	1036	1212	1262
	L,S	M-F	M-F	L,S	M-F		M-F		M-F	M-F				M-F	M-F		M-F	L,S			M-F
København H			06.14	06.14		06.44					07.14	07.44					08.14	08.14	08.44		
Ørestad			06.21	06.21		06.51					07.21	07.51					08.21	08.21	08.51		
Tårnby			06.24	06.24		06.54					07.24	07.54					08.24	08.24	08.54		
CPH Airport			06.29	06.29		06.59					07.29	07.59					08.29	08.29	08.59		
Hyllie			06.42	06.42		07.12					07.42	08.12					08.42	08.42	09.12		
Hyllie		06.45	06.48	06.48		07.18	07.22	07.15		07.45	07.48	08.18	08.15	08.22	08.45		08.48	08.48	09.18	09.15	09.45
Triangeln		06.48	06.51	06.51		07.21	07.25	07.18		07.48	07.51	08.21	08.18	08.25	08.48		08.51	08.51	09.21	09.18	09.48
Malmö C		06.52	06.55	06.55		07.25	07.29	07.22		07.52	07.55	08.25	08.22	08.29	08.52		08.55	08.55	09.25	09.22	09.52
Malmö C		06.54	06.57	06.57		07.27	07.31	07.24		07.54	07.57	08.27	08.24	08.31	08.54		08.57	08.57	09.27	09.24	09.54
Burlöv		06.59	|	|		07.32	07.36	07.29		07.59	|	08.32	08.29	08.36	08.59		|	|	09.32	09.29	09.59
Åkarp		07.02	|	|		|	|	07.32		08.02	|	|	08.32	|	09.02		|	|	|	09.32	10.02
Hjärup		07.05	|	|		|	|	07.35		08.05	|	|	08.35	|	09.05		|	|	|	09.35	10.05
Klostergården		07.08	|	|		|	|	07.38		08.08	|	|	08.38	|	09.08		|	|	|	09.38	10.08
Lund C		07.11	07.07	07.07		07.39	07.43	07.41		08.11	08.07	08.39	08.41	08.43	09.11		09.07	09.07	09.39	09.41	10.11
Lund C		07.13	07.09	07.09		07.41	07.45	07.48		08.13	08.09	08.41	08.48	08.45	09.13		09.09	09.09	09.41	09.44	10.13
Stångby		07.17	|	|		|	|	07.52		08.17	|	|	08.52	|	09.17		|	|	|	09.48	10.17
Örtofta		07.20	|	|		|	|	07.55		08.20	|	|	08.55	|	09.20		|	|	|	09.51	10.20
Eslöv		07.25	|	|		|	|	|		08.25	|	|	|	|	09.25		|	|	|	|	10.25
Eslöv		07.30	07.18	07.18		|	07.54	08.00		08.30	08.18	|	09.00	08.54	09.33		09.18	09.18	|	09.57	10.30
Stehag		07.37	|	|		|	|	08.06		08.37	|	|	09.06	|	09.40		|	|	|	10.03	10.37
Höör		07.43	07.29	07.29		|	08.04	08.12		08.43	08.29	|	09.12	09.04	09.46		09.29	09.29	|	10.09	10.43
Tjörnarp			|	|		|	|	08.18			|	|	09.18	|			|	|	|	10.15	
Sösdala			|	|		|	|	08.22			|	|	09.22	|			|	|	|	10.19	
Hässleholm C			07.43	07.43		|	08.18	08.30			08.43	|	09.30	09.19			09.43	09.43	|	10.27	
Hässleholm C					07.55	08.11		08.34	08.55			09.11	09.34						10.11	10.34	
Vinslöv					08.04	|		08.44	09.04			|	09.44						|	10.44	
Önnestad					08.10	|		08.50	09.10			|	09.50						|	10.50	
Kristianstad					08.16	08.33		08.56	09.16			09.33	09.56						10.33	10.56	
Kristianstad	08.02					08.39						09.39				10.02			10.39		
Fjälkinge	08.11					|						|				10.11			|		
Bromölla	08.19					08.52						09.52				10.19			10.52		
Sölvesborg						08.59						09.59							10.59		
Mörrum						09.13						10.13							11.13		
Mörrum						09.14						10.14							11.14		
Karlshamn						09.21						10.21							11.21		
Bräkne-Hoby						09.37						10.37							11.37		
Ronneby						09.49						10.49							11.49		
Bergåsa						10.08						11.08							12.08		
Karlskrona						10.12						11.12							12.12		

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg
- 0000 Öresundståg
- 0000 Pågatåg Express
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1040	1044	1214	1966	1264	1048	1048	1052	1216	1266	1056	1060	1218	1970	1970	1898	1268	1064	1064	1064	1068
					M-F	M-F	L,S			M-F				M-F	L,S	M-F	M-F	M-F	L	S	
København H	09.14	09.44				10.14	10.14	10.44			11.14	11.44						12.14	12.14	12.14	12.44
Ørestad	09.21	09.51				10.21	10.21	10.51			11.21	11.51						12.21	12.21	12.21	12.51
Tårnby	09.24	09.54				10.24	10.24	10.54			11.24	11.54						12.24	12.24	12.24	12.54
CPH Airport	09.29	09.59				10.29	10.29	10.59			11.29	11.59						12.29	12.29	12.29	12.59
Hyllie	09.42	10.12				10.42	10.42	11.12			11.42	12.12						12.42	12.42	12.42	13.12
Hyllie	09.48	10.18	10.15		10.45	10.48	10.48	11.18	11.15	11.45	11.48	12.18	12.15				12.45	12.48	12.48	12.48	13.18
Triangeln	09.51	10.21	10.18		10.48	10.51	10.51	11.21	11.18	11.48	11.51	12.21	12.18				12.48	12.51	12.51	12.51	13.21
Malmö C	09.55	10.25	10.22		10.52	10.55	10.55	11.25	11.22	11.52	11.55	12.25	12.22				12.52	12.55	12.55	12.55	13.25
Malmö C	09.57	10.27	10.24		10.54	10.57	10.57	11.27	11.24	11.54	11.57	12.27	12.24				12.54	12.57	12.57	12.57	13.27
Burlöv	|	10.32	10.29		10.59	|	|	11.32	11.29	11.59	|	12.32	12.29				12.59	|	|	|	13.32
Åkarp	|	|	10.32		11.02	|	|	|	11.32	12.02	|	|	12.32				13.02	|	|	|	|
Hjärup	|	|	10.35		11.05	|	|	|	11.35	12.05	|	|	12.35				13.05	|	|	|	|
Klostergården	|	|	10.38		11.08	|	|	|	11.38	12.08	|	|	12.38				13.08	|	|	|	|
Lund C	10.07	10.39	10.41		11.11	11.07	11.07	11.39	11.41	12.11	12.07	12.39	12.41				13.11	13.07	13.07	13.07	13.39
Lund C	10.09	10.41	10.44		11.13	11.09	11.09	11.41	11.44	12.13	12.09	12.41	12.44				13.13	13.09	13.09	13.09	13.41
Stångby	|	|	10.48		11.17	|	|	|	11.48	12.17	|	|	12.48				13.17	|	|	|	|
Örtofta	|	|	10.51		11.20	|	|	|	11.51	12.20	|	|	12.51				13.20	|	|	|	|
Eslöv	|	|	|		11.25	|	|	|	|	12.25	|	|	|				13.25	|	|	|	|
Eslöv	10.18	|	10.57		11.30	11.18	11.18	|	11.57	12.30	12.18	|	12.57				13.30	13.18	13.18	13.18	|
Stehag	|	|	11.03		11.37	|	|	|	12.03	12.37	|	|	13.03				13.37	|	|	|	|
Höör	10.29	|	11.09		11.43	11.29	11.29	|	12.09	12.43	12.29	|	13.09				13.43	13.29	13.29	13.29	|
Tjörnarp	|	|	11.15			|	|	|	12.15		|	|	13.15					|	|	|	|
Sösdala	|	|	11.19			|	|	|	12.19		|	|	13.19					|	|	|	|
Hässleholm C	10.43	|	11.27			11.43	11.43	|	12.27		12.43	|	13.27					13.43	13.43	13.43	|
Hässleholm C		11.11	11.34					12.11	12.34			13.11	13.34			13.55					14.11
Vinslöv		|	11.44					|	12.44			|	13.44			14.04					|
Önnestad		|	11.50					|	12.50			|	13.50			14.10					|
Kristianstad		11.33	11.56					12.33	12.56			13.33	13.56			14.16					14.33
Kristianstad		11.39		12.02				12.39				13.39		14.02	14.02						14.39
Fjälkinge		|		12.11				|			|		14.11	14.11						|
Bromölla		11.52		12.19				12.52				13.52		14.19	14.19						14.52
Sölvesborg		11.59						12.59				13.59		14.26							14.59
Mörrum		12.13						13.13				14.13		|							15.13
Mörrum		12.14						13.14				14.14		14.43							15.14
Karlshamn		12.21						13.21				14.21		14.51							15.21
Bräkne-Hoby		12.37						13.37				14.37									15.37
Ronneby		12.49						13.49				14.49									15.49
Bergåsa		13.08						14.08				15.08									16.08
Karlskrona		13.12						14.12				15.12									16.12

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Öresundståg
- 0000 Pågatåg
- L Endast lördag
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag
- S Endast söndag

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1220	1972	1872	1270	1072	1076	1222	1974	1974	1080	1874	1272	1080	1084	11918	1224	1976	1876	1274	1088	1092
		M-F	M-F	M-F				M-F	L,S	M-F	M-F	M-F	L,S		M-F		M-F	M-F	M-F		
København H					13.14	13.44				14.14			14.14	14.44						15.14	15.44
Ørestad					13.21	13.51				14.21			14.21	14.51						15.21	15.51
Tårnby					13.24	13.54				14.24			14.24	14.54						15.24	15.54
CPH Airport					13.29	13.59				14.29			14.29	14.59						15.29	15.59
Hyllie					13.42	14.12				14.42			14.42	15.12						15.42	16.12
Hyllie	13.15			13.45	13.48	14.18	14.15			14.48		14.45	14.48	15.18	15.22	15.15			15.45	15.48	16.18
Triangeln	13.18			13.48	13.51	14.21	14.18			14.51		14.48	14.51	15.21	15.25	15.18			15.48	15.51	16.21
Malmö C	13.22			13.52	13.55	14.25	14.22			14.55		14.52	14.55	15.25	15.29	15.22			15.52	15.55	16.25
Malmö C	13.24			13.54	13.57	14.27	14.24			14.57		14.54	14.57	15.27	15.31	15.24			15.54	15.57	16.27
Burlöv	13.29			13.59	|	14.32	14.29			|		14.59	|	15.32	15.36	15.29			15.59	|	16.32
Åkarp	13.32			14.02	|	|	14.32			|		15.02	|	|	|	15.32			16.02	|	|
Hjärup	13.35			14.05	|	|	14.35			|		15.05	|	|	|	15.35			16.05	|	|
Klostergården	13.38			14.08	|	|	14.38			|		15.08	|	|	|	15.38			16.08	|	|
Lund C	13.41			14.11	14.07	14.39	14.41			15.07		15.11	15.07	15.39	15.43	15.41			16.11	16.07	16.39
Lund C	13.44			14.13	14.09	14.41	14.44			15.09		15.13	15.09	15.41	15.45	15.48			16.13	16.09	16.41
Stångby	13.48			14.17	|	|	14.48			|		15.17	|	|	|	15.52			16.17	|	|
Örtofta	13.51			14.20	|	|	14.51			|		15.20	|	|	|	15.55			16.20	|	|
Eslöv	|			14.25	|	|	|			|		15.25	|	|	|	|			16.25	|	|
Eslöv	13.57			14.30	14.18	|	14.57			15.18		15.30	15.18	|	15.54	16.00			16.30	16.18	|
Stehag	14.03			14.37	|	|	15.03			|		15.37	|	|	|	16.06			16.37	|	|
Höör	14.09			14.43	14.29	|	15.09			15.29		15.43	15.29	|	16.04	16.12			16.43	16.29	|
Tjörnarp	14.15				|	|	15.15			|			|	|	|	16.18				|	|
Sösdala	14.19				|	|	15.19			|			|	|	|	16.22				|	|
Hässleholm C	14.27				14.43	|	15.27			15.43			15.43	|	16.19	16.30				16.43	|
Hässleholm C	14.34		14.55			15.11	15.34				15.55			16.11		16.34		16.55			17.11
Vinslöv	14.44		15.04			|	15.44				16.04			|		16.44		17.04			|
Önnestad	14.50		15.10			|	15.50				16.10			|		16.50		17.10			|
Kristianstad	14.56		15.16			15.33	15.56				16.16			16.33		16.56		17.16			17.33
Kristianstad		15.02				15.39		16.02	16.02					16.39			17.02				17.39
Fjälkinge		15.11				|		16.11	16.11					|			17.11				|
Bromölla		15.19				15.52		16.19	16.19					16.52			17.19				17.52
Sölvesborg		15.26				15.59		16.26						16.59			17.26				17.59
Mörrum		|				16.13		|						17.13			|				18.13
Mörrum		15.43				16.14		16.43						17.14			17.43				18.14
Karlshamn		15.51				16.21		16.51						17.21			17.51				18.21
Bräkne-Hoby						16.37								17.37							18.37
Ronneby						16.49								17.49							18.49
Bergåsa						17.08								18.08							19.08
Karlskrona						17.12								18.12							19.12

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg
- 0000 Öresundståg
- 0000 Pågatåg Express
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1226	1978	11920	1878	1276	1096	1096	1100	1228	1980	11922	1278	1104	1108	1230	1230	1982	1280	1112	1112	1116
		L,S	M-F	M-F	M-F	M-F,S	L			M-F	M-F	M-F			M-L	S		M-F	M-F,S	L	
København H						16.14	16.14	16.44					17.14	17.44					18.14	18.14	18.44
Ørestad						16.21	16.21	16.51					17.21	17.51					18.21	18.21	18.51
Tårnby						16.24	16.24	16.54					17.24	17.54					18.24	18.24	18.54
CPH Airport						16.29	16.29	16.59					17.29	17.59					18.29	18.29	18.59
Hyllie						16.42	16.42	17.12					17.42	18.12					18.42	18.42	19.12
Hyllie	16.15		16.22		16.45	16.48	16.48	17.18	17.15		17.22	17.45	17.48	18.18	18.15	18.15		18.45	18.48	18.48	19.18
Triangeln	16.18		16.25		16.48	16.51	16.51	17.21	17.18		17.25	17.48	17.51	18.21	18.18	18.18		18.48	18.51	18.51	19.21
Malmö C	16.22		16.29		16.52	16.55	16.55	17.25	17.22		17.29	17.52	17.55	18.25	18.22	18.22		18.52	18.55	18.55	19.25
Malmö C	16.24		16.31		16.54	16.57	16.57	17.27	17.24		17.31	17.54	17.57	18.27	18.24	18.24		18.54	18.57	18.57	19.27
Burlöv	16.29		16.36		16.59	|	|	17.32	17.29		17.36	17.59	|	18.32	18.29	18.29		18.59	|	|	19.32
Åkarp	16.32		|		17.02	|	|	|	17.32		|	18.02	|	|	18.32	18.32		19.02	|	|	|
Hjärup	16.35		|		17.05	|	|	|	17.35		|	18.05	|	|	18.35	18.35		19.05	|	|	|
Klostergården	16.38		|		17.08	|	|	|	17.38		|	18.08	|	|	18.38	18.38		19.08	|	|	|
Lund C	16.41		16.43		17.11	17.07	17.07	17.39	17.41		17.43	18.11	18.07	18.39	18.41	18.41		19.11	19.07	19.07	19.39
Lund C	16.48		16.45		17.13	17.09	17.09	17.41	17.48		17.45	18.13	18.09	18.41	18.44	18.48		19.13	19.09	19.09	19.41
Stångby	16.52		|		17.17	|	|	|	17.52		|	18.17	|	|	18.48	18.53		19.17	|	|	|
Örtofta	16.55		|		17.20	|	|	|	17.55		|	18.20	|	|	18.51	18.56		19.20	|	|	|
Eslöv	|		|		17.25	|	|	|	|		|	18.25	|	|	|	|		19.25	|	|	|
Eslöv	17.00		16.54		17.30	17.18	17.18	|	18.00		17.54	18.30	18.18	|	18.57	19.02		19.30	19.18	19.18	|
Stehag	17.06		|		17.37	|	|	|	18.06		|	18.37	|	|	19.03	19.08		19.37	|	|	|
Höör	17.12		17.04		17.43	17.29	17.29	|	18.12		18.04	18.43	18.29	|	19.09	19.14		19.43	19.29	19.29	|
Tjörnarp	17.18		|			|	|	|	18.18		|		|	|	19.15	19.20			|	|	|
Sösdala	17.22		|			|	|	|	18.22		|		|	|	19.19	19.24			|	|	|
Hässleholm C	17.30		17.19			17.43	17.43	|	18.30		18.19		18.43	|	19.27	19.32			19.43	19.43	|
Hässleholm C	17.34			17.55				18.11	18.34					19.11	19.34	19.34					20.11
Vinslöv	17.44			18.04				|	18.44					|	19.44	19.44					|
Önnestad	17.50			18.10				|	18.50					|	19.50	19.50					|
Kristianstad	17.56			18.16				18.33	18.56					19.33	19.56	19.56					20.33
Kristianstad		18.02						18.39		19.02				19.39			20.02				20.39
Fjälkinge		18.11						|		19.11				|			20.11				|
Bromölla		18.19						18.52		19.19				19.52			20.19				20.52
Sölvesborg								18.59						19.59							20.59
Mörrum								19.13						20.13							21.13
Mörrum								19.14						20.14							21.14
Karlshamn								19.21						20.21							21.21
Bräkne-Hoby								19.37						20.37							21.37
Ronneby								19.49						20.49							21.49
Bergåsa								20.08						21.08							22.08
Karlskrona								20.12						21.12							22.12

4–14 juli utför Trafikverket banarbeten mellan Hässleholm och Bromölla/Karlshamn. Sök din resa i appen eller på skanetrafiken.se

TECKENFÖRKLARING

- 0000 Pågatåg
- 0000 Pågatåg Express
- 0000 Öresundståg
- L Endast lördag
- L,S Endast lördag,söndag
- M-F Endast måndag-fredag
- M-F,S Endast måndag-fredag,söndag
- M-L Endast måndag-lördag
- S Endast söndag

Skånetrafiken

4B Köpenhamn–Malmö–Hässleholm–Kristianstad–Karlskrona

10 december 2023–14 december 2024
Går alla dagar om inget annat anges.
För resor under jul, nyår, påsk, midsommar samt övriga storhelger sök din resa på skanetrafiken.se eller i appen.

	1232	1120	1124	1234	1128	1128	1132	1236	1136	1136	1140	1238	1144	1240	1148	1290	1292
					M-F,S	L			M,Ti,F-	O,To			M-F			M-L	M-L
København H		19.14	19.44		20.14	20.14	20.44		21.14	21.14	21.44		22.14		22.44		
Ørestad		19.21	19.51		20.21	20.21	20.51		21.21	21.21	21.51		22.21		22.51		
Tårnby		19.24	19.54		20.24	20.24	20.54		21.24	21.24	21.54		22.24		22.54		
CPH Airport		19.29	19.59		20.29	20.29	20.59		21.29	21.29	21.59		22.29		22.59		
Hyllie		19.42	20.12		20.42	20.42	21.12		21.42	21.42	22.12		22.42		23.13		
Hyllie	19.15	19.48	20.18	20.15	20.48	20.48	21.18	21.15	21.48	21.48	22.18	22.15	22.48	23.15	23.18	23.45	00.45
Triangeln	19.18	19.51	20.21	20.18	20.51	20.51	21.21	21.18	21.51	21.51	22.21	22.18	22.51	23.18	23.21	23.48	00.48
Malmö C	19.22	19.55	20.25	20.22	20.55	20.55	21.25	21.22	21.55	21.55	22.25	22.22	22.55	23.22	23.25	23.52	00.52
Malmö C	19.24	19.57	20.27	20.24	20.57	20.57	21.27	21.24	21.57	21.57	22.27	22.24	22.57	23.24	23.27	23.54	00.54
Burlöv	19.29	|	20.32	20.29	|	|	21.32	21.29	|	|	22.32	22.29	|	23.29	23.32	23.59	00.59
Åkarp	19.32	|	|	20.32	|	|	|	21.32	|	|	|	22.32	|	23.32	|	00.02	01.02
Hjärup	19.35	|	|	20.35	|	|	|	21.35	|	|	|	22.35	|	23.35	|	00.05	01.05
Klostergården	19.38	|	|	20.38	|	|	|	21.38	|	|	|	22.38	|	23.38	|	00.08	01.08
Lund C	19.41	20.07	20.39	20.41	21.07	21.07	21.39	21.41	22.07	22.07	22.39	22.41	23.07	23.41	23.39	00.11	01.11
Lund C	19.44	20.09	20.41	20.44	21.09	21.09	21.41	21.44	22.09	22.09	22.41	22.44	23.09	23.44	23.41	00.13	01.13
Stångby	19.48	|	|	20.48	|	|	|	21.48	|	|	|	22.48	|	23.48	|	00.17	01.17
Örtofta	19.51	|	|	20.51	|	|	|	21.51	|	|	|	22.51	|	23.51	|	00.21	01.21
Eslöv	|	|	|	|	|	|	|	|	|	|	|	|	|	|	|	00.26	01.26
Eslöv	19.57	20.18	|	20.57	21.18	21.18	|	21.57	22.18	22.18	|	22.57	23.18	23.57	|	00.26	01.26
Stehag	20.03	|	|	21.03	|	|	|	22.03	|	|	|	23.03	|	00.03	|	00.33	01.33
Höör	20.09	20.29	|	21.09	21.29	21.29	|	22.09	22.29	22.29	|	23.09	23.29	00.09	|	00.39	01.39
Tjörnarp	20.15	|	|	21.15	|	|	|	22.15	|	|	|	23.15	|	00.15	|	00.45	01.45
Sösdala	20.19	|	|	21.19	|	|	|	22.19	|	|	|	23.19	|	00.19	|	00.49	01.49
Hässleholm C	20.27	20.43	|	21.27	21.43	21.43	|	22.27	22.43	22.43	|	23.27	23.43	00.27	|	00.57	01.57
Hässleholm C	20.34		21.11	21.34			22.11	22.34			23.11	23.34			00.11		
Vinslöv	20.44		|	21.44			|	22.44			|	23.44			|		
Önnestad	20.50		|	21.50			|	22.50			|	23.50			|		
Kristianstad	20.56		21.33	21.56			22.33	22.56			23.33	23.56			00.33		
Kristianstad			21.39				22.39										
Fjälkinge			|				|										
Bromölla			21.52				22.52										
Sölvesborg			21.59				22.59										
Mörrum			22.13				23.13										
Mörrum			22.14				23.14										
Karlshamn			22.21				23.21										
Bräkne-Hoby			22.37				23.37										
Ronneby			22.49				23.49										
Bergåsa			23.08				00.08										
Karlskrona			23.12				00.12										

TECKENFÖRKLARING

0000	Pågatåg
0000	Öresundståg
L	Endast lördag
M,Ti,F-S	Endast måndag,tisdag,fredag-söndag
M-F	Endast måndag-fredag
M-F,S	Endast måndag-fredag,söndag
M-L	Endast måndag-lördag
O,To	Endast onsdag,torsdag

Skånetrafiken