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- A hedonic price approach

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Roslagsbanan's effect on property prices - a hedonic price approach

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Abstract

In recent years has attention been turned to health and environmental effects of public transportation. Especially since Infrastrukturpropositionen (1996/97:53) clearly stated an aim of reducing environmental effects caused by public transportation. In the northeast suburbs of Stockholm is the debated train Roslagsbanan providing access to and from the city. Besides easy access, Roslagsbanan generates disturbing noise. It reaches a maximum level of 70 dB(A) and equivalent level (average)55 dB(A). Since the train has obvious benefits and costs (in measure of environmental quality) it would be interesting to see the how property-owners actually are affected by it. This study is therefore scrutinising how noise and accessibility to the city affect prices on houses in two suburbs, Täby and Danderyd. The commonly used evaluation method for non-marketable goods, Hedonic price model is applied. Since accessibility and noise can be are regarded as non-marketable characteristics of houses, the hedonic price model approach can be used to estimate implicit prices of these characteristic (when all else held constant). The result for noise was unfortunately not significant. Nevertheless was a relationship between accessibility and house prices depicted. It was shown that the implicit price increased as distance to closest station increased until it reached 1000 meters, then implicit price decreased. To conclude, further research is requested to finally make a general statement about the effect Roslagsbanan has on property prices.

Sammanfattning

De senaste åren har hälso- och miljöaspekter av kollektivtrafiken blivit upmärkasammad. Särkilt sedan Infrastrukturpropositionen (1996/97:53) särskilt uttryckt målet att minimera miljö-och hälsoeffekter från kollektivtrafiken. Det inkluderar Roslagsbanan som förser de nordöstra förorterna i Stockholm med transportmöjligheter in till Stockholm city. Uttöver transport medför Roslagsbanan mycket oljud. Maximala ljudnivån uppnår 70dBa, och en genomsnittlig nivå på 55 dBa. Tåget har alltså både för-och nackdelar vilket borde påverka bostadpriserna, då de faktiskt skulle kunna ses som egenskaper till ett hus. Därför undersöker detta arbete hur ljud och kommunikationsmöjligheter påverkar huspriser i Täby och Danderyd. Den frekvent använda värderingsmetoden Hedonisk Prisstudie appliceras i det här arbetet för att med estimeringmetoden OLS estimera de potentiella effekterna roslagsbanan har. Resultatet för oljudet visar sig tyvärr insignificant. Därför kan inga generella slutsatser om ljud dras. Däremot visade avstånd till närmsta station ha en positiv effekt till och med 1000 meter, var efter priserna avtog. Det visade ändå intresanta resultat och god potential för fortsatta undersökningar.

Table of content

1. Introduction

The first part of the paper will provide a brief background story of the subject. Then the research question is presented followed by a short review of the literature about Hedonic price models and noise.

1.2 Background

In 1885 a narrow-tracked train was constructed in effort of transporting foods and goods in the northeast communities of Stockholm. The train's functions developed and today Roslagsbanan serves as an easy transportation system to and from Stockholm. The train departs from Östra Station (located on Valhallavägen) and passes the northeast municipalities; Norrtälje, Vallentuna, Öteråker, Vaxholm, Täby and Danderyd. The northeast sector has nowadays about 250 000 inhabitants that potentially could use Roslagsbanan (SLL 2015).

Figure 1. Map of Roslagsbanan (SLL, 2015).

The train system consists of 38 stations, divided into three different sections; L27Kårsta, L28Österskär and L29 Näsbypark. Together all three sections provides 65 km railroads that passes different characters of habitations. This is directly reflected in the train traffic. The train only stops at stations where habitation is high, otherwise the train continues without stops (Ibid).

Roslagsbanan is a condition for people in north of Stockholm suburbs to arrive at work, school, to healthcare and hobbies. In 2014, approximately 45 000 people used the train to commute each day. The suburbs are growing; hence increased capacity is required in effort of managing the expanding communities. Stockholms län and landsting(SLL, 2016) has therefore decided to improve the train system. A great refurbishment has started, eventually will 22 kilometres of double railways be built, as well as noise protection. In addition, trains and the railway stations will be upgraded. This project is approved by the municipality of Täby and Danderyd and is appreciated to cost about 8 billions (ibid). The refurbishment will generate more departures, easier access to the city but also more noise. (SLL, 2015)

Henceforth is Roslagsbanan clearly an aim of great investments and a major resource for the society. Since profound efforts are put on Roslagsbnanan it is essential to look further at it's potential influence. Apart from transportation, it generates one particularly negative effect; noise. The households next to the tracks are strongly affected by the noise. Several habitants have expressed their discontentment with Roslagsbanan (Danderydsbormotbuller 2015). SL tries to redeem for the inconvenience by (if needed) building noise protection on patios and protection walls along side the tracks (SLL).
250 properties has been offered local noise protection, among them has 47 been implemented and 67 are about to write contracts with property owners.

The train traffic was 2014 and still is estimated with the following frequency;

- six trains /hour in rush-hour to/from Ormsta and Österskär
- three trains per hour to Lindholmen
- three trains per hour to Näsbypark
- 40-minuts train interval to Kårsta

(SL, 2014)

Infrastrukturpropositionen 1996/97:53(Sveriges Riksdag 1996) suggest a further development of environmental adjusted traffic systems. SLL (2015) has attempted to implement the new directional on traffic and created ”Program Roslagsbanan” in effort of reaching the guidelines according to the environmental coordinated proposition. Guidelines are formed for equivalent level and maximum level of noise. Denoted the average perceived level of noise and the occasional maximum level of noise. The recommended levels are; Outdoors; equivalent noise level 55 dBA at the façade. Maximum 70 dBA on patios. Indoors; a maximum of 45 dBA (SLL, 2015).

Even though the most alarming cases of noise distribution is redeemed by SLL, one could still assume that the noise would (if not harmful) still be noticeable, and thereby inevitably be a character of the house. Assuming that all characters of a house determine the property price (marketable and non-marketable), noise would have an impact too(Monson 2009).

The house market is a debated subject due to several reasons that won't be discussed in this paper(TT, 2016). Even so is it a reason to investigate the market with a perhaps newer perspective with focus on environmental qualities. I find it therefor interesting and relevant to look into the potential effect public transportation's noise has on price. Particularly to see if either the benefits or negative externalities dominates one or the other in measures of house prices.

This implies dealing with the regular difficulties of environmental qualities that obviously are non-marketable goods. Luckily there are methods to depict implicit prices for characters of houses. This is called hedonic price model (Haab and McConnell 2002).

By approximating a model it will be possible to generate implicit prices on non-marketable and marketable qualities like square meters and sound quality. When using information of the measured characters of houses (square meters, number of bedrooms among others) the value of air quality (sound) will be discovered.

Succeeding with this model will bring another aspect on public transportation that has perhaps not been disentangled for public transportation in this area before. This is particularly topical due to the wide discussion of the pressured real-estate market (Lucas and Sprängs 2015). Creating a wider view on values of houses associated with transportation possibilities may play a great role for private house owners and also politicians in the area.

1.3 Research question and hypothesis

The purpose of this research is to conclude how Roslagsbanan affect property prices in Täby and Danderyd. In effort to conclude the influence, implicit prices for houses in the effected area of Roslagsbanan will be estimated. Two questions will be answered.

1. Does proximity to Roslagsbanan increase property prices in Täby and Danderyd?
2. Will Roslagsbanan's noise decrease property prices in Täby and Danderyd?

Hypothesis is that proximity to Roslagsbanan will increase property prices after a certain distance. After certain meters where households are not experiencing noise, only benefits of the public transport service will be given. The value of accessibility will dominate the negative effect of being close to the train.

Noise will likely have a negative effect on property prices. Nevertheless it is interesting to see to what extent, if the importance is limited or essential for property buyers. If the noise level isn't essential, it is unlikely that it outshines the benefit of transport service.

1.4 Literature review

In the following section, literature within the subject will briefly summarized and reviewed. The content in the literature review will later in the paper be referred to.

Several studies have investigated property price's relationship to traffic using a hedonic price model. There are several studies on high intensity train and their affect on property prices. Low intensity traffic is not that commonly studied. Even so has highway traffic proven t be very successfully modelled, which gives good hope for this study.

Initially, to get a wider perspective of the subject Jon. P Nelson (1982) work was read. He looks closer at the relationship of highway traffic and property prices by comparing works. It consists of nine different studies in Canada and the US. The study is a review of the nine different reports. It is done in effort of a possible basis for cost-benefit analysis of potential abatement projects. The result is presented as a noise depreciations sensitivity index. To conclude, the survey imply a 0,16 – 0,63 % discount per decibel. Mean of 0,40 %, furthermore will a house adjacent to a highway with 20 dB have a total discount of 8 %. Even higher discount values are possible for high-income neighbourhoods.

The old studies data, methods and results are reviewed, as well as the studies shortcomings that might bias the results. It makes the review particularly interesting since this study will most likely experience the same limitations. Jon P.Nelson exposes the following specification problems with the hedonic price model approach. Selecting a homogenous sample, measuring the noise level and thirdly controlling for other benefits and adverse effects.

The chosen time and area must include enough co-variance between noise and property prices. This is obviously essential for conducting the model but can however be complicated since it is dealing with a local problem that likely only effect a limited area. Consequently the possible sample can be greatly reduced. To get a satisfying size on the sample, Jon P. Nelson detects that researchers tend to use small areas but increase the sample by pooling sales from several years. Alternatively they include samples from comparable neighbourhoods. This might result in unknown biasness in the coefficients and might reduce the models believability.

Secondly this study summarizes several different approaches to measuring the noise. Four different noise approaches are used.
Energy mean sound level (L_{eq})= Steady state continuous sound level, same energy as the actual time-varying distribution. Day-night average sound level (L_{dn})= Level during a 24-hour time period with a 10dB penalty for noises during 10 p.m. and 7 a.m. Noise pollution-level (NPL)= Equals L_{eq} + 2,56* the standard deviation of the noise distribution.

Each of these indexes tries to capture the nature of the fluctuating noise but none is expressed as more suitable for a hedonic price study. No index is expressed as the most suited one, since each index excludes certain information.

In addition, the most appropriate form of the function is discussed. The functional form is most used, regressing the sound index on property prices, alternatively taking the log on property prices. Most appropriate for these sort of studies shows to be a semi log relationship between the dependent variable (property prices) and noise.

Thirdly, it is necessary to control for other factors influencing property prices. It was shown that most of the characteristically values of neighbourhoods and houses remained the same through time. Controlling for the characters was done with either including a few to a dozen explanatory variables. But when addressing noise in studies over longer time periods,Jon P. Nelson mentions one particular application, to created an interaction variable; a product of the time trend and the noise variable. However, the variable was not evinced to be significant which proves that the assumption of relative constant noise levels is well-founded. That deobfuscates the difficulties of accurately controlling for the noises effect on property prices over time. The negative aspects of the highway was tried to be controlled in several ways, using dummy-variables for visualising road, and index for air pollution level. Overall it was shown that it is very difficult to control for disamenities with the roads. They usually result in biasness in the noise variable, due to correlation with omitted variables for other negative highway characters (ibid).

Andersson, Swärdh and Ögren (2015) are also relevent for this study. They investigate how willingness to pay (WTP) for noise reduction on rail and roads are effected by maximum noise levels contra equivalent noise levels. By empirical testing a saple of 2170 observations, they try to conclude the most adequately modelling of the noise effect on their samples from Falköping, Hässleholm, Borås and Falun. They assume that the effects of noise on property prices are a function of equivalent noise level and maximum noise level. To reflect the influence on price, three categories of explanatory variables are included (characteristics and geographic of the property) in the model. Due to high correlation with max and equivalent level, the difference between the maximum and equivalent level $L_{diff,I}$, is modelled together with $L_{eq,1}$ and an interaction term of $L_{eq,1}$, $L_{diff,I}$. This implies that the implicit price of $L_{eq,1}$ is dependent of $L_{diff,I}$ and vice versa. L_{eq} and L_{di}↵ turned out positive which i surprising since it is assumed to effect prices negative is all other constant. However was the interaction term negative (-2,19), confirming that noise decrease property prices.

In addition to the noise variables, are geographical variables added. Distance to closest station is added in effort of capturing accessibility. Distance to road and railways are added to capture potential negative and positive effects of living close to the traffic. Distance to road is positive which means that the positive value of avoiding noise dominates the value of accessibility. Distance to railway station is negative as expected, conforming the logic of improved accessibility increasing prices (Andersson et al, 2015).

Furthermore, the study settles for a log-log model for train, which turned out successful with a model of R^2 on 0,68. The result showed all three variables illustrating noise significant. L_{eq} showed similar results for both models whilst $L_{diff,I}$ turned out different in the two. This implies that adding the L_{max} (through $L_{diff,}$) captures an extra value of disutility from maximum noise levels. Nevertheless is further research on the subject of a maximum levels role in hedonic pricing demanded (ibid).

Wilhelmsson (2000) uses the hedonic price method to analyse the impact of traffic noise from Bergslagsvägen on single-family houses in a Stockholm suburb. 292 single family-houses in Ängby were modelled in a 6-month period in 1996. The sample is very limited as he only studies houses within 300-meters on each side of the road. Noise levels are calculated based on speed, distance to the road (1 meter) and number of vehicles. Each house can thereby be assigned an estimated noise level.

As mentioned in earlier papers is the willingness to pay for negative externalities often the reason of computing a hedonic model study. Which is the case for Mats Wilhelmsson (2000). He tries to take issues into account, regarding asymmetric information and correcting for property tax. When doing so a great negative relationship between property prices and noise is revealed. An average discount on price of 0,6 % per decibel is concluded and the model has a high R^2 of 0,75. The model manages to have the greatest explanation of the variance of price. Which strongly imply the relevance of this type of study.

2. Theory

As mentioned will a Hedonic price model be used to reveal the implicit prices of each character of the houses in Täby and Danderyd within the chosen area. The following section will emphasize the principal theory of the hedonic price model.

2.1 The Hedonic price model

The hedonic price model is an evaluation technique that is successfully used to value housing attributes. Specifically it is a valuation technique for non-marketable goods that are quality-differentiated. The evaluation is based on the idea that a property's' price is a direct reflection of its characteristics. Houses can be regarded as bundles of attributes Likewise, it is assumed that the consumer's utility from a good/property depend on those attributes the good posses. Henceforth implicit prices can be deducted for each attribute of the house (Haab and McConnell 2002).

Despite it doesn't exist a market for attributes like sea view or quietness; consumers are still clearly willing to pay for sea view or decreased noise. This would be noticed in the prices on properties where consumers on the margin should be able to decide their exposure to noise by choosing location (Nelson 1982).

The hedonic model has widely been used for modelling non marketable goods, particularly air pollution. The modelling started with Waugh's study on differences in vegetable prices in 1926. Not until Rosen elaborated the model was it fully understood. This theory chapter is mainly based on his work. Since then has a vast review of hedonic models been written in the 1980's (Haab and McConnell 2002).

One of the earliest documentation on hedonic approaches towards air quality was written by Ridker, Henning and Nourse in 1967 (ibid). This and more recent work has proven that air quality can very straight forward be reflected in prices, captured by hedonic price model.

For a greater understanding for the method A products price can in a differentiated market be explained by a set of features $\mathbf{z} = (z_1, z_z, z_3 \ldots z_n)$. Where Z is a vector for housing characteristics, and each z represents an attribute of the product like square meters, view and noise for example. Price of the vector z is a function of all features, $P(Z) = P(z_z, z_3 \ldots z_n)$(Rosen 1974).

The next part of the method is based on the assumption that a consumer always strives to maximize their utility. When doing so, the utility from buying a house is maximized as well as the utility they get from buying other goods. Given the utility function, $U(\mathbf{z_1}, \mathbf{z_2}, \mathbf{z_n}, x)$, where x is all other goods, and each z is a feature of a good Z, the utility is maximized given the consumers budget restraint. An optimal bundle of products can be calculated by maximizing the utility function with respect to the budget restraint (ibid).

A consumers budget can be expressed as $Y = X + P(Z_n)$ assuming that the price of good X is normalized to 1. Where Y is income, X is good x and $P(Z_n)$ is the hedonic price equation for good Z. The first order condition for maximizing utility with respect to the budget restriction above will be $dP/dZ_n = P_{zn} = (dU/dZ_n)/(dU/dX)$. Meaning that the consumer chooses the nth feature so that the price $P(z_n)$ = marginal rate of substitution of the characters Z_n for the good X(Mats Wilhelmsson 2000).

Furthermore can the implicit prices of the characteristics be estimated. Meaning that differences in property prices reflected to marginal differences in property characteristics (Bateman, et al 2007). Executed by calculating the partial derivative of the price equation. For example, with respect to traffic noise, then the implicit price of noise can be calculated. Generally for a linear function, the implicit price is calculated as dP/dZ_n. Illustrating the effect of a one unit change in Z_n on price. Henceforth can this be regarded as the marginal willingness to pay for a reduction of the noise on the margin. It is therefor particularly useful when dealing with property prices that might be suffering from negative externalities of highways as mentioned in the literature review (Rosen 1974).

In effort of estimating parameters a regression of the hedonic model is done. The hedonic model is frequently computed in functional form, though criticism is addressed to the form because of not properly capturing the relationship of the characteristics. It is a clear trade off between complete functional form and flexible function form because the risk of increased collinearity of attributes. Consequently this uncertainty is part of causing random error with the estimations. Even so, economic theory doesn't motivate flexible functional forms as more appropriate (Rosen 1974).

Also flexible functional form will likely increase collinearity, the interactive term of a flexible functional form causes even more collinerarity (Haab and McConnell 2002).
Computed in log linear form, the formula of the regression line; $Y = \beta_0 + \Sigma\, \beta_i * x_i + \varepsilon_i$, i=1…,n (ibid).

It should therefor be noted that when selection the functional form, a function is rarely linear. Semi-log form is therefore frequently used with price as dependent variable; meaning only selected variables are in logarithmic form. Alternatively the log-log form can be used when all variables are estimated in logarithmic form. When having a log-linear form, the implicit prices are differently calculated. The equation looking like; $LnP = \beta_0 + \Sigma\, \beta_n * Z_n$. The implicit prices are calculated as $dP/dZ_n = \beta_n * P$ (Rosen 1974).

The dependent variable is often sales prices. The independent variables are supposed to explain the variation in the dependent variable. Only characteristics that surpassingly affect the price should be included in the model, otherwise the result won't show a significant result on how the property prices vary.

The estimation method is done with the commonly used OLS (Ordinary Least Squares). It's a widely used method of estimating parameters of the coefficients in a regression line. The regression line is computed in effort of minimizing the errors of the approximated line and the observations. Furthermore are coefficients included that makes the observed values as close to the estimated function as possible (Stock and Watson 2015).

3. Application

In this section the empirical work of creating a hedonic price equation on Roslagsbanan is presented. The studied years and data set will be presented and thoroughly explained; also summary statistics will be provided. The chosen approach of including the noise will be described. Furthermore will an informative overview of the chosen study area be provided. Finally the limitations of the empirical work will be enhanced and motivated.

3.1 Limitation

The most obvious limitation is the studied area. Like mentioned, Roslagsbanan passes several municipalities, Österskär and Åkersberga to mention two. This study only examines the effect generated by Roslagsbanan has on Täby and Danderyd. These suburbs were chosen because of several reasons. Firstly the houses are quite homogenous in many aspects. Täby and Danderyd are typical suburbs with many different sorts of houses, detached houses and rowhouses to mention a few. The houses are likely to be close to transportation (Roslagbanan) to the city.

In addition both Täby and Danderyd are similar in providing comfort in the form of malls. Both Täby Centrum
and Mörby Centrum are located in the middle of the municipalities and provide grocery shopping and retailing among other services (Mörby centrum/Täby centrum). Also these two municipalities have reported great discontentment of the noise. Almost the whole train section in both Täby and Danderyd passes adjacent houses. The high noises upsets the habitants and has lead to many complaints to SLL. This can be regarded as an indicator that these two municipalities are particularly affected by the noise (SLL, 2016).

One of the highest difficulties in this study is descriptive data. Finding useful information on noise generated by Roslagsbanan has proven to be a great challenge. Luckily it was finally possible to get access of maps illustrating the calculated equivalent noise level (55dBA) and maximum noise level (70dBA) for 2014. These calculations are done for 2014, but will still be useful of sales in earlier years. Very small changes has (noise-wise) taken place, the train departures are fairly the same, the sound is local and is therefor (like mentioned earlier) assumingly constant over time.

Unfortunately, it has not been possible to get information on how exactly these calculations has been made. It is not clear if it takes each particular noise protection into account. Even so, are the calculations isolated and made for Roslagsbanan alone. It does not include other parameters generating noise (SLL, 2015).

There are different approaches to including the effect of noise. Equivalent noise levels are used as well as combinations of other noise variables. In this study has only equivalent dBA and maximum dBA been collected through a map. It has therefor not been possible to assign dBA measures for each house, but rather a summary if the house is within the effected area or not. Assigning dBA for each house would be preferred since it would then be able to calculate implicit prices for a dBA increase. Since this isn’t possible will the interpretation instead be how much max dBA (70) and equivalent dBA (55) affects prices rather than a marginal effect. This should be taken into account when interpreting the result.

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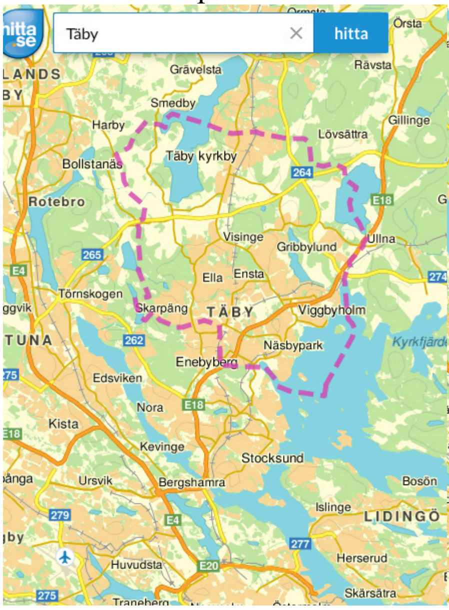
3.2 Area description

Roslagsbanan passes through the municipality of Täby and Danderyd located north of the capital Stockholm. Danderyd and Täby are both part of the county of Stockholm. Danderyd consists of 27 km^2, it is located approximately 12 km from the city. Täby is located about 21 km from the capital and consist of 61 km^2(Hitta.se 2016).



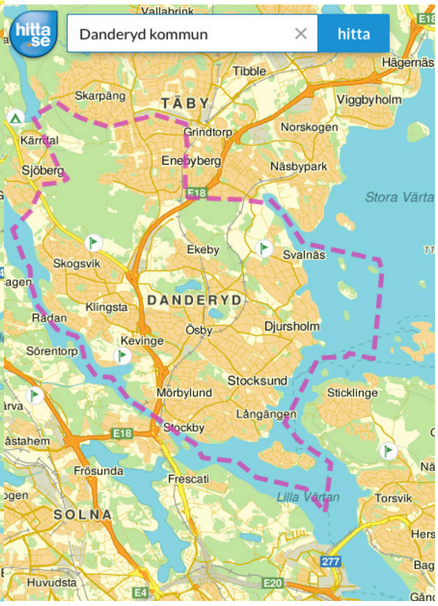


Figure2. Map of Täby (Hitta.se 2016)   Figure 3. Map of Danderyd (Hitta.se 2016).

In 2015, 32 421 people lived in the municipality of Danderyd. The movement of habitants were quite big. Where of 2 909 people moved into Danderyd, whilst 2 741 persons moved from Danderyd. Danderyd presented the highest median income in 2014, of 343 500 SEK, compared to Sweden median 252 774. Illustrated in the map, is Danderyd surrounded by water (SCB, 2014). Täby had 68 281 inhabitants in 2015. 5 286 moved to Täby whilst 3 196 moved from Täby. There is clearly high circulation in both municipalities. Täby has the highest median income after Danderyd of 331 029 SEK (SCB, 2015). Coastal areas are illustrated in the map.

3.3 Data

Valueguard has agreed and given access of sales on houses in Täby and Danderyd between 2012-2015. So a model will be estimated using time series data. The time series is chosen because of two reasons; the departures are nearly unchanged through those years and the estimated noise level are done for 2014. The year 2015 is mainly included to get a large sample with a good potential of a significant result. According to SLL, this should not be a problem since there haven't been any relevant changes that potentially could effect the noise level in the studied area between 2014-2015. Consequently the years 2012-2015 is assumed to be an appropriate time series to study. In total 2389 observations are provided but finally were 1804 used (since they are the only ones that according to SL's travel planner can use Roslagsbanan (SL, 2016)).

The following information is given. The full address of the sold property, The date of the contract, The price of the house in SEK(Price), type of building(BuildT) (00=unknown, 01=detached 02= linked house 03=row-house), points for standard(Standard) (according to The Swedish Tax Agency, large number= higher standard), distance to beach(DistBeach)

(01=less than 75 m and private beach, 02=less than 75 m without private beach, 03= more than 75 m but less than 10 m, 04= more than 150 m to beach). In addition, Number of rooms(Nroom), Property area measured in square meters(PrptyA), Other livingarea or secondary area measured in square meters(OtherLivnA), Livingarea(LivnArea) measured in square meters, Livingarea^2 (LivnArea^2).

In effort of computing a regression with prices of different years, the prices of the properties is corrected to prices of 2012. This way the prices can be compared over time despite inflation. The adjusted prices are computed by dividing each years CPI (Consumer Price Index) index with the index of 2012. The adjusted CPI for each year is after worth multiplied with the relevant price. This regards average income aswell.

Table 1. CPI

	2012	2013	2014	2015
CPI	314,2	314,06	313, 49	313,35
adjCPI	1	0,999554	0,99774	0,997294

3.4 The variables

The model will have the adjusted selling price as dependent variable and commonly to this sort of studies will the price be computed in logarithmic form.

Apart from the information provided by Valueguard has a few more variables have been added to the model. Two dummy-variables for noise is added, they are the most important ones for the study. They should be interpreted as MaxLevel (0= not within affected area, 1=within the area), EqvLevel(0=not within the affected area, 1= within).

This implicate that MaxLevel captures if the house experiences occasional disturbing noise of 70 dB(A). EqvLevel imply that the house is within the area that is constantly experiencing a 55 dB(A) on average (see appendix).

Furthermore is an attempt of isolating the effect of noise caused by Roslagsbanan done by capturing noise from other traffic. The largest road passing Täby/Danderyd is E18. Therefor is a dummy variable introduced for addresses within 300 meters of the Europa way E18. It should be interpreted as 1= 300 m or closer to E18, 0= farther from E18 than 300 meter. This approximation was done in hitta.se(2006) .

Moreover is the travelling time from the closest train station to the end station in Stockholm Östra Station (Stockholm the city) included. The travelling time is estimated in 07.00 am traffic on the SL(2016) website, that suggests the closest station. The estimated travelling time includes minutes of walking to the station and the time spent on the train.
The relationship is likely not linear so the variable is squared in hopes of better capturing the value of short travelling time.

Table 2. Summary statistics

Variable	Mean	Median	Minimum	Maximum
E18	0,065	0	0	1
EqvLevel	0,03	0	0	1
MaxLevel	0,051	0	0	1
BuildT	1,019	0	0	3
BuildYr	1971	1974	1800	2014
Price	5,83E+06	5,30E+06	1,71E+06	1,50E+07
PriceAdj	5,82E+06	5,29E+06	1,71E+06	1,50E+07
LnPrice	15,497	15,481	14,352	16,523
LivnArea	152,16	143	46	415
LivnArea^2	25164	20449	2116	1,72E+05
OthrLivnA	32,091	12	0	4,61E+06
PrptyA	810,27	827	86	1,31E+04
DistBeach	3,983	4	2	4,00
Standard	30,035	30	20	50,00
Nroom	5,949	6	2	13,00
TrvlTme	32,387	33	13	57,00
TrvlTme^2	1093	1056,5	0	3249,00
DistStion	1117,1	1150,5	30	2147,00
DistStion^2	1,52E+06	1,32E+06	900	4,61E+06
Income	35901	33592	23417	5,95E+04
IncomeAdj	25164	20449	2116	1,72E+05

In addition to the travel time, are geographical variables added. Distance to closest station measured in meters is added in effort of capturing accessibility. It is approximated using SL's (2016) travel adviser that gives distance to the closest station from the house.

Finally the model is modified with a socio demographic measure. The average real income for each neighbourhood is added. The information is gathered through hitta.se's "livstilskarta", that is based on data from SCB Skatteverket, Transportstyrelsen och Valmyndigheten. The average income is then calculated with respect to 2012 CPI index like the prices.

The variables associated with marketable characteristics like size and number of rooms are assumed to be positive. According to earlier mentioned literature this is a legit assumption. Beach is expected to be negative since a higher number means larger distance to beach. In earlier mentioned literature has view a clear reflection on price. So being close to the beach would imply sea-view and most likely affect prices positively(Haab and McConnell 2012).

Average income in the neighbourhood is likely positive; meaning that higher income will increase the property prices. This makes sense since buyers are likely to have larger bidding potential. Consequently, even if the realtor correctly estimates the property price, the price is possibly increased if the buyers are wealthier.

Type of building is assumed to be negative, since 03 is row-house, which normally are smaller and less pricy due to less privacy compared to a in other aspects perfectly similar house but detached (Monson 2009). So higher number will decrease dependent variable price. The three binary variables concerning noise are all assume to be negative since if the property is within the affected area = 1. As read in other hedonic price model has all noise or negative externalities variables resulted with variables of negative sign.

The model will hopefully have the following appearance after running the regression on OLS. (same order on coefficients as listed above)

$$LnPrice = \beta_0 - \beta_1*E18 - \beta_2*MaxLevel - \beta_3*EqvLevel - \beta_3*BuildT - \beta_4*TrvlTime + \beta_5*TrvlTime^2 + \beta_6*DistStion - \beta_7*DistStion^2 + \beta_8*OthrLivnA + \beta_9*PrptyA + \beta_{10}*Nroom + \beta_{11}*BuildYr + \beta_{12}*DistBeach + \beta_{13}*Standard + \beta_{14}*IncomeAdj + \beta_{15}*LivnArea + \beta_{16}*LivinArea^2 + \varepsilon_i$$

Where the β's are the parameters to estimate and $\varepsilon_i = 0$.

4. Result

In the following section the econometric result is presented and interpreted. The variables are presented and implicit prices are estimated. Finally the credibility of the model is tested.

4.1 The model

Using the program Gretl, the hedonic model is computed with OLS, correcting with robust standard errors. N = 1804. If one * significant at 90%, ** significant at 95 % and *** significant at 99%.

Table 3. Econometric result

variable	coefficient	std. Error	t-ratio	p-value	
constant	16,337	0,8349	19,57	2,08E-77	***
E18	-0,0471	0,0242	-1,942	0,0523	*
max_level	0,0278	0,0405	0,6858	0,4929	
eqv_level	-0,0326	0,0487	-0,6685	0,5039	
typeofbuilding	-0,07	0,0141	-4,962	7,65E-07	***
traveltime	-0,0818	0,0083	-9,813	3,54E-13	***
traveltime^2	0,0009	0,0001	7,351	2,98E-13	***
distStation	0,0005	5,30E-05	8,461	5,40E-17	***
distStation^2	-1,07E-07	2,30E-08	-4,654	3,49E-06	***
otherlivingA	0,0006	0,0002	2,821	4,80E-03	***
propertyA	0,0001	4,92E-05	2,117	2,96E-02	**
nrrooms	0,0086	6,20E-03	1,386	1,66E-01	
buildingyear	0,0002	4,00E-04	0,4206	6,74E-01	
distancetobeach	-0,2758	3,58E-02	-7,701	2,22E-14	***
standard	0,0071	1,70E-03	4,305	1,76E-05	***
incomeAdj	2,42E-06	7,31E-07	3,313	9,00E-04	***
livingare	0,0074	9,00E-04	8,038	1,65E-15	***
livingarea^2	-1,24E-05	2,37E-06	-5,221	1,99E-07	***
Sum Sqresidual	9,16E+01	S.E of regression	0,227		
Mean dependent var	15,496	S.Ddependvar	0,394		
R-Squared	6,73E-01	R-squaredAdj	0,669		
N= 1804					
Income omitted					

Finally the calculated model is;

LnPrice= 16,3377 – 0,0471*E18 + 0,0278*Maxlevel – 0,0325*Eqvlevel -0,0700*BuildT - 0,0817*TrvlTime + 0,0009*TrvlTime ^{2} + 0,0005*DistStion – 1,06953e-07 DistStion^{2} +0,0006* OthrLivnA+ 0,0001*PrptyA + 0,085*Nroom + 0,0002*BuildYr - 0,2758 *DistBeach + 0,0071* Standard + 2,42130e-06* IncomeAdj + 0,0083*LivnArea -1,477^{-05}*LivinArea^{2}

Income was omitted due to perfect multicollinearity, which is expected since IncomeAdj is solely adjusted income before calculating it to 2012 year CPI. Consequently perfectly correlated and could potentially harm the other approximations accuracy, therefore excluded.

The mean implicit prices are calculated by taking the partial derivative of the price function. So, multiplying the coefficients mean, with mean adjusted price of 5 817 400 SEK. For the variables squared, the implicit prices are calculated differently.

Mean implicit price living area= mean adjusted price+ (0,0083+ 2* 1,477^{-05} *living area mean)
Mean implicit price travel time= mean adjusted price + ((-0,0817)+ 2*0,0009 * traveltime mean))
Mean implicit price of distance to closest station= mean adjusted price + (0,0005+ 2*1,06953e-07 *distance to station mean)
(the explanatory variables coefficient are added in the calculation.

Table 4. Implicit prices

variable	coefficient	implicit mean price	mean
E18	-0,0471	-2,74E+05	
max-level	0,0277	1,61E+05	
ekv_level	-0,0325	-1,89E+05	
typebuilding	-0,07	-4,07E+05	
traveltime	-0,0817	-4,75E+05	32,387
traveltime^2	0,0009	5817432,307	
distStation	0,0005	2,91E+03	1117,1
distStation^2	-1,07E-07	5,82E+06	
otherlivingA	0,0006	3,49E+03	
propertyA	0,0001	5,82E+02	
nrrooms	0,0085	4,94E+04	
buildingyear	-6,14E-05	-3,57E+02	
distancebeach	-0,2756	-1,60E+06	
standard	0,0072	4,19E+04	
incomeAdj	2,42E-06	1,41E+01	
livingarea	0,0083	4,83E+04	1,52E+02
livingare^2	-1,24E-05	5,82E+06	

The implicit prices are estimated with the mean of price, which means that the calculated implicit price is not constant (mean price is part of the formula). This is important when interpreting the result. These calculations can't therefor be regarded as the constant WTP (Willingness to pay) for the characteristics.

4.2 Estimated coefficients

Since the model is computed in semi log form, the result is interpreted as one unit change in X of β_1 is equal a 100 * β_1 % change in property price. However, the variables computed in squared form require further work for interpreting the result.

Overall the result shows in several aspects expected values. The constant was assigned 16,34, which is interpreted as the intercept. Secondary area and lot area both showed the expected signs and are significant at 95 and 99%. Even so is the effect on price very limited. If the lot area is increased 1 m^2 the 0,00058*100 = 0,058 % increase of property prices. However it is worth remembering that there is seldom only 1 m^2 difference in comparable properties. If there were a 10 m^2 difference the effect on price would be more apparent. It could therefor be regarded as a reasonable estimation.

In total was 4 characteristics presented insignificant. Two of them are rather surprising. Number of rooms has in earlier studies (for example Nelson, 1982) reflected the property price quite well but obviously not in this one. Building year did also turn out insignificant with a positive sign. This is not expected since these explanatory variables would normally directly effect the property price, and would therefor also have significant coefficients but not for study. The other variables were successfully estimated with significance of either 95 or 99 %.

Furthermore can the elasticity of the variables be interpreted as; the percentage change in the predicted value of price due to a one-percentage change in the characteristics. So the elasticity of (Y, X) with respect to X is ; $\beta_i * X_i$ (Stock and Watson 2015).

4.3 Econometric credibility

According to the adjusted R^2 the model describes 67 % of the variance of prices. This is a quite high and tells that the model suitably explained differences in houses of Täby and Danderyd. However, Gretl depicted data matrix close to singularity, consequently should all statements and interpretations be carefully handled. This can normally be caused by low variety in the dummy variables (Stock and Watson, 2015). First the problem was tried to dealt with by excluding dummy variables that potentially lacked variance in the sample. Even so was no improvements depicted.

To further analyse the fit of the model, A white's test was computed. It illustrates the variance of the conditional distribution of U, checking for heteroscadasity (if the variance of conditional u vary along X). The null hypothesis is that heteroskedastity is not present, this results in a Lagrangian multiplier of 540,783 and a P-value 1,45087e-042. The null-hypothesis can be rejected if the calculated LM is larger than the calculated chi-square value. This is the case, the chi squared value 161 is distinctly smaller than the LM. Therefor is the null hypothesis rejected, consequently heteroskedasity can be presented which obviously is negative for the models credibility (Stock and Watson, 2015).

In effort to control for multicollinerarity (when relationship between two independent variables are perfectly linear) that can result in inaccurate approximation, a Variance Inflation Test is computed. Where a number above 10 indicates multicollinearity. (Stock and Watson, 2015)

Table 5. VIF test

Variables	value
E18_300	1,092
maxlevel	2,589
eqvlevel	2,47
typeofbuilding	2,644
traveltime	100,096
traveltime^2	89,285
distancestation	31,919
distancestation^2	26,303
otherlivingarea	1,661
lotsize	2,518
numberofrooms	2,505
buildingyear	1,499
distancetobeach	1,023
standardpoints	1,261
incomeadjusted	1,419
livingarea	33,653
livingarea^2	28,898

Accoring to the test are 6 variables implying high collinearity. However this is expected since these 6 are computed in squared form as well. They can therefor be neglected. Other variables pass the test.

The sum of the squared residuals measures the errors of the estimated regression to the actual data. A small number indicates a well fitted regression line where the observations are close to the regression line. The model is consequently explaining more or the data. Gretl presents 91,7 as sum of the squared residuals. However, this should be dealt with care, since a model with enough estimators can virtually fit a wide data even though it doesn't duplicate the actual relationship explaining the dependentvariable(ibid).

4.4 Noise and distance to Roslagsbanan

Some of the reviewed characteristics of the model are more important for this study than others. Specifically was 5 variables included in effort of isolating the effect Roslagsbanans noise had on property prices. The binary variable E18 was the only noise -related variable that was significant. Illustrating that price decrease 4,7 % when it is located within 300 meters from the road E18. This is also very reasonable, and fit former studies well. It is positive that one of the isolating variables turned out significant.

Unfortunately were both Max and Equivalent level insignificant. However, the result is still interesting. Both were expected to have negative signs since noise is assumed to negatively affect prices (shown in earlier studies), but this was not the case. Being within the max level-area will have 2,6 % increase change of price. Whilst the equivalent level decrease prices with 3,3 %. Which could be interpreted as it is preferable to experience seldom-high noises, than constant high average noises.

Traveltime was also proven insignificant. Probably due to high correlation of the other variables regarding noise. Attempts were made to improve these variables significance but no combination was discovered as more relevant than the first one. Consequently must these variables including travel time and travel time in squared be regarded with caution. Henceforth can’t any statement concerning travel time and house prices relation be made.

Luckely was “distance to closest station” successfully estimated. It can therefor be interpreted as a measure of peoples WTP for accessibility and also the sensitivity of noise. Like mentioned is the interpretation not as straight forward as the other variables because a squared regressor is added aswell. In this case they have different signs, which means that a one meter increase in distance does not imply a constant increase of property price of 0,05 %. It will likely increase to a certain level but then decrease due to the distance squared that is –1,06953e-07 it will somewhere increase at a decreasing rate.

The analysis of the distance effect holding all other constant can be done after two steps. First is each of the regression models coefficients multiplied with it’s mean and then summarized. This way a new intercept is created, so when distance is equal to zero the natural log of price is zero.

LnPrice= 16,3377 – 0,0471*E18 Mean + 0,0278*MaxLevel Mean – 0,0325*EqvLevel Mean -0,0700*BuildT Mean -0,0817*TrvlTime Mean + 0,0009*$TrvlTime^2$ Mean +0,0006* OthrLivinA Mean + 0,0001*PrptyA Mean + 0,085*Nroom Mean + 0,0002*BuildYr - 0,2758 *DistBeach + 0,0071* Standard + 2,42130e-06* IncomeAdj + 0,0083*LivnArea $-1,477^{-05}$*$LivnArea^2$= 15,2

Next can the log of adjusted price be calculated for each chosen distance by the following formula; Lnadjustedprice = 15,2 + 0,0005*dist - 1,06953e-07 *$dist^2$
In addition is price and implicit price calculated. By antilog the price above, you get the actual price. For the implicit price, the following formula is used from the derivative; implicit price= price*(0,0005*dist+ (2*- 1,06953e-07 *dist))

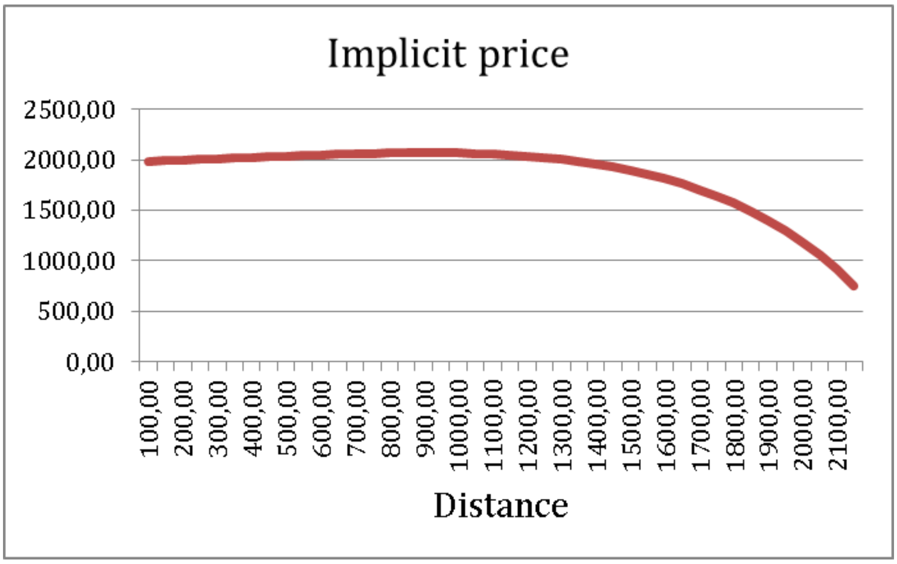


Figure 5. Illustrates the price and distance.

The implicit price is at first increasing when distance increases. Even so, at 1000 m the implicit price of distance to station decreases. At 2150 m is the implicit price 758 SEK. Which can be compared to it's peak at 950 m where the price is 2068 SEK. This implies that proximity to Roslagsbanan in some extent increase property prices.

5. Discussion and concluding remarks

The hedonic model was computed in effort of answering the two research questions.

1. Does proximity to Roslagsbanan increase property prices in Täby and Danderyd?
2. Will Roslagsbanan's noise decrease property prices in Täby and Danderyd?

According to the first hypothesis would proximity to a certain degree increase property prices. Assumingly where the house's distance to the train is enough for benefitting of being close to the train but without experience noise. This can to some extent be considered true according to the implicit prices of the distance to the closest station. Like proven would the willingness to pay increase the farther away from the station until 950 meters, where implicit prices started decreasing. Quite logically does people want to live closer than 950 meters to the station. At 950 meters is the peak reached, implying that it is the most attractive distance to the station. Perhaps because the train doesn't disturb the view the noise isn't depicted.

This question was introduced to capture the distance of where we are willing to put up with noise to have easy access to the city. This implies that the benefits of accessibility dominates the potential disturbing noise. Nevertheless should the possibilities that there are other factors than the distance to Roslagsbanans closets station also effect prices and make them decrease after 950 meters. Several geographical variables are added in the model (E18, DistBeach) but the decreased property prices could still be explained by other unbiased estimates. Perhaps are all neighbourhoods with lack of connection to Roslagsbanan less desirable for other reasons. Perchance they have farther to services like shopping malls and other facilities or doesn't have schools nearby. Yet, that doesn't seem to be the case when taking a quick look at the addresses. Even so, is it clear that it exists some sort of relationship between Roslagsbanan and house prices, and to some extent it appears positive.

The second research question can't unfortunately be explained with a significant explanatory variable like the proximity to Roslagsbanan. All variables modelling noise of Roslagsbanan was insignificant. Yet, E18 was significant at 90 % and modelled with a negative sign which imply that the approximated model is somewhat successfully isolated from noise generated by E18.

Since the model over all had a lack of fit and warned for singularity, the coefficients should be interpreted with caution. Perhaps if the sample were more limited like Wilhelmsson(2000), the problem would be solved. Nevertheless is the sign of the noise variables still stating an interesting subject. Like captured in Andersson et Al (2015), does both equivalent and maximum noise level effect property prices. They experienced multicollinearity and had to create a variable of the difference between the equivalent and the maximum noise level. Which might be the reason that both of the variables where insignificant in this study too. It would have been preferable to have measures of dB(A) for each house like former studies did and compute the difference of the two measures. Since that wasn't possible it was difficult to get a significant and completely isolated result of the effect of noise on houses.

Even so, it is interesting that the maximum level variable was positive and the equivalent variable was negative. Suggesting that people are willing to experience occasional high noises if they also experience the benefits of easy access to the capital (Since they are close to the train). Whilst constant disturbing noise does not weigh up for the benefit of public transport. This would be interesting to investigate further, what the differences are and exactly how much Max dBa people are willing to put up with.

A further alternative interpretation to mention is that the relationship of house prices and Roslagsbanan's noise perhaps doesn't exist. House prices are perchance not affected by that externality and does therefor not give significant result on the variables. It could be interpreted, as people actually don't pay attention to the noise. The real-estate market is under pressure and a profound excessive demand could perhaps force buyers into not being picky about characteristics as noisy location (Lucas and Sprängs, 2015). This would imply that the market isn't in equilibrium and that the hedonic price model's assumption on equilibrium is violated. In that case would not the hedonic price function be able to give a correct estimation of the implicit prices (Wilhelmsson, 2000).

Despite the potential violation of the assumption, the result is nevertheless illustrating that noise and accessibility has some affect. Finally, assuming that the assumptions isn't violated this study illustrates possibilities of further investigation of the subject.

This raises many important questions for community planning. That public transport obviously has a potential negative effect in society that should be taken into account. Furthermore is this especially an interesting subject for society and individual house owners in the effected areas. Future research could perhaps become argument for different community planning or an argument of extended compensation by SLL. Since there are obviously more to investigate I suggest further research. A deeper analysis could potentially establish the peculiar relationship of property prices and disturbing noise from Roslagsbanan.

Appendix

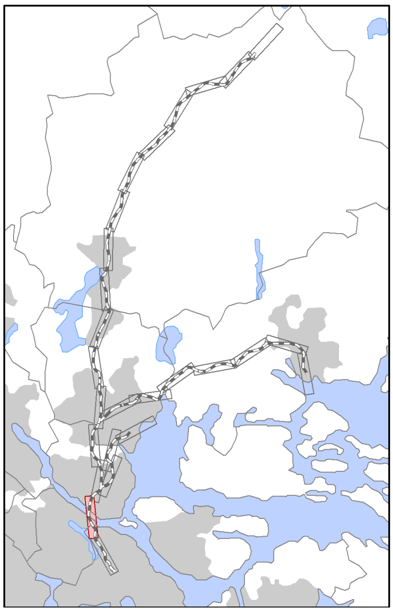
Example of the maps used when chategorising houses into MaxLevel and EqvLevel(SLL, 2015).

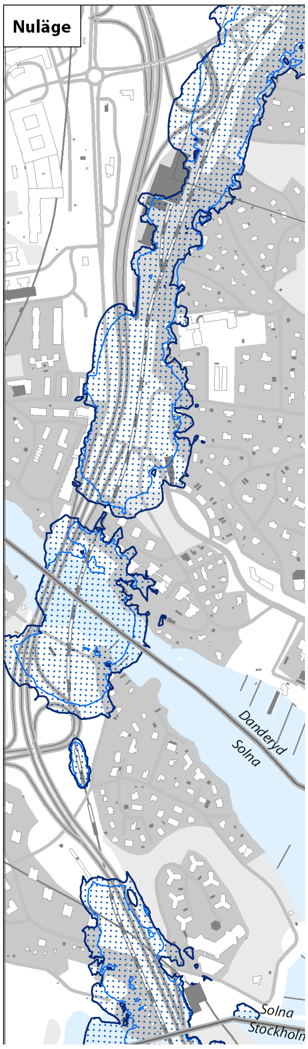
Influensområde och markanspråk

Roslagsbanans markanspråk utgörs av den mark som idag används för spår, stationer, depåer och teknikbodar.

I markanspråket ingår även de områden som behövs för att kunna förstärka banans kapacitet, dvs. plats för dubbelspår, ny depå, bullerskydd och planskilda korsningar.

I markanspråket ingår även det generella skyddsavståndet om 25 meter, som tillämpas utmed järnvägen





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