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What is the role of Bicycle Parking for Increased Cycling in Large Cities?

– a Literature Review

Final Version, 30 October 2012

What is the role of Bicycle Parking for Increased Cycling in Large Cities?

– a Literature Review

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Project no.: 1012,1715 – Parkering i storstad

File address: L:\5645\2009\10121715 - Parkering i storstad\3_Dokument\33_Underlag\A2 Litteraturstudier\Litteraturstudie om cykelparkering\2012-10-30 Bicycle Parking - Literature Review.doc

Version History

Date	Version	Description	Updated by
2011-03-22	1.4	Final Swedish version	P. Envall
2012-09-18	1.5	English translation, editions	C. Goodall
2012-10-30	1.6	Editions	P. Envall

Cover Photo: Pelle Envall

Contents

Summary

This study describes the depth of knowledge in regards to the importance (or unimportance) of good bicycle parking in *larger* cities (such as Stockholm; 800,000 inhabitants and Malmö; 300,000 inhabitants, for example) The study is the form of a literature review and describes, amongst other things, how good bicycle parking solutions can contribute to achieving policy goals such as increasing the proportion of people travelling by bicycle and public transport by making it easier for multimodal journeys (see chapters 3 and 4).

The results of the study show that bicycle users in cities consider high quality bicycle parking to be important. It also shows that there is research that is poorly distributed amongst planning practitioners. The study goes through in some detail, the quality requirements that bicycle users place on bicycle parking in larger cities. These quality characteristics can be summarised as follows:

- Proximity to destination point/ main entrance.
- Location in relation to direction of travel (i.e. placed on the same side of the road to where the cyclist has travelled from)
- Theft security (e.g. fixed stands to lock the bicycle to; or lockable garages)
- Weather protection (shelters)
- Capacity, in relation to demand
- Perceived security after dark (fear of assault)

International studies show that investments in improved bicycle parking can increase the number of bicycle trips by between 8 and 13%, depending on the extent of investments (see p. 8). The higher figure is an average for investment in anti-theft bicycle parking at workplaces where none exist today. Swedish studies indicate that bicycle parking adjacent to, for example, a workplace entrance has a fairly significant socio-economic value to cyclists, greater than was previously expected (see p. 10). The report also notes that there seems to be a relatively strong need for new investment in bicycle parking in some areas of the country (see Table 2, Table 3 and Section 2.6). One study shows that there is a lack of bicycle parking at 57% of surveyed underground stations in Stockholm and in addition, a relatively large number of problems with sub-standard theft prevention security at existing bicycle parking.

In addition, several international and Swedish studies indicate that improved bicycle parking in cities is an important and sought-after provision for cyclists, although there are several knowledge gaps. Gaps in knowledge on a detailed level about what is *good enough* quality bicycle parking in different contexts and the degree to which different types of improvements (short walking distance, increased security and theft prevention standards etc.) may contribute to increased cycling and more satisfied users. This literature review also identifies three main areas for further research is this area; new studies that are deemed important to carry out to provide a better basis for the design of (more) cost effective Swedish investment strategies in the field.

1. Introduction

1.1. Background

This study is part of a larger research project called Parking in the city (*Parkering i storstad*) about the automobile and bicycle parking solutions for Sweden's three largest cities/ urban areas. The project is funded by the The Swedish Transport Administration (*Trafikverket*), contact person Elin Sandberg.

Pelle Envall has been responsible for the study. Martin Bath and Karin Jansson have provided material for the report. Dr. Eva Ericsson has examined the quality of the study's content and conclusions. Comments on the draft report have also been gathered from Trafikverket by Elin Sandberg and Margareta Grandin.

In March 2011, a minor update of the study was done (Appendix to the summary, new sections 2.6. and 4.8, and minor clarifications). Updating has been done in collaboration with the research project CyCity, funded by Vinnova. See http://www.cycity.se for more information.

1.2. Aims

The aim of this study is to identify and classify the contents of the previous research on bicycle parking. The literature compilation shall:

- Report what we know about the various parking measures and their impact on different policy objectives in the field;
- Identify key knowledge gaps, and
- Provide suggestions for future work in this field.

1.3. Method

This Literature review is partly based on a structured literature search and partly on examination of well-known Nordic and English language texts in the field. A third important starting point for this literature review has been a recent literature study of bicycle parking at public transport nodes (Envall & Lindberg 2009).

The structured literature search was undertaken using five article databases: ScienceDirect, TRAX (VTI), Google Scholar, ELIN (LTH) and ELTIS. This search was done in summer 2009. The review of articles was limited until it was possible to get an overview of the search results (i.e. less than 70 hits). To find bicycle parking articles, words such as "bicycle usage", "bicycle", "ride", "parking", and "car park" were used. Items have been sought in Swedish and English and to some degree in French. The literature search was carried out by Martin Båth.

An updated article search was also made in August 2010 on ScienceDirect. ScienceDirect includes the most prestigious scientific journals in its service area. The keywords used were "bicycle" and "parking". The second stage search was limited to the following journals: Transport Policy; Journal of Transport Geography; Transportation Research Part A, D and E; Accident Analysis & Prevention; Cities; American Journal of Preventive Medicine; Building and Environment; Landscape and Urban Planning; Health & Place; Progress in Planning; and Land Use Policy. This yielded 102 hits.

Through the above searches we found, unfortunately, relatively few sources that reported with original data on how different users perceive different bicycle parking quality and bicycle parking design solutions etc. In an attempt to ensure that the study was as thorough as possible, a structured inquiry was undertaken among more than 15 European design practitioners and bicycle experts known within the field. These informal 'interviews' were conducted by Karin Jansson at the international cycling conference Velo City Global, which took place on 22-25 June 2010 in Copenhagen. Velo City conference is

the largest of its kind and brings together researchers and bicycle planning experts from around the world.

The main results of the poll at Velo City Global are integrated into this report. Jansson (2010) presents more details of the results from the survey at the conference, including survey questions and more.

1.4. Report Structure

The report has three main parts:

Chapter 2 gives a brief overview of the material we have found about bicycle parking design and what users think about different types of solutions. This section also describes briefly what users perceive as problems in the field. The section lists a number of major studies; divided into international and Swedish empirical studies, and publications of textbook nature/ literature reviews. Chapter 2 also contains a brief review of the empirical research Swedish texts in the field are explicitly based upon.

Chapter 3 and 4 provides more information on a selected number of issues related to different policy objectives within transport planning, such as bicycle parking's role in increasing bicycle use and making public transport more competitive. The chapters aim to highlight what evidence is available in the literature indicating to what extent bicycle parking solutions of a certain quality or design can contribute to policy objectives.

Chapter 5 discusses the gaps that exist in the area that may be relevant for continued research and development efforts.

Finally, Chapter 6 presents our conclusions and suggestions for future work in this field.

2. Overview of Major Studies

This section presents a brief overview of major studies and research in the field of bicycle parking.

2.1. International Empirical Studies.

Table 1 presents an overview of a selection of international empirical studies on bicycle parking i.e. studies which have collected or reported data on users' preferences and as such, the likely effects of various improvements.

Table 1. Overview of a selection of international surveys of bicycle users' preferences regarding bicycle parking.

Author (Year), Title	Type of Study (n), Sample/ Respondents	Content and Purpose/ Objective.	Selection of Results*
Pucher et al. (2010), Infrastructure Programs, and Policies to Increase Cycling: An International Review	Compilation of results from 139 previous studies. 14 case studies of cities with a package of measures to increase bicycle use.	Assesses a number of policy measures attributed to increased bicycle use incl. bicycle parking measures.	Improved and more secure bicycle parking supports the increased use of bicycles.
Martens (2007), Promoting Bicycle-and-Ride: The Dutch Experience	Compilation of results in a number of studies in several communities in the Netherlands.	Exploring Dutch experience of a national program of actions aimed at increasing bicycle-use and public transport passengers, primarily through improved bicycle parking facilities.	In general, the implemented improvement measures were successful and resulted in increased satisfaction among users as well as increased bicycle use. The results apply to both improvements at train stations and bus stops. Two minor improvement projects, including new bicycle racks at bus stops resulted in increased bus travel. Improved bicycle parking and other measures at five Dutch stations led to a significant increase in the customer satisfaction index increasing on average from 5.3 to 7.1 on a scale of ten.
Wardman et al. (2007), Factors Influencing the Propensity to Bicycle to Work	Statistical multi-variable analysis of data from amongst other things, National Travel Survey (NTS) in the United Kingdom. Four data sources are combined into one model, only travel <12km from NTS.	Examines factors and measures that are associated with increased bicycle use.	The presence of secure indoor parking for bicycles (e.g. bicycle storage at work) raises bicycle use for travel to work by about 13%. The organization of outdoor parking for bicycles raise bicycle usage for the same trip by about 8%. Base level of 5.8% of journeys to work made by bicycle in the data. Increases were statistically significant.
Hunt & Abraham (2007), Influences on Bicycle Use	Stated preference experiments, mailed (n 1128). Cycling journeys to all-day events, Edmonton, Canada.	Examines the importance of infrastructure design for cyclists, including how cyclist's value cycling amongst traffic compared with bicycle lanes, theft-proof parking and changing- room possibilities.	Access to 'theft-proof bicycle parking' at the destination point is valued as equal to a 'reduction' of bicycle travel time by over 26 minutes in mixed traffic (p. 463). Access to showers at the destination is valued on average to travel time reduction of about 4 minutes (p. 466). Statistically significant data.
Rietveld & Daniel (2004), Determinants of Bicycle Use: Do Municipality Policies Matter?	Statistical analysis of the potential causes of the differences between the cyclists in 15 Dutch cities (percentage of bicycle trips of all journeys <7.5 km).	Examine the extent to which municipality initiatives and transport planning impact bicycle traffic volumes.	The study indicates that local policy initiatives are linked to the use of bicycles in a particular place (p. 545). Demonstrated that the delays (measured as number of stops on bicycle paths) influence bicycle use negatively, while the occurrence of parking fees for cars increases bicycle use positively.
Martens (2004), The Bicycle as a Feedering Mode: Experiences From Three European Countries.	Analysis of Travel habit statistics and previous literature in the field.	Examines the combined journeys by bicycle and public transport in the Netherlands, Germany and Britain.	The share of rail passengers cycling to train stations in the three countries (who therefore parks their bicycle at the station) is roughly equal to share of total bicycle trips as a proportion of the total number of trips in each country, if not slightly higher. That is, for example, in The Netherlands 27% of all travel is done by bicycle (for the main part of the journey) where 30% used the bicycle as transportation to train stations with regional and/ or national train lines.

* Key findings in relation to the purpose of this report; trends & possible knowledge gaps.

Pucher et al. (2010) examined 139 international studies of cycling measures, 65 of which were published in established scientific journals. The purpose of this review was to assess the effect of a number of policy measures aimed at increasing bicycle use. Regarding bicycle parking, Pucher et al (page 115), concluded that there are only a few studies on the effects on bicycle use of better and more secure bicycle parking. The studies that exist, including Wardman et al (2007) and Hunt & Abraham (2007) confirm that better bicycle parking supports increased bicycle use (see below for more information on these studies).

Wardman et al. (2007) presents a statistical multivariate analysis of data from the UK National Travel Survey. The results show that the presence of secure indoor parking for bicycles (e.g. bicycle storage at work) raises bicycle use for travel to work by about 13%. The provision of outdoor bicycle parking raises bicycle usage for the same trip by about 8%. Access to safe indoor parking and showers at destination increased bicycle use by 22%, rising from 5.8% to 7.1% of all journeys. The increases are said to be statistically significant.

Hunt & Abraham (2007) present an analysis of a survey that used stated preference techniques in Edmonton, Canada. The survey was conducted in 1994. Only cyclists participated in this study. The survey was distributed directly to riders and posted back to the researchers. To increase response rates among less experienced riders, surveys were also placed on parked bicycles. The survey had a response rate of about 33%. Each experiment in the survey consisted of three basic variables; type of bicycle link (e.g. bicycle path, bicycle lane or mixed traffic); type of parking (theft-proof parking available, not available); and changing facilities (available, not available). As shown in Table 1, the study showed that the cyclists had a strong preference for theft-proof bicycle parking. The riders examined in Hunt's and Abraham's study were to cycle to a hypothetical all-day event, such as an all-day meeting or private gathering (which in turn meant that the bicycle would be parked for a long time at a given location). Hunt and Abraham concluded that the study suggests that cyclists in Edmonton are widely concerned about parking and theft.

Hunt and Abraham's study also showed that young people value theft-proof bicycle parking higher than older riders. Respondents under 18 had a 70% higher valuation of theft-proof parking than respondents older than 28 years. It can, according to Hunt & Abraham (p. 465) be due to the fact that cycling is often more important as a means of transport for younger people. This is because older people, to a greater degree are more likely and able to replace the bicycle journey with travel by other modes.

The study also showed that cyclists who have a bicycle with a higher purchase price than 400 Canadian dollars[1] valued theft-proof parking higher than those with bicycles below this price. Respondents owning bicycles with a higher purchase price than 1300 Canadian dollars had slightly lower valuation of the theft-proof parking than those with bicycles in the price range 900-1300 Canadian dollars. Hunt & Abraham had difficulty explaining this. One possible explanation that is not mentioned in the study may be that bicycles' purchase price may not be entirely consistent with the current economic value at the time of the study, and thus less desirable for theft. Those who buy expensive bicycles may have them longer and the older the bicycles are, the less you worry about getting the bicycle stolen because they are worth less, even if the bicycle was expensive when purchased.

Rietveld and Daniel (2004) show that local policy bicycle initiatives have a significant impact on bicycle use. In the study, however, bicycle parking is shown to be less important for bicycle use than, say, accessibility and comfort (measured as number of stops cyclists have to do). However, it may be worth noting that it is difficult to obtain from the study exactly what data the study is based on for the specific subject of bicycle parking quality (e.g. proximity, theft risk etc.).

[1] Approximately 230 Euros at 1994 exchange rates.

2.2. Swedish Empirical Studies

Table 2 presents an overview of a selection of Swedish empirical studies on bicycle parking. As shown in the table below, the largest Swedish empirical studies on bicycle parking are in the Stockholm/ Mälardals area (see for example, Stockholms Stad, 2004).

Table 2: Overview of a selection of Swedish studies on bicycle users' preferences regarding bicycle parking.

Author (Year), Title	Type of Study (n), Sample/ Respondents	Content and Purpose/ Objective	Selection of Results*
Envall & Lindberg (2009), Cykelparkering vid kollektivtrafiknoder (Bicycle Parking at Public Transport Nodes).	Surveyed (n 91) cyclists that parked at Huddinge and Gävle train stations.	Highlighted what train passengers see as the main problems, and what if any preference they have regarding bicycle parking.	44% of respondents were very or somewhat dissatisfied with current bicycle parking: Anti-theft security, weather protection and important aspects of quality in addition to proximity. One should divide cyclists in to different customer segments, as different groups seem to have slightly different preferences.
Börjesson (2009), Värdering av tid och bekvämlighet vid cykling (Value of Time and Comfort when Cycling)	Stated preference experiment (n 756) with cyclists that travelled more than 15 minutes in Stockholm.	Improve knowledge of cyclists' valuation of travel time but also other aspects incl. parking	*"Bicycle stands right next to the destination"* valued at six krona per trip in the investigation. The study analysed four parameters against each other: travel time, presence of bicycle stands, the presence of bicycle lanes and stops at traffic signals.
USK (2007), Behov av cykelgarage (The Need for Bicycle Garages).	Interviewed (n 459, cyclists that parked at three train stations in Stockholm.	Examined preferences among bicycle users for new bicycle garages at the Central Station, Karlberg Station and Södra Station.	Just over two-thirds (69%) believe they would use the proposed bicycle garage, 19% do not think so, and the remainder were unsure. Half of the riders say they are willing to pay for a place in a bicycle garage; most commonly mentioned amount was 100 SEK/ month and 10 SEK/ day.
Provus (2006, 2010), Cykelparkering vid resecentrum (Bicycle Parking at Public Transport Interchanges.	Surveyed (n 1143) people who "usually park their bicycle at Uppsala Central Station. Response rate of 60%.	Explored explicitly what cyclists find important for future bicycle parking at a new transport interchange. Highlighted the extent to which users prefer different types of parking and willingness to pay more.	3 of 4 specified that they would use bicycle service/ repair services if they existed at the station. 41% of respondents indicated that they bicycle more than 4km/10-15 min to the station. Cleanup of bicycle stands removing damaged bikes should be carried every 1-3 months.
Stockholms stad (2004), Att cykla i Stockholms innerstad (Cycling in Stockholm's Inner City)	Survey of (n 451, cyclists that pass Stockholms' inner city boundaries. Also interviews (n 240).	Identified problems and proposals to improve cyclists' situation in Stockholm's inner city.	The survey indicated that 87% wanted bicycle stands (bollards model), where you can easily lock the bicycle frame of the bicycle to the stand (according to the City of Stockholm 2008, p. 5). About a third said they seldom or never find a vacancy in existing bicycle stands.
Ericson (2000), Ökad cykelpendling, men hur? Increased Bicycle Commuting, But How?	Postal survey (n 239). Both regular bicycle users and non-cyclists, Stockholm (west, southern suburbs)	Investigation of measures that would get respondents to bicycle to work/ school more.	The study noted that 16% of people would bicycle more often to work /school if there were "more parking facilities for bicycles". 35% of people said the same regarding theft-proof parking facilities. Ericson noted that these two questions had as many answering yes as the single largest category "better bicycle paths," for which 47% indicated that it would cause them to bicycle more.

* Key findings in relation to the purpose of this report; trends & possible knowledge gaps.

Table 2 shows that all Swedish studies in the field are based on what respondents *say* they want or as in Börjessons (2009) study of a poll where people were to choose between a number of fictitious elections (stated preference experiments). This differs from studies that examine how users have *actually* acted in a certain situation. On page 10 is a table summarising such studies, some of which are described in more detail below.

Börjesson (2009) concludes from a study in Stockholm that "bicycle stands right next to the destination" are valued at 6 SEK per trip. It is worth noting that this is significantly higher than the figure specified in the Swedish Road Authority's Effect Catalogue for Public Transport Measures. It states that "high quality bicycle parking" with "shelter against rain and low theft risk" has the economic value of 1.70 SEK per user in 2006 prices (Vägverket 2008a, p. 75). Vägverket (2008a) indicates no obvious source for their valuation, so it is difficult to assess why the numbers differ so greatly. It is also worth noting that Vägverket's Effect Catalogue is for new construction and improvements (Vägverket 2001, 2008b) and does not report on any correlation of improvements to bicycle parking and increased bicycle use. For comparison, a British study (Wardman et al., 2007, p. 344) show that the difference between having and not having 'bicycle stands outside the workplace'[2] has the value of 2.5 minutes of 'bicycle time'. Bicycle storage/ indoor parking for bicycles is valued at the equivalent of 4.3 minutes bicycle time. Wardman, et al. do not further explain why the use of the indoor parking is valued so high. However, an important reason may be higher theft security standards for indoor parking.

The study by Ericson (2000, Appendix 1, p. 11-13) surveyed both experienced cyclists and non-cyclists. The study reported both what respondents cited could get them to bicycle more to work/ school and the degree to which a number of factors prevented respondents from cycling or cycling more to work/ School than they did at the time of the study. The two issues gave slightly different answers. As shown in the table above, 35% of respondents believe that secure bicycle parking facilities would get them to bicycle more to work/ school. Regarding the factors that prevented people from cycling to work, the parking issue was relatively less important than several other factors; 10% of the respondents indicated that the risk of bicycle theft/ vandalism was a major barrier for them, while 9% reported poor parking facilities for bicycles was a major obstacle in cycling to work more often than they did at the time of the study. For comparison, 49% of respondents stated that "slipping on ice" was a major barrier to cycling or cycling more to work, 25% reported a lack of good bicycle paths and bicycle lanes as being a major factor for the same type of trip. Ericson (2000) gives no clear explanation for why the results of the two issues differ so widely as they do for bicycle parking. However, it is worth noting that one question explicitly asks about travel, both to work and school, while the second question explicitly asks for work trips. One possible explanation for the differences is because the risk of bicycle theft is or is perceived as a (much) bigger problem among students and school children compared with those employed (see also Hunt & Abraham 2007).

2.3. Textbooks and Literature Reviews

Table 3 below shows a summary of a number of Nordic publications relating to the subject of bicycle parking and their contents. The publications are not primarily reflecting the results of an investigation, but instead, are more of a textbook nature. As the table shows, the subject of bicycle parking has been discussed in a fairly large number of publications.

[2] It is not clear from the document the type of bicycle stands being referred to ("outdoor cycle parking facilities").

Table 3. Nordic handbooks and textbooks regarding bicycle parking.

Author (Year), Title	Type of Report	Contents, Purpose/ Objective	Number of Pages Relating to Bicycle Parking	Selection of Results *
SKL (2010), GCM-handboken (Pedestrian, Bicycle and Moped Handbook)	Handbook, Public Sector Publication.	Advice about pedestrian, bicycle and moped traffic to support planners and designers in; planning; detailed design; and operation and maintenance. Specifies that bicycle traffic has an important role to play in the quest for a sustainable society and the reduction of car journeys (p. 3).	9 pages (167 page Report)	The appropriate type of bicycle stand and to some extent location of the bicycle stand depends on how long the bicycle is parked in a specific location (see p. 126). Four categories: a) short-term parking <30 min; b) up to 4 h; c) all-day at school or workplace; d) parking overnight). Examples of bicycle parking standards for new developments (p. 123). Bicycle parking standard is an "important tool" (p. 122). Occupancy rate should not exceed 0.9 (p. 122). Distance between parking and destination point should preferably not exceed 25m (p. 124).
Boverket (2010) Gör plats för cykeln (Provide Space for Cyclists)	Guidance, government publication	Guidance and inspiration for the planning of bicycle parking at stations.	49 pages	Further development of the publication Boverket (2009). Reports on the establishment of bicycle parking permission and planning permission requirements and how the issue can be handled in the local planning process for the construction of new stations etc. (see p. 24-25).
Boverket (2009), Planera för cykelparkering vid stationer och resecentra! (Planning for Bicycle Parking at Stations and Interchanges.	Guidance, government publication	Reporting to the Government to draw up guidance on the issue of bicycle parking considerations in spatial planning. Examines bicycle parking design etc. at 7 stations.	49 pages	Many actors are responsible for the issue of bicycle parking at stations. In order achieve results in practice, in terms of good standard bicycle parking, there needs a lot of cooperation (p. 27). Recommends that a national need- assessment be done regarding bicycle parking improvements at all major Swedish train stations (p. 40).
Envall & Lindberg, (2009) Cykelparkering vid kollektivtrafiknoder (Bicycle Parking at Public Transport Nodes.	Litterature Review, Consultancy report.	Identified user requirements for bicycle parking at public transport nodes; investigated possible importance of good bicycle parking for public transport passengers, highlighting the existing methods to determine the appropriate type of parking solutions.	36 pages, of which 10 are a literature review.	There is probably a relatively substantial willingness to pay for theft safe bicycle parking solutions at Swedish stations, but no established method to determine the optimal 'design solution' as when the garage is justified. There is great variety in the textbooks within the field of dealing with theft safety.
Hörlén et al (2009), Cykelgarage: inspiration, idéer & hårda fakta…(Bicycle Garages: Inspiration, Ideas and Hard Facts)	Idea Study	Inspiration, ideas and facts for planning and design of bicycle garages.	119 pages, many with illustrations.	Reports on a survey of 300 people in Malmö which shows that 73% of respondents think it is important or very important to be able to lock the bicycle frame (the study most likely directed to parking by stations and bus stops, see p. 9).
Josefsson (2009), Parkering i Lund: - en jämförelse av parkeringsnormer…(Parking	Litterature Review, working paper.	The study compares Lund's parking standards for cars and bicycles with those in nine other Swedish municipalities, to inform an upcoming review of local parking guide-	Approx. 10 pages of 41.	Eight of the nine surveyed municipalities have bicycle parking norms or proposals for norms (i.e. more or less fixed standards for the no. of bicycle stands developers have to include in designs). The number of bicycle places per home ranges between 2-2.5 plac-

in Lund: A comparison of Parking Norms/ Standards.		lines.		es/ home. Several places that have bicycle parking norms do not seem to use them to any great extent. One interviewee did not even know that a bicycle norm actually existed.
Celis et al (2008) Danska cykelförbundets parkeringshandbok (Danish Cycling Unions Parking Handbook)	Textbook	Provides good and bad examples of bicycle parking design. Aims to contribute towards improvements in bicycle parking in Denmark to the same standard as in the Netherlands.	100 pages, many illustrations.	Space required for parking varies with different designs, from about 1 square meter per bicycle to about 2.35 square meters. Includes bicycle parking rates for many different activities/ building uses (see p. 41).
Stockholm stad (2008), Cykelparkering i staden (Bicycle Parking in the City)	Handbook, Local Publication.	A guide to those that plan and implement bicycle parking in Stockholm.	37 pages	A key aspect of the location of cycle parking facilities is proximity to destinations and public transport. New bicycle stands that the City of Stockholm implement shall be theft-proof, i.e. it must be possible to lock the bicycle frame. The report recommends a number stands of different stand designs that are suited to various urban environments.
Banverket (2007), Åtgärder för att öka kombinerade resor med cykel och tåg (Measures to increase combined trips by bicycle and train)	Analysis, investigation and response on behalf of the Government.	The purpose of this report is to present concrete measures to increase opportunities for combined trips by bicycle and train. The study also aims to propose an appropriate division of responsibilities in the construction and operation of bicycle parking at travel centers and stations.	23 pages	There are often difficulties in implementing improvements to bicycle parking at stations, "no one wants to take responsibility for the financing, construction and operation" (p. 4). The analysis concludes that local authorities or alternatively 'station managers' are the ones that are best placed to take responsibility. Reports a rough assessment that the cost "for increased bicycle parking" at existing stations amounts to around SEK 240 million (p. 22).
Vägverket m.fl. (2007) TRAST (Transport for an Attractive City Handbook)	Public Sector Textbook.	TRAST is a guide for policy makers and should be used as a tool for planners to create a balance between the various modes and between mobility needs and other urban qualities.	2-3 pages (whole report 342 pages)	Indicates two evaluation measures of bicycle parking's quality: distance from the entrance; and occupancy at the center (p. 212). The parking should allow for locking of the bicycle frame; should be well-lit; and aesthetically pleasing. Theft-secure bicycle parking and guarded garages are more important in big cities than in small towns (p. 205).
Halvarsson (2005) Cykelhantering vid stationer (Bicycle Management at Stations)	Public sector handbook.	Compilation of existing knowledge regarding bicycle parking at train stations.	33 pages	Bicycle parking should offer sufficient number of places where there is demand and the rider knows that the bicycle parking is both safe and practical. Parking should also offer the opportunity to lock the bicycle frame to a fixed stand where maintenance includes removal of illegally parked and abandoned bicycles.
Statens Vegvesen (2002) Sykkelhåndboka (Bicycle Handbook)	Norsk handbok, Public Sector Document.	Guidance for planning and design of cycling facilities.	3 pages (whole report 101 pages)	Bicycle parking should be a natural part of a bicycle plan. Bicycle usage requires good bicycle parking. Where possible, you should strive for a walking distance of 25m or less to the nearest parking facility. To ensure that bicycle parking requirements are built it should be included in the building permit/ local plans. Recommended parking standards for residential houses: 1-3 places/ household.
Vägverket (2000) Nationell	Public sector	Strategy for increased bicycle traffic and how to make it saf-	1-2 pages (whole re-	Proposes two focus areas for the Vägverket and others working with bicycle parking (p.

strategi för ökad och säker cykeltrafik (National Strategy for increased and safer bicycle traffic)	policy document	er	port 88 pages)	28): to develop "an awareness-raising document that show how better bicycle parking can be designed with high standards of theft security, aesthetics and function" and to work out "proposals on how to use the standards for bicycle parking in detailed and local development plans"
Kommunförbundet (1998) Det finns inga dåliga kläder…(There is no Such Thing as Bad Clothes…)	Examples book, textbook character, public sector document	Provides a basis for local discussion and possible decision to promote increased bicycle traffic.	2 pages (whole report 99 pages)	Good bicycle parking is essential. Parking should be close to the final goal and protect against vandalism and theft. Property owners must to significant extent take responsibility for bicycle parking. Rules for how illegally parked bicycles may be removed is unclear and needs to be changed. The report provides examples of how theft secure parking can be charged.
Holmberg & Hydén m. fl. (1996) Trafiken i Samhället (Traffic in Society)	Textbook	Introduction to road traffic engineering.	1 page (whole report 263 pages)	Bicycle parking is easy. The cyclists look to minimize walking distance between parking and their destination. Bicycle parking should be in the direction that most cyclists arrive. Shelters are important for long-term parking.

* Key findings in relation to the purpose of this report; trends & possible knowledge gaps.

2.4. Empirical Robustness

Stockholm Stad's handbook for design of bicycle parking (Stockholm Stad, 2008) and Lund's summary of parking standards per home/ flat for the bicycle (Josefsson, 2009) seem to be the most detailed work in their respective fields.

The study of Josefsson (2009) contains a review of nine local authorities' parking standards[3] for bicycles in new developments. The study is also based on 12 interviews with officers at local authorities. The study is therefore probably the most comprehensive in terms of how municipalities work with parking standards for bicycles regarding new housing developments. Things worth noting from Josefsson's study are that several of the largest Swedish cities do not have parking standards for bicycles in connection with new construction, while several smaller towns and cities do. This, despite the fact that TRAST (Vägverket et. al., 2007, page 205) indicates that the solutions that offer high-theft security are more important in larger cities than in smaller ones e.g. provision of locked bicycle rooms in new apartment buildings.

One of the major Swedish cities that do apply parking standards for bicycles in planning applications is Malmö with about 300 000 inhabitants. Josefsson's study concludes that Malmö seems to have the most thorough and well-functioning concepts for bicycle standards out of the major cities investigated (see Josefsson 2009, p. 33-34). Josefsson also describes that interviewees in Uppsala, a city with 200 000 inhabitants, indicate that bicycle parking "does not require much space and is therefore easy to arrange" and no parking standards for bicycles are therefore needed.

Stockholm Stad's Handbook (Stockholm 2008) is written for those who implement plans for improved bicycle parking in the city. The textbook is the most detailed Swedish guide in the field. As a comparison, it describes the design examples and bicycle users' preferences, etc. with 35 pages, while the national textbooks TRAST and GCM handbooks describe the same thing in less than ten pages each. Table 4 below shows briefly the studies and data that underpin the advice on bicycle parking in a number of manuals/ handbooks.

[3] A parking standard is the number of parking places for bicycles that a local authority demands that a developer provides as a part of a new development, before issuing a building permit.

Table 4: Empirical studies that explicitly underpin some Swedish texts in the field (taken from Envall & Lindberg, 2009, p. 14, updated August 2010)

Publication, title, year	'Own' Empirical Studies	Other important source material	Comments
GCM-handboken (SKL 2010)	-	Swedish and international litterature, TRAST	References data from such surveys at Lund and Uppsala train stations, Dutch manuals and Halvarsson (2005). No 'direct' references.
Ge plats för cykeln (Give space to the bicycle) (Boverket 2010), resp. Planera för cykelparkering vid stationer (planning for bicycle parking at stations (Boverket 2009)	Survey at two train stations (n 91), telephone contacts of station managers/ plan administrators.	Swedish and international literature, review of detailed plans at a dozen stations.	Do primarily a short review of Swedish and international user surveys.
Cykelparkering i staden (Stockholm stad 2008) Bicycle Parking in the City.	Survey on types of bicycle stand, n 451 (Stockholms stad 2004). Survey of the need for bicycle garages (USK 2007)	Swedish and International Litterature.	Most of the advice is based on empirical studies/ surveys conducted in Stockholm (1997, 2004, 2007).
TRAST (Vägverket m fl. 2007)	-	Dutch guidlines (1997)	Advice on general proximity and parking at stations, in particular, based on the Dutch guidelines.
Cykelhantering vid järnvägsstationer (Halvarsson 2005) Bicycles at Train Stations.	Circa 15 personal contacts with both Swedish and foreign planning practitioners and consultants.	Swedish and international literature.	Also study visits and case studies in Uppsala.

As the table above shows Stockholms Stad's handbook is based largely on results of their own empirical studies regarding bicycle users' preferences. As also shown in the table, the majority of publications are based on advice given in the field and the principles set out either in international guidelines or reviews of previous case studies.

Apart from the above, it may be worth mentioning that the study of Halvarsson (2005) provides a comprehensive explanation of how to deal with bicycle parking at stations. It presents the rules relating to the removal of bicycles. This is also reported in SKL (2010, p. 130-131) and Kommunförbundet (2004). In Halvarssons study, like many of the other guides, it can be somewhat more difficult to distinguish between advice and tips that are based on empirical evidence and those that are not.

It is also noteworthy that two of the most detailed studies in the field, Halvarsson (2005) and Josefsson (2009) are student dissertations or theses.

2.5. Comment on the Differences Between Advice in Various Handbooks

Envall & Lindberg (2009) emphasise that there are significant variations in some of the advice given on bicycle parking in various handbooks. For example, they say that the textbook "Traffic in Society" (Holmberg & Hyden et al., 1996) does not explicitly specify theft-security as a quality of bicycle parking. This could be because there have been significant changes in preferences over time (i.e., many cyclists are now placing greater demands on theft security than before). In the same vein, it is interesting to note that the Norwegian handbook for bicycle planning (Statens Vegvesen, 2002) indicates that one should strive for a distance to the nearest bicycle parking of 25m or less while TRAST (Trafikver-

ket m. fl. 2007, p. 212) indicates that <50m between the entrance and bicycle parking is a good standard for local streets.

There also appears to be some inconsistencies between studies. Josefsson (2009) shows for example that, eight of the nine surveyed medium and large Swedish cities have bicycle parking standards or draft standards. TRAST (Trafikverket m. fl. 2007, p. 210) states that it is "quite unusual" that municipalities have standards for bicycle parking and Malmö and Linköping are "exceptions".

It is also worth noting that the results of some of the most comprehensive and interesting Swedish surveys on bicycle parking's role in increasing bicycle traffic, such as Ericson 2000, are not explicitly recognized in several Swedish handbooks (e.g. Trafikverket m. fl. 2007, p. 203-4, 318-332). Reporting of experience from internationally widely cited studies on the effects of bicycle planning also seems lacking in many handbooks. Several of the textbooks examined do for example not, us knowingly, report on published research on the importance of few delays and stops for cycle usage, i.e. the study by Rietveld & Daniel (2004)[4].

2.6. Comment on the Planning of Bicycle Parking in Practice

As shown in Table 3 and Section 2.5 above, Swedish and Nordic planning handbooks include clear indicators for the evaluation of existing and new bicycle parking quality in terms of; design requirements for theft safety standards (see Stockholm 2008); the proximity between the destination point entrance and bicycle parking (see Statens Vegvesen 2002, Trafikverket m. fl. 2007, p. 212); and occupancy rates (SKL 2010, page. 122). These measures are relatively easy to evaluate, at a relatively low cost. In some cases, performance measures have been published for a relatively long time.

Despite this however, several major evaluations of bicycle parking quality made in practice (e.g. SL, 2009a and 2009b) do not include many of the qualities that the handbooks and research shows as important for bicycle users. SL for example reported the occupancy rate of 76 underground stations in Stockholm (SL 2009b) but the same study reported no systematic information on the extent to which existing bicycle parking meets handbook requirements of good proximity to destination points and local attractions, or good theft-safety standards. It can be the case that in practice, transport planning seems to ignore users' quality preferences for bicycle parking. If that is the case, there is a more general problem which should not be ignored. There is unfortunately, documented cases of relatively large studies that probably should be deemed as 'not up to standard', at least not if you apply the relatively simple 'recommendations' for quality evaluation as set out in the planning manuals.

It may also be worth noting that the conclusions of SL's studies are similar to those in the Swedish Rail Administrations (Banverket 2007, page 22.). Both reports show that there is a relatively large need for improvement in bicycle parking. There is, for example, lack of bicycle parking at 57% of surveyed underground stations in Stockholm (SL, 2009b). In addition, there are many problems with substandard theft safety standards for existing bicycle parking.

3. More Information on a Selection of Issues

3.1. Chosen Issues

In order to structure information in the literature review, a number of issues were selected. These questions were based on what we perceive as common reasons to implement bicycle parking measures, i.e. based on a number of policy objectives. The policy objectives that were selected were:

[4] Rietveld and Daniel (2004, see page 544) in their statistical analysis of 15 municipalities in the Netherlands found that three fewer stops per 10 km bicycled increases the bicycle's modal share by almost 5%, as measured by the bicycle trips as a proportion of all trips shorter than 7.5 km by all modes.

- Increase bicycle use in accordance with government objectives set up in this area (Vägverket, 2000; Regeringen, 2008, page 147).
- Increase public transport use by facilitating the combination of trips by public transport and cycling (Regeringen 2008, pages 55, 147).
- Create 'orderliness' so that no other road users are prevented or delayed by illegally parked bicycles (e.g. Halvarsson 2005).
- Create a high(er) standard for users, such as to reduce the risk that bicycle owners gets his/her bicycle damaged, or are forced to park far from their destination point and thus have longer travel times (e.g. Regeringen 2009, page 18 and 28; SKL, 2010)
- To reduce bicycle theft and the costs that are associated with theft for insurance companies and users.

Chapter 4 below structures information in existing studies based on their relevance to the various policy objectives above.

4. Support in the Literature Showing that Improved Bicycle Parking Contributes to Policy Goals

4.1. Introduction

What evidence is available in the literature showing that good bicycle parking solutions can contribute to different policy objectives such as increased satisfaction for bicycle users? Are there gaps in knowledge about what we actually know? If an authority or other actor wants to invest in improving existing bicycle parking, what should they invest in if they want to make cyclists (more) satisfied? These are some of the questions that this section attempts to address.

4.2. Bicycle Parking Measure's Role in Increasing Bicycle Use

A number of previous studies have addressed whether bicycle parking quality can increase bicycle use, and if so under what conditions. The main studies and knowledge pools in this area are perhaps the studies of Pucher et al. (2010), Eriksson (2009), Wardman (2007), Martens (2007) and Ericson (2000). Wardman (2007) and Martens (2007) present probably the most specific studies in the field.

Pucher et al (2010, p. 122) conclude that various measures to increase bicycle use is more effective if they are part of a coherent package of measures. In order to increase bicycle use on a larger scale a package of measures in four different areas is a prerequisite (improved bicycle infrastructure where bicycle parking measures are included, communication activities, supporting land use/ urban planning policy and 'restrictions' for car use).

Eriksson (2009) presents an overview of a number of studies that have studied various measures and causes of high or low bicycle use. These studies consist of: those applying Theory of Planned Behavior; statistical analysis of travel patterns as well as surveys and interviews.. Of the studies examining the general motivations and barriers to bicycle use, one can conclude that fear of having their bicycle stolen in various studies are presented as one of several "frequent obstacles" for cyclists (Eriksson, 2009, page 13). How important obstacles such as lack of good bicycle parking, relative to other problems, varied according to Eriksson in different studies. In a British study, bicycle parking issues were one of the two most significant barriers to individuals who were considering to start cycling, just started cycling or who wanted to bicycle more regularly (Gater Leben & Appleton, 2007, reprinted in Eriksson, 2009).

Wardman et al. (2007, p. 347-348) present perhaps the most compelling evidence that good bicycle parking is important for bicycle use. Their model study shows that the presence of secure indoor park-

ing for bicycles (e.g. bicycle room at work) raises bicycle use for travel to work by about 13%. The organization of outdoor parking for bicycles increases bicycle usage for the same trip by about 8% (see also section 2.1).

Also the results of Hunt & Abraham (2007) provide strong support for improved bicycle parking. They showed that theft secure bicycle parking solutions can be of great importance to increased bicycle traffic in a city; especially on trips where bicycles are parked for a long time (see Table 1). In addition, Hunt & Abraham show that the theft-proof bicycle parking is more important for younger people than for older and theft secure parking is much more important for those with bicycles with a higher purchase price than those who bought older used bicycles.

Martens (2007) describes a number of studies showing that improved bicycle parking at railway stations is associated with an increased number of bicycles parked there, as well as increased use of bicycles (see also Section 4.3.2 below). This, despite the fact that bicycle parking at many stations in the Netherlands was generally of a relatively good standard even *before* improvement measures were implemented (Martens p. 328).

As mentioned earlier, 35% of respondents in a study in Stockholm answered that theft-secure parking facilities would cause them to bicycle more to work/ school (Ericson 2000, see also Table 2 of this report).

4.3. Bicycle Parking's Role in Increasing Competitiveness of Public Transport

4.3.1. Handbooks

TRAST (Vergverket m. fl. 2007, p. 261) indicates that Dutch data shows that "*comfortable and secure bicycle parking*" may "*increase rail travel by up to 10 percent."* The same figure is given in Ingelström (2005, p. 10). The publication "Bicycle parking in the city" (Stockholms Stad 2008, p. 4) indicates the same thing as TRAST adding that there are analyses showing that the "*maximum potential*" is "*30-35 percent increase in public transport if there would be no limitations in the availability of bicycles and bicycle parking*"[5].

SKL (2010, p. 125) indicates that in Holland and Denmark public transport "*may increase by 5-10% if the possibility of getting to and from the stations by bicycle improves.*"

Among several experts on bicycle planning is the notion that more and better bicycle parking in itself increases demand, especially at major public transport nodes. Several experts indicated that an expanded bicycle parking at a larger station 'quickly becomes full again' (see Jansson, 2010).

4.3.2. Empirical Studies

In a small study (n 91) at two train stations in central Sweden, 44% of respondents were very or somewhat dissatisfied with the current bicycle parking (Envall & Lindberg, 2009). The study was performed at Huddinge commuter station in Stockholm and at the railway station in central Gävle, 170km north of Stockholm.

Martens (2007, p. 333) presents the results of a before/ after study of the number of bus passengers at seven stops in the rural province of Brabant which improved bicycle parking or implemented new bicycle stands of a slightly different type (from a simple stand, to a stand with weather protection and high-theft security). The number of bus passengers travelling increased 20% (from 520 to 618 passengers). Overall, the number of passengers at the seven stops went from just over 1,300 to more than

[5] Stockholm Stad (2008) states that the following sources were used in their analysis: Van der Lineage, J A. (1993) Potential growth of public transport use as a result of Improving the transport chain bicycle/ public transport. In Cycling in the city, pedalling in the polder. Recent developments in policy and research for bicycle facilities in the Netherlands. Centre for Research and Contract Standardization in Civil and Traffic Engineering CROW, Ede (the Netherlands).

1,700 travelers in the survey. However, there were not only improvements in bicycle parking, but also other improvements such as new bus stop shelters. They also did a marketing campaign to distribute information on the improvements. Martens also indicates that several other studies in other locations in the Netherlands have reported similar results, i.e. that improved bicycle parking at bus stops have resulted in increased bus travel.

Neergaard (2001) reviewed how three cities in Europe work with bicycles in combination with public transport. She concludes "that bicycle parking and other measures aimed at getting more people to use the bicycle in combination with public transport is an area that gains greater importance in several countries". The relatively large investments that have been made in Germany and the Netherlands are, according to Neergaard, not only investments in better bicycle infrastructure but also an integrated part of public transport strategies to attract new passengers. Neergaard could not through her literature review find any evaluations of how different quality of bicycle infrastructure and the public transport nodes affect public transport patronage.

4.3.3. Statistics on Multimodal Journeys

According to information presented in Ingelström (2005, p. 9), about one out of ten people (9%) bicycle to or from Swedish railway stations today. Data reported in TRAST and presented in Bicycle Handling at Railway Stations (page 6) show that 13% of travelers take the bicycle to stations. As a comparison, about 25% of Danish rail passengers bicycle to the station and 5% of Danish train passengers bicycle from the station. According TRAST the variation in bicycle share is large between different stations (in Skåne between 7% and 37%). In the Netherlands more than 29% of train passengers bicycle to the station and 6% of bus passengers bicycle to bus stops (Martens, 2007, p. 328).

In addition to the above findings it may be worth noting that Martens concludes that measures to improve bicycle parking at public transport nodes in the Netherlands had not been implemented in the absence of an explicit policy of 'Bicycle & Ride' (combination trips by bicycle and public transport). This is because the complicated responsibility relationship that exists in the area where no authority, not even in the 'bicycle country' Netherlands saw bicycle parking at public transport nodes as their responsibility (Martens, 2007, p. 336).

4.4. Bicycle Parking Measures for Increased Quality for Users

As mentioned earlier, TRAST describes bicycle parking as a "key factor" for the function of a traffic network. The qualities that TRAST highlights are that parking solutions should be designed so that "cyclists know there is a place and it is difficult to steal the bicycle" (Vägverket 2007, page 210). The same publication also states that "bicycle parking should be located so that it is safe and can be quickly accessed by cyclists" (p. 217).

Hörlén et al (2009) reported a survey of 300 people in Malmö. In the survey, 73% of respondents indicate it is important or very important to be able to lock the bicycle frame to a fixed object. The survey was probably directed to users who parked the bicycle at stations and bus stops; it is unclear if the study also included 'non-cyclists' (see p. 9.). In the same survey, 60% of respondents said that the distance from the parking area to the destination point is *important* or *very important*.

In Stockholm Stad's survey of 451 cyclists who parked at three stations in central Stockholm 87% of respondents indicated that they wanted bicycle stands of the bollard model, that is, where you can lock the frame of the bicycle (see Table 2 of this report and the Stockholms Stad 2004).

Martens (2007) reviews the previously mentioned results of several previous studies on bicycle parking in the Netherlands. One of these studies (pp. 330-331) showed that improved bicycle parking and other measures at five smaller Dutch stations led to a significant increase in the customer satisfaction index from 5.3 to 7.1 on average, on a scale of ten. In the study 11% of respondents stated that improved quality of bicycle parking at stations was a reason for them to bicycle more to the station. Our inquiry among European experts and suppliers in the field clearly showed that there seems to be an

increasing pressure from users and purchasers for solutions that require higher theft security (see Jansson, 2010).

Martens (2007) concludes that the proportion of users who value different theft security measures varies between locations in the Netherlands. Important factors are/ seem to be, the perceived risk of theft in different areas and cyclists' strategy for dealing with high risk of theft, especially by using a bicycle of low monetary value for commuting (see Martens, 2007, p. 335). As mentioned earlier, there are major differences between the results of stated preference experiments that evaluate bicycle parking, see Section 2.1.

The city of Lund, Sweden conducted in 1999 to 2005 annual surveys of satisfaction and the importance in the quality of different aspects of bicycle infrastructure needs. The investigations were aimed initially only to cyclists. Questionnaires were given to cyclists at bicycle friendly stretches (see Holm & Edman 2000). Later however, the surveys have been directed to different audiences to different degrees. In at least one recent study, a random mailing list was used aimed at local residents (Lund 2006). This latter study thus includes responses from both habitual cyclists and 'non-cyclists'. The studies showed initially that cyclists were relatively dissatisfied with bicycle parking in general in Lund, but they gradually become more satisfied, probably as a result of a number of measures implemented. Since the studies are not specific to a particular location, it is not possible to see how a particular action in a particular location has affected users' satisfaction.

4.5. Bicycle Parking Measures to Provide "Orderliness"

A relatively common reason to take action in the field of bicycle parking is to create order and tidiness, hence to curb bicycles parked in improper locations (see e.g. Halvarsson 2005, p. 27). This in order to stop parking blocking escape routes or in places that hinder pedestrians and/or people less abled.

Although creating orderliness seems to be an aspect of importance in the practical handling of bicycle parking, as yet we have not found any studies that assess the extent to which various measures, such as increased capacity for bicycle parking, can help to solve problems with inappropriate parked bicycles at other locations in the bicycle park proximity.

A Japanese study involving the phenomenon of illegally parked bicycles shows that bicycle users to a significant proportion based the choice on where they park their bicycle related to other cyclists' behavior. In other words, people park where others have already parked his/ her bicycle. This is the case even if bicycle parking is 'inappropriate' or prohibited on the site (Fukuda & Morichi 2006, p. 315). The same study also presents data showing that the proportion of illegally parked bicycles at three stations in the Tokyo region varies greatly from place to place (between 2-95%).

Provus (2006) conclude in their study that abandoned bicycles at Uppsala's new travel center should be moved/ taken care of every 1-3 months. We also know that many cities have or are developing more sophisticated procedures to deal with problems associated with improperly parked and/ or 'abandoned' bicycles.

4.6. Bicycle Parking Measures to Reduce Bicycle Theft

Although different types of bicycle stands and design solutions (e.g. supervised bicycle garages) makes it difficult for a thief to steal bicycles, we have not found any studies in this area. As reported in Jansson (2010) it does not appear that bicycle stand manufacturers and retailers know of such studies.

Peter Davenport is a UK supplier of bicycle stands and indicates that he has not seen any solid before and after study of customer satisfaction for improvements to bicycle parking. Davenport states that he would be happy to see such studies developed. This is because he is convinced that such evaluations would indicate the need for upgrading of existing "front-wheel" stands to more theft-proof bicycle parking solutions (Davenport 2010).

To build more (guarded) indoor parking at public transport nodes and anti-theft marking of bicycles are two examples of actions that cities in continental Europe perform in order to reduce bicycle theft (see Jansson, 2010).

4.7. Comment on Other Possible Effects of Policy Goals

It is also conceivable that various measures such as improvements in the quality of bicycle parking, in turn, may have some secondary effects, i.e. effects other than those mentioned in the previous section. One possible secondary effect is that measures aimed at reducing the damage to bicycles and bicycle theft at larger public transport nodes could encourage cyclists to invest in new and better bicycles thus scrapping their old bicycles.

A Swedish handbook (SKL 2010, p. 122) writes, for example, with more theft-proof bicycle parks "we can get newer, more comfortable and safer bicycles on the streets." That is to say that there is a positive effect on road safety; an old poorly maintained bicycle is replaced with a new one with better brakes. It is well known that cyclists have different strategies for managing the risk of theft, where one strategy is to use a bicycle of low value for trips to destinations with poor bicycle parking/ high perceived risk of theft whilst another more expensive bicycle on other trips (see Martens, 2007). We have however not found any firm empirical evidence to confirm or dismiss that theft secure bicycle parking leads to a change in the economic value and safety standards of the bicycle fleet.

4.8. Benefits of Improved Bicycle Parking Compared to Other Measures

If you want to compare the benefits of investments in improved bicycle parking to other improvements it is perhaps the study of Wardman et al. (2007) that is most interesting. Wardman et al. (p. 344) shows that the difference between having and not having 'bicycle stands outside the workplace' corresponds to the value of 2.5 minutes of travel time on the bicycle. Theft-secure indoor parking for bicycles is valued at the equivalent of 4.3 minutes cycling time. The construction of a new anti-theft bicycle parking garage directly at the entrance to a workplace, for example where one does not exist today should therefore, somewhat simplified, equivalent to remove up to 5-6 red lights on the cyclists' way to work. This would much likely make the bicycle the best option for significantly more people on more trips. Note that these figures are based on a UK study. However, it should be reasonable to assume that a Swedish study in large cities would come to a somewhat similar conclusion.

5. Discussion of Relevant Knowledge Gaps

5.1. Identified Knowledge Gaps

Our literature review shows that there are few before/ after studies of measures and their impact on bicycle parking, at least in those sources that are publicly available or published in scientific journals. This is a conclusion also supported by Martens (2007, p. 327), Wardman et al (2007, pp. 340, 349) and Pucher et al. (2010).

Lindelöw (2009, p.31) writes that *"the link between the rate of cycling and the presence of bicycle parking seems to contain significant, but relatively unexplored, potential."* Worth noting is also Pucher et als (2010) synthesis. Their conclusion is that there is an urgent need for more research on the impact of different measures and their effect on bicycle use.

In addition to the above we have identified a number of other gaps. The following points illustrate some of these gaps in our understanding of bicycle parking quality and it's role to users:

- Studies on bicycle parking at home seem to be completely missing from the literature (prevalence, the importance of quality for bicycle ownership, cycle use, etc.)

- Multiple studies indicate that theft-security quality (lack of 'sufficient theft-secure bicycle parking) is a design aspect that can be very important if you want to increase bicycle use and make users more satisfied, particularly with regard to long-term parking (see Hörlén et al 2009, Hunt & Abraham, 2007; Wardman 2007 , Stockholm Stad 2004, Ericson 2000). There is however still some confusion over how different groups of cyclists prioritise between such improved anti-theft security, improved weather and proximity to their destination.
- There are a number of studies related to willingness to pay for anti-theft solutions (e.g. manned bicycle garages at public transport nodes). These studies have varying quality, and appear to be made in isolation from each other.
- No study has included the potential impact on the demand for theft-secure parking due to the introduction of electric bicycles (with a higher value). Users of electrical bicycles may perceive a higher risk of theft at long-term parking at public transport nodes.
- We have not found any studies that illustrate the effects of various anti-theft securities and their impact in terms of number of stolen bicycles.

As previously mentioned, we have not found any studies on bicycle parking at homes, either in Sweden or in international journals. The shortage applies to before and after studies of user satisfaction associated with improvements in specific locations and lack of analysis of bicycle parking design and its importance for bicycle use. Bicycle parking at home is a policy issue which municipalities, through Planning and Building Laws (PBL) have a responsibility to ensure that property owners, to a reasonable extent, provide good bicycle parking facilities. Studies of what users regard as good enough cycle parking at home in different areas/ buildings can be an important input to the demands municipalities place in zoning and building permits regarding bicycle parking facilities. Such requirements are already placed on Swedish developers (see Josefsson, 2009), but no empirical knowledge of what bicycle users requirements are exist, to our knowledge.

In addition to identifying where there are gaps in knowledge, it is naturally important to reason about the knowledge gaps that are most important to try to address. There are, however, often many different policy objectives. It may therefore be difficult to know which of the different policy objectives are the most important to address. The handbook TRAST mention, however, that 'good' bicycle parking in general is an "important factor" for the function of a transport network (Vägverket et al. 2007, page 210). It may be interpreted that bicycle parking measures in TRAST are mainly focused on achieving *good enough* quality for existing users. However, as shown in Martens (2007) and section 4.1 above, measures primarily aimed to facilitate the needs of existing bicycle users are also associated with an increase in bicycle use.

6. Conclusions

6.1. General Conclusion on Bicycle Parking Quality in Metropolitan Areas

As noted in most handbooks, bicycle parking quality can be measured by a number of factors, including:

- Proximity to destination point/ main entrance
- Location relative to direction of travel/ arrival
- Theft Security (e.g. ability to lock the bicycle frame, lockable garage)
- Shelters
- Capacity (relative to demand)
- Perceived security after dark (fear of assault)

Generally, one can say that the above factors are likely valued differently depending on the person and context. Theft Security is considered to be (more) important for many bicycle users in large cities than in small towns (see TRAST, Vägverket m. fl. 2007, p. 205). However, we have not found any firm empirical evidence to confirm this. The study by Stockholm Stad (2004) showed that 87% of respondents want to have bicycle stands where you can lock the frame of the bicycle which confirms that theft security aspects are important for urban cyclists. A similar survey in Malmö showed that 73% of respondents felt that it is *important* or *very important* to be able to lock the bicycle frame to the stand (Hörlén et al., 2009). For comparison, 60% of respondents in the Malmö study stated that the distance from the parking area to the destination point is *important* or *very important*. International experience also indicates that the (perceived) quality of theft-security in parking areas is a key factor for users in major cities, at least when parking for a long time; for example, at public transport nodes (see Hunt & Abraham, 2007) It is also a measure which leads to more people choosing the bicycle on short trips (Wardman et al., 2007).

It is also clear that in large urban areas there is more need of good practices regarding 'orderliness/ abandoned bicycles'. Capacity issues are also more important for users in the city where often several hundred or thousand cyclists use the same parking. Another aspect of importance in the city but less so in small towns is the cost of land/ space. That is, there is often an attractive alternative use of land adjacent to stations in major cities. This in turn creates a certain pressure in major cities to create underground bicycle garage solutions. A solution that frees attractive above-ground space for more economically strong use.

6.3. Conclusions on Priority of Knowledge Gaps.

Important future additions to the literature in this area include studies of bicycle parking quality (proximity, weather, theft-security) and its relation to user satisfaction. Another important aspect may be to assess the potential of improved bicycle parking in a city or region as a whole, and its ability to increase bicycle use in a country, as an individual measure or as part of a package of measures (see Pucher et al., 2010). A particularly interesting addition to the literature would be to know more about the demands users place on good bicycle parking at home and the importance of different solutions for bicycle possession, theft presence/ risk and bicycle use.

In future studies, it may be important to include non-cyclists because of the health benefits that are linked to physical activity e.g. by cycling to work or the shops. One should at least in future studies clearly show if the results are related to 'non-cyclists' or 'experienced cyclists'. This because those who answer a survey not only affect the results, but can also affect how the results should be used, depending on what the study is trying to accomplish.

6.4. Inadequate Implementation of Existing Research and Development

Besides the fact that there are several knowledge gaps in the field, it is also worth noting that results from Swedish studies that exist in the area seem relatively poorly disseminated (see also section 2.6 of this report). Finding the largest studies in the field required us a certain amount of detective work, phone calls and email communications. Some studies have been so poorly dispersed that not even experts who wrote several Swedish handbooks in the field seem to be aware of them. This applies to the study by Ericson (2000), for example. Our poll at the Velocity conference also gave an indication that many studies seem to be unknown in the field (see Jansson, 2010).

One possible explanation why Ericson's study is not included in some handbooks may be that it was published in a sector other than the 'transport sector' and therefore has not spread to any degree within the transport planning profession. In this case, the study was developed in the area of environmental policy through the City of Stockholm's Environmental Agency. Our conclusion from this is that there seems to be a relatively strong need to gather material and studies on cycling in one place. This is so that the material becomes available to planners, consultants and researchers whatever sector developed the material.

One Swedish study in the field has not been examined in detail because of lack of resources and that we only became aware of the study late in the project (by chance). The study is by Håkansson (2008).

6.5. Further Work

Based on our work, we have identified three main areas for further studies in the field. These are:

1. Survey and/ or interviews on the quality of bicycle parking at homes.
2. Before/ after studies in connection with the improvement of bicycle parking at public transport nodes.
3. How electric bicycles possibly change user requirements and requirements for bicycle parking (especially long-term parking at public transport nodes).

Point one above is needed as a basis for the further development of bicycle parking standards in urban planning. The purpose of the second proposed future study area, before and after studies in connection with investments in new bicycle parking, is to provide a better basis for the design of cost-effective investment strategies in that field.

Bicycle parking at home is an area that we believe can be relatively easy to increase our knowledge. This could be interesting, not least because of the increased interest that exists for bicycle parking standards (Vergverket m. fl., 2007; Josefsson, 2009). Investigation in to what is sufficient in terms of convenience and anti-theft standards for bicycle parking at home is an important addition to the literature. A study in this area could include examining where people park at home (e.g. short-term parking, overnight parking), bicycle parking solutions, access to different parking solutions, and a comparison of those places with access to a bicycle room and those without. The study could, for example also include individuals who have had access to such a bicycle room and compare this to frequencies of bicycle theft at home.

A second important addition to the literature is to systematically evaluate a number of the improvements made in the field, especially improvements to bicycle parking at public transport nodes. At public transport nodes trade-offs are often needed to be made between the various requirements and preferences of bicycle parking (proximity, theft-security, shelter, etc.). Before and after studies of bicycle parking at public transport nodes can also be important because of high land values at stations and thus relatively high investment costs for such bicycle parking solutions. A third reason to focus, at least in part, continuing work in the field on bicycle parking at public transport nodes is the need for infrastructure improvements in these locations (see Boverket, 2009).

Electric bicycles are recognized as a third area for further study because electric bicycles are relatively expensive. This type of vehicle is thus probably more theft-prone than many other bicycles (it might also be that owners' experience is that their electric bicycles are especially theft-prone). It is thus primarily the electric bicycles' price that makes them interesting to study, although there are also some other aspects, for example, battery theft.

In addition to the above, it can also be interesting, if possible, to cross-reference data on average prices of new bicycles 2000-2010 and the new and increased demands that seem to be placed on theft-secure bicycle stands.

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