A CASE STUDY OF BICYCLE FACILITIES NETWORK IMPLEMENTATION:

THE SEATTLE BICYCLE MASTER PLAN

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ABSTRACT

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Cities across the United States have increasingly adopted Bicycle Master Plans (BMPs) to promote the bicycle as an environmentally and economically sustainable form of urban transportation. BMPs embody a community's vision for integrating bicycles into existing transportation infrastructure, while outlining the policies for adoption necessary to support cycling. Despite widespread adoption of BMPs by state and local governments, minimal attention has been given to factors that influence successful plan implementation. Through a review of the literature from the planning and public health fields, this study assesses the empirical support for the proposition that creating bicycle facilities increases ridership. Interviews with key participants involved in implementation of the Seattle Bicycle Master Plan from 2007-2009 are analyzed to identify factors influencing implementation of projects as part of the Bicycle Facilities Network. An "ideal" policy implementation framework is used to structure interviews and is subsequently assessed for its applicability in the Seattle case. A positive correlational relationship is found between bicycle facilities and bicycle use, although self-selection cannot be ruled out due to limitations of the research designs currently employed in the literature. Several factors are identified that are critical to BMP implementation, including the presence of dedicated funding, a Complete Streets policy, the political will of elected officials, and public support of constituency groups. Problematic for implementation are a lack of streets space, public opposition, and expenses associated with capital projects. The implementation framework used to structure interviews was successful in identifying major influences on implementation and its use is recommended for future case study research on bicycle facilities implementation.

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Acknowledgements

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1. Introduction

The U.S. Energy Information Administration's assessment of greenhouse gas emissions for 2008 holds the transportation sector's motor gasoline usage as responsible for 1134.9 million metric tons of carbon dioxide, an amount corresponding to 19.4% of the total emitted that year. As the predominant contributor to human-induced global climate change, curbing emissions of CO_2 in the transportation sector will be a critical piece in addressing one of the defining issues of our time. Buried within these figures is a dependence on the automobile for short trips. The 2009 National Household Travel Survey found that when all trips are considered for 2009, 50% of trips were 3 miles or less, with the automobile being responsible for 72% of those trips. Bicycling currently only accounts for 1.8% of all trips less than 3 miles, while 85% of all biking trips are 3 miles or less. Distances covered by a cyclist of average physical ability, then, have the potential of supplanting many of the trips currently covered by the automobile. Yet until recently, the bicycle has been considered by the Federal Highway Administration as "one of the forgotten modes." (FHA, 2010)

Efforts aimed at promoting the bicycle as a viable means of sustainable transportation in the United States have stemmed from a growing interest at the federal, state and local levels in addressing urban pollution, greenhouse gas emissions, traffic congestion, and public health. Public policy has paralleled this interest to some extent, with 33 of the largest 51 United States cities reporting public commitments to the goal of increasing cycling, up from 2008 when only 25 cities reported having these goals (Alliance for Biking & Walking, 2010). Federal spending on pedestrian and bicycle improvements has followed suit, increasing at an exponential rate from only $6 million in 1990 to $783 million in 2009 (FHA, 2010). While these funds account for only a small percentage of the federal transportation budget, it is clear that the bicycle, previously considered a fringe mode of transportation, has benefitted as a result of this remarkable shift in priorities.

In service of these commitments, the adoption of Bicycle Master Plans (BMPs) has been viewed by local governments as an essential component in making communities more conducive to cycling (Litman et al., 2009). A BMP is a planning document that embodies a community's vision for integrating bicycles into existing transportation infrastructure, while outlining the policies for adoption to support cycling. BMPs identify goals, objectives and evaluation criteria for bicycle planning, design, education, enforcement and encouragement, in turn outlining specific actions for municipal agencies to implement these objectives (Litman et al., 2009). As of 2010, 25 states and 40 cities have adopted BMPs. Charting the longitudinal progress of states and cities in adopting these plans on a nationwide level has not been possible, however, as baseline data was not collected in previous years (Alliance for Biking and Walking, 2010).

In September of 2006, Seattle's former Mayor Greg Nickels released Seattle's Climate Action Plan a strategy document outlining specific action items necessary for the city to meet or exceed the international Kyoto Protocol's climate pollution reduction goals. Citing that nearly a quarter of Seattle's greenhouse gas emissions come from cars and that most trips are within five miles from home, the CAP directed the Seattle

Department of Transportation (SDOT) to complete the Seattle Bicycle Master Plan (referred to in this paper as SBMP, or simply “the Plan”) in 2007 (City of Seattle, 2006). The support of elected officials embodied in the CAP, coupled with the support of the public and the concurrent passage of a dedicated funding source through the voter approved “Bridging the Gap” transportation package, provided the necessary conditions for SMP adoption in 2007. After three years of discussions, City Council members passed the SBMP unanimously on November 5th, 2007 (Lindblom, 2007).

Central to achieving the Plan’s goals of increasing bicycle mode share and safety in Seattle is the creation of a 450-mile network of bicycle facilities connecting the entire city, referred to as the Bicycle Facility Network (BFN). Bicycle facilities, for the purposes of this paper, refer to on and off-street bike lanes, including multi-use trails. The creation of the BFN is considered “fundamental” to achieving the goal of the plan (SDOT, 2007), representing the bulk of public investment in the Plan that will in turn make lasting and extensive changes to Seattle’s transportation infrastructure. The Network itself is defined as including all current bicycle facilities as well as proposed ones that are detailed as specific action items in the Plan. The completed BFN is expected to connect all parts of the city and, providing a bicycle facility within one-quarter mile of 95% of Seattle residents.

The creation of bicycle facilities guided by a BMP represents an enormous investment by localities in terms of staff, funding, and changes to existing street space. Seattle, a medium size city of just over 600,000 residents (U.S. Census Bureau, 2010), estimates the cost to implement the SBMP at $240 million (based on 2007 dollars)

(SDOT, 2007). By comparison, Portland's 2030 BMP envisions 681 miles of facilities at a projected cost of $613 million. Such large public investments beg the question of whether there is empirical support for the creation of bicycle facilities as an effective long term strategy for increasing the number of bicycle riders. Without such knowledge, localities contemplating the creation of a BMP cannot be confident that bike lanes and off-road trails are likely to have the intended benefit when implemented.

The purpose of this study is to identify factors that influenced implementation of the SBMP during the period of 2007-2009. A policy implementation framework created by Hogwood and Gunn (1984) is used as the basis for interview questions posed to key respondents who had first-hand involvement with implementation of the SBMP during the study period. Interview responses are analyzed by corroborate significant factors and themes and are discussed in Section 3, Data. In light of Hogwood and Gunn's requirement that a policy or program be based on a sound theory of cause and effect, a second question posed by the study involves whether a relationship can be established between bicycle facilities and increased ridership. An assessment of the theory underlying the policy, in terms whether a direct and causal relationship exists, is necessary to determine the extent to which the policy is likely to achieve the stated end of increasing ridership. To this end, an analysis of models in the peer-reviewed literature that address bicycle ridership will provide a basis for evaluating the extent to which it meets the criteria for causality with minimal linkages.

The study concludes with a brief assessment of the policy implementation framework chosen in its relation to identifying factors through the interview instrument employed by the author. The policy implementation framework created by Hogwood and Gunn was successful in organizing the interview instrument to elicit responses from study participants, with several critical factors identified. Refinements will be suggested for future researchers to test against other U.S. cities in the process of implementing bicycle plans based on the information provided by key respondents in the Seattle case. Models detailing influences on bicycle use show that a positive relationship exists between bicycle facilities and ridership, but a significant number of variables may serve to mitigate the effect, depending on local variables. The direction of the relationship is uncertain, and meeting Hogwood and Gunn's requirement for causality is not possible given the current state of literature.

This study contributes to the fields of transportation planning and public health by assessing whether empirical evidence exists for the creation of bicycle infrastructure in order to increase ridership. Understanding what factors influenced implementation in the Seattle case will provide planners and advocates contemplating the creation of a plan a "lessons learned" from a medium-sized, Pacific Northwest city.

The following section establishes the need for the current study by reviewing the current literature available on bicycle policy and program implementation. Specific study questions are then defined along with appropriates methodologies and data to determine factors influencing implementation of the SBMP and bicycle ridership.

2. Literature Review and Methodology

The creation of a Bicycle Facilities Network outlined in SBMP Objective #1 (Appendix A) is a common approach to increasing bicycle ridership and safety. Widespread enthusiasm for this approach exists across the U.S. in part based off the successes of Northern European cities where bicycling represents a larger percentage of the total transportation modal share and more extensive networks of bicycle infrastructure exist. Pucher and Dijkstra (2003), in a widely cited article, assert that policies aimed at non-motorized transport in the Netherlands and Germany are responsible for the large share of total trips made by bicycles in these countries. Bicycle modal shares of 28% and 12% for the Netherlands and Germany respectively, compared to 1% of all trips in the US, combined with higher levels of safety in terms of injuries and deaths, lead many to the commonsense conclusion that these countries' policies are responsible for successes. While the authors succeed in showing that both Dutch and German cities have made substantial bicycle infrastructure investments, implemented innovative traffic calming devices, and incorporated cyclists' rights into both their traffic education and enforcement regulations, such correlations are not evidence of causality or a quantitative assessment of the effect on cycling. Such observations lack an empirical basis for understanding the influence of any of these policy or design prescriptions on subsequent increases in bicycling.

As discussed in the Introduction, a focus on infrastructure investments has characterized the American approach to increasing bicycle use and safety, if to a lesser extent than many of the Northern European countries with high bicycle mode shares.

Several key transportation acts during the 1990s provided devoted to the construction of on-street bike lanes and off street trails. Notable is the $286.4 billion federal transportation bill, SAFETEA-LU, which provides substantial funds devoted exclusively to construct bicycle facilities (Krizek et al., 2009). The emphasis on creating both on and off street bicycle lanes in order to make the existing streetscape a more viable option for bicyclists is characteristic of the approach of many Bicycle Master Plans. Despite the observation by some advocates and non-motorized planning professionals that many BMPs do not get implemented, there is a dearth of empirical research that provides an analysis of factors thought to influence the process of getting projects prioritized in BMPs on the ground. In the following section, a review of the one academic study and one professional guidance document on bicycle program and plan implementation is presented in order to establish the need for the current study.

2.1 Review of Bicycle Policy Implementation Literature

Extensive searches of academic databases yielded only one academic study on the implementation of bicycle policies. Stating that abstract common cycling goals set through the National Cycling Strategy often translate into very different local results, Gaffron (2003) surveys 92 British local authorities to explore the mechanisms that contribute to implementation outcomes. The study is of interest in that local authorities are required to prepare five-year local plans and encouraged, though not obligated, to include policies for pedestrians and cyclists in these plans. While the inclusion of bicycle facilities can’t be assumed, the study does identify both hindering and helping factors for local bicycle policy implementation. Factors for cycling that were most obstructive were lack of funding, lack of staff, and lack of staff time. Factors that were found to aid policy implementation include having a national policy framework for cycling, other national transport strategies and policies, and having a committed/motivated officer(s). Overall, lobbying activities of local pressure groups and the political composition of the city council were not found by respondents as having great influence over later outcomes. Other important findings included the role of a policy champion is often sufficient to influence implementation results, but this may also indicate that other highly motivated actors who oppose the policy can have a restrictive influence. The local authorities' commitment to the policy through political will and resources were likewise found to be important.

Lagerwey's (2009) "Creating a Roadmap for Producing & Implementing a Bicycle Master Plan", provides a guide to BMP design and execution intended to be applicable to a wide variety of local needs. The document identifies two factors external to the implementing agency that are thought to assist with plan execution. First, the routine accommodation of bicycle infrastructure during maintenance and capital projects is listed as the "single best way" to implement physical improvements recommended in a plan. This can be achieved through the adoption of a "Complete Streets" policy which requires that the needs of all transportation modes be taken into account when re-paving or building new streets (Lagerwey, 2009). These policies ensure that provisions such as sidewalks, curb cuts, bike lanes, traffic calming and inviting crossings are included in all road projects and not as an optional add-on (Alliance for Bicycling and

Walking, 2010). Second, the availability of a dedicated funding source is likewise seen as beneficial, and considered a viable option to pursue even in increasingly turbulent economic times. Dedicated funding sources for bicycle projects and programs have included general funds and tax assessment measures approved by voters (such as levies, the issuance of bonds, and millage, etc.) and through grants and partnerships from public or private entities.

Other general strategies are aimed specifically at implementing staff focus on the goal of increasing transparency, accountability, and information provision after plan adoption. One such strategy details securing a place on the agenda of the group responsible for monitoring implementation of the plan in order to start making monthly reports. The "Roadmap" similarly suggests presenting an annual work plan to the designated group that consists of measurable tasks for their review and approval, and documenting all successes. Finally, the document highlights the need for ongoing public outreach even after the adoption of the plan due to the potential for public backlash that serves to slow or stop the plan.

The above study and policy guide identify that there is a clear need for information related to factors influencing non-motorized transportation policy implementation. These studies represent first steps for assisting policy makers in making more informed decisions by allowing them to assess their own context in relation to general strategies or factors that influence implementation outcomes. Yet the scope of both studies is limited in important ways for the purposes of this study. Gaffron (2003) does not discuss bicycle lanes specifically, in favor of a more general “cycling policies”. This is necessary due to the author studying a large number of local authorities that have likely adopted widely divergent policies under an overarching national framework. The low response rate of the study, 45%, was identified by the author as normal for such surveys, but may conceal a response bias on behalf of localities that are not interested in cycling or walking policies. In such a case, important factors that inhibit policy adoption and/or subsequent implementation may be underrepresented.

Lagerwey’s (2009) “Roadmap” document, while a valuable summary of the insights and experiences learned in Seattle, is limited in many respects. Only two pages of the document discuss implementation specifically and in a general way. For example, three of the six implementation steps suggested included (such as “Get the Plan adopted”, “Document Your Success”, and “Seize the Day”) are more suggestive of general elements to include in plan adoption and implementation and do not represent an effort to systematically gather and corroborate data in relation to the process of implementation.

The lack of studies dedicated to Bicycle Master Plans should be considered alarming given that their adoption represents large public commitments requiring agreement among elected officials, stakeholders, transportation planners, activists, and consultants, with funding commitments of several hundred million dollars being commonplace for medium sized cities. Currently, over 40 U.S. cities have developed and adopted BMPs, a number that will likely continue to rise in coming years. The literature review establishes that research has not kept pace with the adoption of these plans and that there is little in the way of empirical guidance on the factors that will lead to a higher probability of a successful implementation outcome. The state of the literature warrants a closer look at what factors have proven to be important for influencing the construction of bicycle lanes and trails, as envisioned in the Seattle Bicycle Master Plan. To assist with filling the current gap in knowledge, the following section outlines the questions to be addressed by the present study and method chosen to analyze factors influencing Seattle's implementation of a BMP.

2.2 Study Question and Methodology: BMP Implementation

An implicit assumption of this study is that the state of the literature necessitates first describing what factors are thought to influence a plan before explanatory or quantitative studies are conducted. Prematurely proceeding with explanatory studies that assess the relative impact of various factors would neglect the fact that the researcher may not currently know what those factors are. To assist in this endeavor, the current study employs a case study methodology incorporating semi-structured interviews to answer the primary study question:

Question #1: What are the facilitating and obstructing factors identified by implementing staff that influenced the development of the Bicycle Facilities Network during the 2007-2009 period?

The case study presents itself as the most appropriate methodology in that it is unique in allowing the researcher to retain the holistic and meaningful characteristics or real-life events (Yin, 2003). This was deemed a necessary attribute given the inherent nature of political and organizational processes. Because the lines are not clearly delineated between the phenomenon (implementation of bicycle infrastructure projects) and context (community support, municipal policy constraints, budget constraints, etc.), a methodology that will allow for collection of both was determined to be of paramount importance. The case study methodology is also well suited to this endeavor in that it does not require behavioral control of contemporary events, allowing the author to address both exploratory and explanatory elements that are inherent to the research question.

As opportunities for direct observation were not possible, and documentation and records do not directly address the factors related to influences on SBMP implementation, the use of interviews was deemed most appropriate to answer the research question regarding influences on implementation. The use of interviews as a data source is especially pertinent to the methodology chosen as they are considered one of the most important and essential sources of case study information (Yin, 2003).

Participant selection consisted of identifying key informants with direct involvement in implementation during the Short-Term Implementation Period (2007-2009) of the Seattle Bicycle Master Plan. Potential study participants identified in SBAB meeting minutes as being involved directly with SBMP implementation were contacted between May and June of 2010, yielding five study participants. Participants consisted of two agency staff directly involved with implementation, a bicycle policy advocate, a consultant involved with the plan, and a member of the Seattle Bicycle Advisory Board that advises the implementing agency on program decisions. Three of the five participants were directly involved with the development of the SBMP, either through the Mayor's Citizens Advisory Board or as City of Seattle planning staff. Four of the five participants were employed as transportation professional in various capacities, with the final participant being a professional in another field tasked with advising the City of Seattle on decisions related to bicycle policy.

Due to the possibility of jeopardizing a study participant's employment or standing within the community should someone take offense to an interview response, a Human Subjects Review was submitted to, and approved by, the Evergreen State College. Interview participants were informed upon first contact that their participation was to be completely voluntary and that there would be no compensation for their time. Study participants were given the option of retracting statements and dropping out of the interview at any time with no consequence. In order to allow participants to provide information freely without fear of professional risk, all interviews are cited as anonymous.

Interviews were conducted between August and November, 2010, or, less than a year from the end of the study period. Semi-structured interviews with individuals (one interview was agreed to with two participants concurrently, due to their limited availability) were conducted over a period of one hour to ninety minutes either in the offices of the study participant or a location deemed more suitable to them. Study participants were asked a series of structured questions (Appendix B) developed by the author and based on the synthesis of several theories of policy implementation presented by Charles (2005), discussed in detail below. Participants were reminded that the scope of questions refers to activities in the SBMP that took place after the initial adoption of the plan in 2007 through 2009, and to limit speculation about events that have not happened. Responses were audio recorded for later transcription and analysis.

2.2.1 Policy Implementation Evaluation Framework

Designing an interview instrument able to address factors influencing SBMP implementation required meeting two competing demands. First, interview questions need to allow for open-ended responses that would reasonably ensure the major factors influencing implementation would be covered. Second, questions needed to be confined to areas most likely to affect plan implementation. The need for an established policy implementation framework was deemed necessary to guide question development by providing an existing structure that would increase the chances of identifying factors while mitigating the possibility of researcher bias having an undue effect on responses.

Literature specific to bicycle planning and policy implementation yielded little precedent for adopting one approach over another. As discussed in the review of literature, the author identified only one study that focused specifically on factors influencing bicycle policy implementation. In conducting a literature review to provide a basis for choosing a conceptual model to structure her study, Gaffron (2003) notes that not only were there no widely accepted theories of the nature of policy implementation process, there was no standard methodology for studying it. Gaffron concluded that researchers, in analyzing program and policy implementation, have to rely on a synthesis of the theoretical framework of implementation analysis, judgment of the applicability of different approaches in their particular area and the conclusions they draw from their own data.

Given the lack of precedent, academic databases were queried for an implementation analysis framework that met several criteria, based off the author's best judgment of the applicability of the framework to non-motorized plan implementation. It was determined that the policy implementation framework synthesized by Charles (2005) from previous work in the field of implementation analysis (Hogwood and Gunn, 1984; Ison and Rye, 2003 ; and Sabatier and Mazmanian, 1979) could reasonably provide a basis for developing a survey instrument to comprehensively address a number of factors likely to affect SBMP implementation. Charles' framework (Table 1) synthesized work on good practice in implementation from previous theory and studies in order to identify the key success factors for effective implementation of regional traffic incident management program.

The use of Charles' iteration of the "ideal" policy implementation framework is justified due to its meeting several criteria established by the author. First, it was determined that the framework covered the types of issues that may influence the development of the SBMP. Monthly meetings minutes of the Seattle Bicycle Advisory Board (SBAB, 2007-2009) provided an appropriate source of data to assist in this assessment. A significant strength of this data source can be found in the wide range or representation available at any meeting. Neighborhood bicycle activists, commuters, bicycle policy advocates, various city agency staff, and members of the Board bring a

Table 1: Theoretical Policy Implementation Framework

Context: external circumstances	Circumstances external to the implementing agency do not impose crippling constraints (HG); Relative priority of objectives not undermined over time (SM); Political stability (IR)
Resourcing: time, skills, funds	Adequate time and sufficient resources are made available; & required combination of resources is actually available (HG); Leaders of implementing agencies possess significant managerial and political skills (SM); Rationalize financing and investment streams: allocate funding in a balanced way (ECMT); program timing. (IR)
Theory: cause and effect	Policy based upon a valid theory of cause and effect; & relationship between cause and effect is direct (HG); Program based on sound theory (SM).
Leadership: governance, institutions	Single implementing agency (HG); Provide a supportive legal and regulatory framework: ensure the rules and regulations clearly specify roles (ECMT); Policy champion clearly dedicated to the task of implementation (IR)
Clarity: clear policy and strategy	Complete understanding of, and agreement upon, the objectives to be achieved, and that these conditions persists throughout the implementation process; & tasks are fully specified in the correct sequence (HG); Policy contains unambiguous directives and structure the implementation process to maximize success (SM); Establish a supporting policy framework (ECMT)
Coordination: good communication and coordination	Perfect communication and coordination , between the various elements or agencies involved (HG); Improve institutional coordination and cooperation: with responsibilities commensurate with resources for implementation to occur (ECMT); flexible and open attitude toward public reaction (IR)
Compliance: require and obtain compliance	Those in authority can demand and obtain perfect compliance (HG)
Support: stakeholder support	Program is actively supported by constituency groups (SM); encourage effective participation, partnerships and communication (ECMT); Public trust and support (IR)
Monitoring: data collection and monitoring	Improve data collection, monitoring and research: carry out consistent monitoring (ECMT); Monitoring outcomes (IR)

Note: HG refers to Hogwood and Gunn; IR refers to Ison & Rye; ECMT refers to European Council of Ministers of Transport; SM refers to Sabatier and Mazmanian. Table from Charles, P (2005), pg. 611.

diverse array of professional backgrounds and experience to assist in advising the Seattle Department of Transportation specifically on SBMP implementation issues. As the intention of these meetings was not to assess and corroborate factors influencing the Plan in a systematic way, data gleaned from this source is most beneficial in providing a first look at influences on BFN development during the Short-Term Implementation Period. Factors influencing implementation identified by the author during the course of SBAB meetings were able to be categorized in five of the nine categories presented by Charles (2005), the results of which are provided in Table 2 below.

The framework presents another advantage in that is has been used in previous transportation related studies. Both Charles (2005) and Ison and Rye (2003) successfully employed the framework to analyze implementation of a regional transportation strategy, and travel planning and road user charging programs, respectively. Charles' formulation of Hogwood and Gunn's (1984) "perfect" implementation framework was also determined by the author to meet the need of using concepts that are readily understandable to practitioners in the field who may not be familiar with implementation analysis, and would be confused by obscure jargon. A final consideration was the adaptability of the framework to the current study's purpose, particularly the limited amount of time available to conduct interviews. Charles' formulation of the framework does not present itself so much as an integrated system but is modular in that questions can be developed around particular areas of the framework and not others. For these reasons, and with little precedent to go off of, Charles' iteration of the original Hogwood and Gunn framework was chosen as a basis for creating an interview instrument.

Table 2: Content Review of Seattle Bicycle Advisory Board Notes- Potential factors Influencing Implementation of the Seattle Bicycle Master Plan, 2007-2009

Potential implementation issue identified in SBAB Meeting Notes	Implementation Framework Category	# of times mentioned by participants	SBAB meeting
South Lake Union Streetcar danger to cyclists	Context: External circumstances	10	Nov 07. Mar 08. Apr 08. Mar 09. Sept 09.
Role of SBAB and SDOT (board and implementing agency) in facilitating project implementation	Coordination: good communication and coordination	4	Nov. 07, Mar. 08, Aug. 08, Nov. 09
Bridging the Gap availability	Resources: Time, Skills, Funds	4	Oct. 08, Nov. 08
Prioritization scheme for choosing projects/opportunity cost	Clarity: clear policy and strategy	3	Sept. 09, Mar. 08
Producing list of projects and prioritizing based on scoring system	Clarity: clear policy and strategy	2	Oct. 07, Feb. 08
Businesses angry at bikers after implementation	Support: stakeholder support	2	Mar. 08
New ferry waiting lane precludes inclusion of bicycle lanes	Context: External circumstances	1	Mar. 09
Peak parking and bike lanes	Context: External circumstances	1	Oct. 09
Opposition to Plan from neighborhood residents	Support: stakeholder support	1	Mar. 09
Community Council opposition	Support: stakeholder support	1	Apr. 08
Constituency support and issue creation	Support: stakeholder support	1	Apr. 08
Complete Streets	Context: External circumstances	1	May 08
SDOT potential budget cuts	Resources: Time, Skills, Funds	1	Aug. 08
Timing of funding	Resources: Time, Skills, Funds	1	Mar. 08

2.2.2 Interview Instrument

A comprehensive assessment of all factors influencing "perfect" implementation included in Charles' framework was determined to be inappropriate for the scope of this study. For practical reasons, it was deemed necessary to keep interviews at approximately one hour's length in order to increase the response rate of participants and decrease a respondent's likelihood of dropping out of the study. Twelve core questions were developed with several sub-questions for probing and follow-up that would cover aspects of each of eight of the core categories the framework (Table 1). As the framework only suggests factors that would support the ideal implementation of a program, the absence or contradiction of such factors is assumed to obstruct implementation. This assumption was used as a basis for developing questions whose responses will allow for the identification of both positive and negative factors influencing implementation of the Seattle Bicycle Master Plan.

The use of interview data was deemed by the author to be an inappropriate data source to answer the question of whether Hogwood and Gunn's requirement for a valid theory underlying a policy or program was fulfilled (see "Theory: cause and effect" category, in Table 1 above). The next section outlines the second study question, as well as the need to employ a methodology on separate data that models the relationship between bicycle facilities and bicycle ridership.

2.3 Study Question and Methodology: Theory Behind Policy Implementation

Hogwood and Gunn's (1984) implementation framework states that an important aspect of implementation is that the policy incorporates a valid theory of cause and effect with minimal linkages, that "if X is done at time t(1) then Y will result at t(2)." Several authors echo this sentiment, with one noting that successful plans and programs that intend to increase bicycling need to be based on empirical knowledge of who cycles, where, and why (Moudon, et al. 2005). As a condition for effective implementation, Sabatier and Mazmanian (1979) similarly contend that a policy should consider all major factors directly contributing to the problem within the scope of the program and correctly relate each of these factors to the desired outcomes. Using Hogwood and Gunn's formula, a theory underlying the Seattle Bicycle Master Plan could be phrased as follows: *"If 450 miles of bicycle facilities are provided to be within ¼ mile of 95% of Seattle resident over the 10 year (2007-2017) implementation period of the Seattle Bicycle Master Plan, then bicycling will triple at the end of that time."*

With limited resources and no agreed upon model of determinants of bicycle use, it is outside the scope of this study to venture predictions specific to the city of Seattle in terms of tripling its share of cycling commuters from its 2007 rate of 2.27% to 6.81% in 2017. Assessing the theory behind the policy through the use of interview data was also deemed problematic in that respondents may reflect unwarranted assumptions about the positive effect of bicycle facilities on ridership. Indeed, Krizek et al. (2009) state that such assertions "are often bantered about by planning agencies and advocacy groups", despite the fact that evidence that can reliably support such statements has not been forthcoming.

A more appropriate data source can be found in through the use of predictive models of bicycle use found in the peer reviewed literature of both the public health and transportation planning fields. These models are less prone to be influenced by professional assumptions due to the need to demonstrate statistical significance, and can be critiqued for the strengths and weaknesses of their underlying study design.

Analysis of models of bicycle use is conducted through an assessment of their conclusions in terms of several of Hogwood and Gunn's criteria held up as ideals for successful policy implementation. First, the ideal condition the implementation framework assumes is that the relationship between a policy and outcome must be positive and causal. Second, the relationship must be direct and have few if any intervening links in the chain of causality. A third criterion assumed by the author concerns the strength of the evidence: measures and constructs should be well agreed upon and results should be repeatable across conditions, while adequately explaining variations. An assessment of models in meeting these criteria will provide the basis for determining how the evidence compares to the ideal theory aspect of the implementation framework, and to what extent the conditions are satisfied. The second study question is thus framed as:

Question #2: Does empirical evidence exist for the proposition that creating bicycle facilities (in the form of on and off road lanes) has a positive, direct, and causal relationship with bicycle ridership?

In the section that follows, the results of qualitative data obtained from interviews will be used to explore the first research question to identify factors found to be significant in influencing SBMP implementation outcomes. The results of models of bicycle use will then be analyzed to answer the second study question concerning the influence of bicycle infrastructure provision on ridership outcomes. As will be seen, this assessment would be incomplete without also considering the often significant effects that individual, attitudinal, socio-demographic, environmental, and geographical factors have on bicycle ridership.

3. Data

The following section (3.1) will present the results of the qualitative data gathered through the use of interviews with bicycle implementation staff, along with coding techniques and the criteria for determining how responses are significant. Significant factors affecting implementation are then discussed in detail according to categories in Charles (2005) framework. Section 3.2 will review the results of models of bicycle ridership and the use of ecological models to categorize results in terms of individual/attitudinal, socio-demographic, environmental and policy level factors. A discussion of the results in terms of Hogwood and Gunn's (1984) criteria that the theory underlying the policy demonstrates a cause and effect relationship with minimal linkages will finish the chapter, in preparation for Section 4, which will provide a final analysis and conclusions of the major study findings.

3.1 Factors Influencing Implementation of the Seattle Bicycle Master Plan

Qualitative data from interview responses with implementing staff provides the basis for answering the first study question concerning the facilitating and obstructing factors that influenced the development of the Bicycle Facilities Network during the 2007-2009 Short-Term Implementation Period. Interview responses were digitally recorded and later fully transcribed to reduce errors due to recall. Interview transcripts were analyzed in terms of the factors identified by respondents and their corresponding influence on implementation. Interview responses were coded by the factor they addressed and subsequently rated by the author for their effects on implementation using a simple scale: Critical for implementation, supportive of implementation, neutral or no effect on implementation, problematic for implementation, and barrier to implementation. Categories were broadly defined according to the following scheme:

- **Critical for implementation:** The factor was defined by the study participant as being of paramount importance in regard to implementation outcomes. The absence of the factor would have created a significant barrier to implementing projects in the Bicycle Facilities Network.
- **Supportive of implementation:** The factor was defined by the study participant as contributing positively to implementation outcomes, but was not identified as being a critical piece.
- **Neutral or no effect on implementation:** The factor identified by the study participant was not associated with implementation outcomes, or had no discernible effect.
- **Problematic for implementation:** The factor identified by the study participant served to significantly impede projects, but not stop them entirely.

- **Barrier to implementation:** The factor was determined by the study participant to halt the construction of projects, and only in its absence could the plan move forward.

A separate category, “not categorized”, was reserved for survey responses that were either not well developed, conflicted on the influence of implementation, or too contextual to readily assign a category to. Factors that were identified by three or more respondents as having a particular effect on implementation were labeled “convergent”, meaning that the effect of the factor on implementation was assessed similarly by the majority of respondents and will be considered a significant study finding. If a factor contained three or more responses that differed in the magnitude, but not the association of the effect (i.e., two responses for critical for implementation, one for supportive of implementation, but three positive overall), responses were likewise labeled convergent and considered significant. Due to the study design generating a large number of responses and a need for confidentiality, convergent factors identified by participants are summarized below (Table 3) based on the effect reported. Factors that were only mentioned by one interview respondent or that were not sufficiently developed were not considered.

Overall, study participants identified the presence of a dedicated transportation project funding source (“Bridging the Gap” levy), political will, an ordinance that requires the consideration of bicycle facilities in all City transportation projects (“Complete Streets”) and the support of constituency groups as being critical factors influencing a positive implementation outcome.

Table 3: Factors identified by study participants that influenced implementation of the SBMP 2007-2009 (by # of times factor was mentioned in interviews, categorized by associated effect)

Implementation framework category	Factor	Critical for implementation	Supportive of implementation	Neutral or no effect on implementation	Problematic for implementation	Barrier to implementation	Mixed Influence on implementation	Not categorized*
V. Resourcing: Staff, Time, Funding, Expertise	**Bridging the Gap**	5						
I. Context and Leadership:supportive policy framework and absence of external constraints	**Complete Streets**	2	2					
VIII. Enforce Compiance	**Political will**	3	1					1
XIb. Support- Consituency groups/public	**Support of constituency groups**	2	1					
X. Leadership: Policy champion	**Policy Champion- Cascade Bicycle Club**		4					
II. Resourcing-Timing	**Gas Prices**		3					
XIa. Support-public trust	**Public Trust**		3	1				
V. Resourcing: Staff, Time, Funding, Expertise	**Adequate staff to accomplish objectives**		3					
I. Context and Leadership:supportive policy framework and absence of external constraints	**Seattle Climate Action Plan**			3				1
II. Resourcing-Timing	**Focus on the environment**			3				
I. Context and Leadership:supportive policy framework and absence of external constraints	**Limited street space to accommodate all uses**				4			
V. Resourcing: Staff, Time, Funding, Expertise	**Funding Capital Projects**				3			
XIb. Support- Consituency groups/public	**Opposition to projects/ bicyclists and infrastructure the "unusual other"**				3			
VII. Leadership-single implementing agency	**Dependencies on other agencies/publi process**		1				3	1
XI. Support-flexible attitude toward public reaction	**Public process**		2				3	
III. Political Stability	**Political stability**		2					3
IX. Agreement on objectives to be achieved	**Mix of facilities- Sharrows vs. bike lanes**							5
VI. Monitoring-Improve Data Collection; carry out consistent monitoring	**Data**		2	1				2
I. Context and Leadership:supportive policy framework and absence of external constraints	**City Comprehensive Plan**		1		1			
V. Resourcing: Staff, Time, Funding, Expertise	**Requisite expertise at implementing agency**		2	1				1
I. Context and Leadership:supportive policy framework and absence of external constraints	**Seattle Transporation Strategic Plan**		2					
II. Resourcing-Timing	**Focus on health/well-being**		2					

*response varied in many instances and did not converge on any one factor, or were difficult to categorized for contextual reasons.

Supportive of implementation was the presence of the Cascade Bicycle Club in the role of policy champion, an increase in support due to high gas prices during a portion of the study period, public trust, and having adequate staff to accomplish the objectives of the SBMP. Seattle's Climate Action Plan and environmental concern were not characterized by study participants as having an influence on the implementation of the Bicycle Facilities Network.

Problematic for implementation was the fact of limited street space to accommodate all uses, difficulty funding capital projects such as bridges and multi-purpose trails, and public opposition to projects. No significant barriers to implementation were identified during the Short-Term implementation period. This finding is not surprising given that the SBMP is in the early phases of implementation and has flexibility in the projects it chooses, coupled with the fact that SDOT met its projects goals over the three year study period.

Participants discussed the need to interact with other agencies and the requirement for public process as having mixed, but ultimately positive, effect on implementation. Left uncategorized were the roles of political stability and that of data and performance measures in implementation outcomes. Responses in this case were not sufficiently developed, speculative of events that have yet to happen, or could not be adequately assessed during the study period for the Seattle case.

Overall, the interview instrument was successful in identifying factors of varying influence on Bicycle Facilities Network implementation efforts. All interview questions based off of aspects of implementation identified in Charles' iteration of the framework generated responses, with five framework categories (Context, Resourcing, Compliance, Leadership, and Support, see Table 1 above) of eight having converged on responses for one or more factors.

In what follows, a more in depth treatment is provided of the facilitating and obstructing factors identified by key respondents during the course of interviews. Factors identified by participants as influencing implementation are organized according to categories in the implementation framework presented by Charles (2005) in Table 1 above. It is only through a consideration of the major themes present across convergent responses (three or more respondents reporting a similar effect) that the contextual influence of individual factors can be assessed in terms of the effect on bicycle facilities implementation in the Seattle case.

3.1.1 Context and Leadership: Policy Framework and External Constraints

Hogwood and Gunn (1984) note that some obstacles to implementation are outside the control of program administrators because they are external to the policy and the implementing agency. They may be physical, such as a lack of space to develop bicycle infrastructure projects, or political, when projects are unacceptable to certain groups or interests (neighborhood associations, commercial trucking groups, etc.) that can successfully lobby effectively against them.

The interview instrument had participants consider the effect of a supportive policy framework, as outlined in Charles' theory in the section on Clarity: Clear Policy and Strategy (Table 1). While the external environment may serve to constrain a policy, it may provide an environment that reinforces actions that lead to the successful implementation of Bicycle Facilities Network projects. Several policies outlined in the SBMP as supportive of the Plan include the Complete Streets policy adopted by City Council in 2007, Seattle's Climate Action Plan, and the "Bridging the Gap" initiative passed by Seattle residents in 2006 that will make approximately $3 million available annually to implement the Plan (SBMP, 2007). Alternatively, the possibility that existing policies may conflict with Plan implementation in important ways needs to be explored and assessed for its effect on the process.

Respondents considered the Complete Streets Ordinance critical to successful implementation, while the Seattle Climate Action Plan was thought to have a largely neutral effect as a framing document.   The lack of street space to implement projects was considered to be problematic, although responses did not converge on whether this effect was more of an issue during Plan development or Plan implementation. The City of Seattle Comprehensive Plan was not found to have convergent responses, but is briefly discussed due to the potential constraining effect it could have on project implementation. The following four subsections will discuss each factor related to the policy framework and external constraints in more detail.

3.1.1.a Complete Streets Ordinance

The Complete Streets ordinance, passed by Seattle City Council on April 9, 2007, was mentioned in the SBMP as one of several policies that "will play an important role in building support for its full implementation". (SBMP, 2007) The Complete Streets ordinance requires SDOT to "plan for, design and construct all new City transportation improvement projects to provide appropriate accommodation for pedestrians, bicyclists, transit riders and person of all abilities, while promoting safe operation for all users, as provided below." (City of Seattle, 2007) The policy objectives could be achieved through single projects, or incrementally through a series of smaller improvements or maintenance activities over time. An example of the application of the Complete Streets legislation would be that SDOT, when conducting a repavement or capital project, would be required to consult the Bicycle Master Plan and consider bicycle improvements to be included before the project is executed.

Four study participants out of five viewed the Complete Streets ordinance as either a very supportive, or critical, policy in regard to implementation of the SBMP. As a statute enacted by the City of Seattle, Complete Streets is a legal requirement that institutionalizes the consideration and accommodation of projects outlined in the SBMP that may have been overlooked in the absence of such a policy. One respondent with experience throughout the U.S. working on BMPs noted that not only was it an important piece in adoption and implementation in Seattle, but it may be *the* catalyst for getting BMPs on the ground:

"[The Complete Streets ordinance] was a very, very important policy in terms of getting the Bike Plan adopted because it said that we are going to be inclusive and accommodate all modes in projects and programs... There's a lot of plans that get developed that don't get implemented, but when it is combined, I think, with a Complete Streets policy then it really motivates everyone to do that."

According to one participant, the benefit of routine accommodation of historically underserved transportation modes did not have any apparent influence on the timing or complexity of projects. Its value, again, lay mainly in what advocates see as an improvement to the planning process by considering the SBMP whenever transportation projects overlap an area in the Bicycle Facilities Network:

"So, have projects been easier or harder to implement? I don't know, but I think they have been better implemented… the city is very aware that when they are doing projects that they have to consider the BMP. I think it has improved the process, whether it has sped it up or slowed it down, I don't know."

The importance of the ordinance is underscored by one advocate in noting that the passage of a Complete Streets policy is no easy feat:

"You know, the Complete Streets ordinance took four years to craft and get passed, I think it is the most important piece of policy language."

Responses readily converge on the routine accommodation of bicycle facilities in all city transportation projects as a critical factor in ensuring that they are not overlooked. The legal requirement to do so has the effect of institutionalizing the process and gives advocates standing in cases where the Complete Streets ordinance is not adhered to. For these reasons, the existence of a Complete Streets policy is considered to be a critical factor in the Seattle case.

3.1.1.b. Seattle Climate Action Plan

The Seattle Climate Action Plan (CAP), released in September of 2006, represents former Mayor Greg Nickel's overarching strategy for reducing global warming as recommended by his appointed Green Ribbon Commission. The impetus behind the CAP was Mayor Nickels' concern that climate disruption would have detrimental impacts on drinking water and electricity generation for the city, that reducing emissions would improve public and environmental health while creating green jobs, and that there was a need to address “the lack of meaningful federal action on an issue so critical to the health of our city, country and our planet.” (City of Seattle, 2006) In light of these needs, the document provides a series of action items the city, businesses and individuals can take to reduce the city’s greenhouse gas footprint

The Climate Action Plan is specifically called out in the SBMP as providing a supportive policy context, yet study participants expressed doubt that the CAP had any direct effects on the implementation of projects. While not diminishing the importance of mitigating greenhouse gases or the role that non-motorized transportation will play in that endeavor, one study participant noted that:

“[The CAP] was certainly used to get grants, it was certainly mentioned in everything we did, but it was sort of one of those umbrella efforts where you just took everything you were doing and say. “Ok, we were doing all these things to improve climate change.” There was a lot of verbiage about it, but I don’t think there was anything we did….that would not have happened if we didn’t have that climate change initiative. It didn’t give us a new policy that we didn’t have in terms of saying “yes” to bicycling. It didn’t provide us with more funding that we didn’t have because that already came through [the] Bridging the Gap [levy]. “

Another interviewee supported this point of view in that the CAP did not provide any new framework that was either supportive or limiting of the SBMP, assisting implementation only,

“…insofar as it said “Complete the Bicycle Master Plan.” In the implementation strategies flowing from that, we are integrated into the updates to our Comprehensive Plan and development, and we have an upcoming change to the Transportation Strategic Plan (TSP) that is coming up. But the last TSP offered that policy framework.”

Another respondent concurred with this same point, but noted that the policy could be used to other ends:

"My understanding…. is that [the CAP] was sort of a large overarching policy. But I don't know if there were any methods of trying to implement that other than being consciously aware of the policy when the city does projects. There was a recent project called the re-channelization of Nickerson Street, which was and is very controversial because the proposal was based on perceived safety of pedestrians and also to a lesser degree cyclists, but there was to be an impact on freight traffic. So the City Council had a hearing which a number of people participated in… Councilmember O'Brien, one of the things he talked about specifically in that hearing was the importance of implementing or complying with the policy of reducing adverse effects on the climate with respect to this project."

The outcome of invoking the need to comply with the city's climate change strategy appears limited, however. When the same respondent was asked if mentioning the CAP affected the position of opponents to project implementation, he remained doubtful:

"Not to a large degree. I think people understood it, heard it, but it wasn't certainly a central topic among all the presenters or Council members…I think most of the commenters were more practical, "How is this going to affect my business?" "How is this going to affect how I walk, how I cross, how I use the road?" And I think that is more what people were personally concerned about that came and testified."

As can be seen, participants were in agreement in regard to lack of direct effects on implementation stemming from language in the CAP. The CAP's usefulness lies mainly in its ability to reframe the implementation of the Bicycle Master Plan in terms of larger environmental goals. To the extent that it allows for the City to apply for grants as a part of a larger environmental strategy, the possibility of a positive benefit exists. However, it was not found to be particularly effective in addressing the immediate concerns of an opposition that may be motivated primarily by what are perceived as inconveniences stemming from a loss of existing entitlements. A strong convergence in respondent opinion exists that the CAP, as a supportive document to the SBMP, did not have any discernible effects on project implementation.

3.1.1.c City of Seattle Comprehensive Plan

An additional framework document that was thought to affect the plan was the City of Seattle Comprehensive Plan. The Washington State Growth Management Act (GMA) (36.70A RCW) requires local communities most affected by growth to engage in comprehensive planning for the development of the community over a twenty year period. The GMA requires these cities and counties to adopt regulations to protect resource lands and critical areas, designate urban growth areas, and include mandatory planning elements that must be addressed. Most relevant to the present study is the Transportation Element, which requires jurisdictions to: identify expansions needed to meet present and future demand; provide land use assumptions used in estimating travel, facilities, and service needs; and provide level of service (LOS) standards for all locally-owned arterials and transit routes, among other required tasks.

The Seattle Bicycle Master Plan mentions the Comprehensive Plan as being a framework document, and it was seen by one interview participant as having "general policy language there just saying that it's the cities priority to promote bicycling and to construct streets for all users." No specific mechanism was mentioned by interview participants through which the Comprehensive Plan positively impacted actual facilities, separate and aside from the SBMP itself. One study participant brought up a potential restrictive influence due to the methodology used to calculate the LOS standards required by the Growth Management Act:

"The Comprehensive Plan is the force of law under RCW Chapter 36 under the GMA, so whatever we say in there, whether its level of service, how we comply with our need

to provide adequate amount of infrastructure for the development that is going on in the city… if our level of service is intersection delay for vehicles, that going to undermine the SBMP because intersection delay essentially means taking a pipe cleaner to every intersection and for lack of a better phrase, screw everybody else. I still think our level of service metric is not completely adequate for allowing us the flexibility with our public roadway network that we would want. The city uses something called screen line grid, which is an acceptable approach in an urban area but it is not fine grained enough in its analysis. We would like to see a multi-modal quality of service model employed. When we get into the compromise between transit buses and bike accommodation, if we have a diminishing level of transit service, that can preclude some of the improvements that we had pushed for in the plan."

The participant went on to mention specific projects that were modified so that the existing LOS could be maintained and accommodate the heavy load of Metro Transit buses on these routes. While there was not a convergence of responses on the subject of diminished LOS affecting projects, this example was notable in demonstrating how a framework policy document could provide generally supportive policy language, but still have a negative effect on projects as other modes are prioritized. This response is suggestive of the need to assess the impact of metrics used to gauge an arterial's level of service to ensure that the bicycle is not precluded in favor of other modes.

3.1.1.d Street Space

"One of the big difficulties…of implementing the BMP in Seattle is kind of a geographical problem. A lot of the streets are fairly narrow and there are a lot of really tight spaces…it is really hard to add bike lanes. That means you have to take away a lane somewhere, either parking or a roadway lane and a lot of lanes are narrow. Physical room is a tough reality…People are used to parking here and having a center lane for turning and what not. Those things are hard to get out."

The issue of a lack of urban street space was brought up by three interview participants as problematic, but not necessarily a barrier to implementation. Participants defined this resource constraint in terms of narrow streets and the built-up nature of the city. Similarly, existing entitlements that add to the convenience of motor vehicle users represents a further constraint on space available in the form of opposition to projects. One participant suggested that the type and quality of infrastructure provided may be the downgraded from a designated bicycle lane to a sharrows:

"We're living in an urban environment and we are dealing with a scarce urban resource which is street space and a lot of competition for that space. Everything from the planting strips, to the sidewalks, the street trees, the parking, the vehicle lanes and the streetcars and everything else. Anytime you see a shared lane marking it means there probably wasn't space for bike lanes. Not in all cases, but in many cases that is why you have shared lane markings because you have run out of space."

While agreeing that the constraint exists, another participant contradicted the notion that street space was a problem at the time of implementation:

"There are constraints on just about every project that way. But that constraint was not something that emerged when you do implementation, that emerged already when we did the plan, that's why the plan says "put a shared lane marking here"… they already identified that constraint in the planning process, they didn't have to wait until the implementation phase to figure that out."

This statement supports the notion that a lack of physical space is primarily an issue at plan development. Another respondent contradicts this statement, however, noting that in many cases the data was not available at plan development or competing uses made planned facilities impossible to implement. There was a lack of knowledge regarding,

"…on the ground realities that we couldn't have known at the level of detail necessary at plan development. We have had projects that were slated for bike lanes that have wound up with shared use lane arrows for a number of reasons, some of them are that Metro prefers not to weave in and out of bike lanes with buses."

Taken together, the interview responses converged in characterizing a lack of street space as diminishing the quality of project implementation by affecting the types of facilities that were ultimately recommended. Regardless of whether the data is available during the Plan development or only discovered at project implementation, narrow street spaces, existing entitlements for competing modes, and related factors can be shown in the Seattle case to negatively affect implementation outcomes by constraining the options available to provide for a mix of facility types appropriate to accommodate a variety of users.

3.1.2 Resourcing- Timing

The issue of the timing of implementation was called out specifically by Ison and Rye (2003) as important to the process, while noting that it may be considered indirectly in the question of external circumstances. The authors' do not specifically define the term "timing", only differentiating it from "time" as a resource. For the current studies' purposes, it is inferred from previous work that timing is best defined as contextual events or trends pivotal in affecting implementation outcomes during the 2007-2009 period. Because policy issues tend to be highly interrelated and agencies are immersed in economic and political systems characterized by change over which they have little control, any particular policy decision may face erosion of political support over time as other issues are deemed more important (Sabatier and Mazmanian, 1979). Just as likely, a policy decision may receive more support if events make the issue more salient in the eyes of the public. Events such as recent high profile bicycle/car accidents that increase the sense of urgency around Plan implementation, increases in gas prices or environmental awareness, national spotlighting of the Plan that builds support, or the economic crisis (2007-present), are all context specific factors that may help or hinder implementation efforts.

Participants were asked to discuss the impact of larger contextual events occurring between 2007-2009, not intentionally willed by policy actors (to differentiate between the policy framework, addressed above in section 3.1.1. Respondents were given examples such as the current financial crisis, increasing environmental consciousness and concern about global climate change, and increasing gas prices. These examples appeared to have influenced responses to some extent, but respondents were free to report whether a given trend influenced the Plan or not. The following sections will discuss the impact of increased environmental awareness, which was largely seen as having a neutral effect on implementation, and an increase in gasoline prices, considered important for increasing ridership, and possibly, public support for the Plan.

3.1.2.a Environmental Awareness and Concern

In addition to former Mayor Greg Nickels' Seattle Climate Action Plan, several indicators of increased awareness around climate change can be found during the study period in the areas of advocacy, media, and research. As one indicator of the rapid growth of interest in climate change, a study published by the Center for Public Integrity reports that the number of interest groups lobbying on climate change in the U.S.

jumped by more than 400 percent (to 770) during the period of 2003 to 2008 (Lavelle, 2009) Also during the study period, Gallup conducted the first comprehensive survey of global awareness and attitudes about climate change (Pugliese and Ray, 2009) again, a possible indicator of the rising importance of this issue. Similarly in 2009, UNESCO, in partnership with the United Nations Environment Programme, organized the International Conference on Broadcast Media and Climate Change, bringing together national broadcasters, scientific organizations and climate related agencies, resulting in a resolution to give increased media exposure to the issue of climate change.

The growth in awareness of climate change and the environment during the study period could be expected to lead to increasing support among Seattle residents. Three study participants discussed the role of environmental awareness as it relates to the Seattle Bicycle Master Plan, noting its limited to non-existent role in each circumstance:

"…we see that there is only a certain segment of the public that operates from the altruistic perspective in terms of determinants of personal choice. Most of the public operates from an either enlightened or unenlightened self-interest model. So gas prices can affect you directly, we don't see much of the "I am doing my part to prevent climate change." The people riding will recognize and support their behavior externally with a lot of rationale, but I don't think it is a driver on this. There was a significant series of focus groups that followed a US EPA conservation PSA series around the country. Most of the participants in the focus groups were actually quite offended by the notion that they had to go out of their way and change something about their lives in order to make someone else's life better. I think some of the responses were "I recycle, I am doing my part." So driving less, taking transit, all of that….was found to not only be ineffective, but it had a very negative reaction from the focus group audiences. Whether it would have the same reaction here is different, plus we just saw a social marketing study that came out of Victoria recently, where people were very aware of the negative consequences of their car use and a number of them indicated that they chose to moderate their car use, switch modes, switch directions pick their home based on their understanding of the negative implications of car use."

Another study participant concurs with this notion that environmental awareness and concern about climate change hasn't been seen as a motivating factor, citing the current Mayor's position as support:

"And even Mayor McGinn mentioned this at the Commute Seattle meeting that environmental reasons aren't primary, it's more like the convenience of biking, the cost savings of biking, you don't get stuck in traffic- that could be a factor. The cost of parking is a factors and the availability of bike parking is a huge factor- to be able to get around by bike downtown is so efficient."

Another expert on SBMP implementation echoes this sentiment:

"It is certainly nice it was there it was helpful, but I think environmental reasons get overly rated. For example, if you get back to citizens support…you ask any person on their bike why are you riding your bike, you are lucky to get one out of twenty mentioning the environment. Now that may be a background reason. But today, it is raining, and I have to make a decision about whether I am getting out on my bike and it is probably a whole bunch of other personal factors that are much closer, right here, that define that"

Notable in each of the examples above is that the topic was not the larger trends that influenced support or opposition for SBMP project implementation but the personal determinants of the decision to ride a bicycle. The possibility exists that respondents misunderstood the question, which would invalidate the responses given to some degree. The final quote above, however, suggests another dynamic at play- the responses may be indicative of an assumption among non-motorized transportation professionals that support for implementation of the SBMP is related to the decision to ride a bicycle- the reasons why one chooses to do so are therefore secondary and environmental awareness ranks low as a motivator. Regardless, while the data does not lead to a definitive answer, increased awareness and interest in climate change and the environment is considered by study participants to have a neutral effect on implementation outcomes.

3.1.2.b Increase in Gasoline Prices

The timing of the SBMP short term implementation period coincided with a larger trend of unprecedented increases in U.S. gasoline prices. Prices rose to an average high nationally at $4.11 per gallon in August 2008, with a West Coast high of $4.44 per gallon in early July 2008 (EIA, 2011). Articles ran during this time reported, anecdotally, that gas prices were responsible for increasing number of bike sales and usage, both locally in Washington State (Raderstrong, 2008) and nationally (Hurdle, 2008). An online survey sent out to bicycle retailers by the Bikes Belong Coalition (2008) provides support to these notions, with 95% of bicycle shops reporting new customers who cite gas prices as a reason for their bike transportation related purchases, and 80% of retailers attributing increased bicycle sales to higher gas prices.

When asked about this trend, three respondents believed there to be a correlation between gas prices and increased bicycle ridership, with the following being a typical response:

"We were able to draw a correlation between increases in gas prices and increased bicycle use, but at the same time we were making so many changes on the ground in Seattle that it is really hard to isolate the variables. Nationally they saw a huge uptick as well where the changes weren't necessarily being made so we might be able to draw a stronger connection."

As with increased interest in climate change (discussed above), it was again notable that while the original question specifically asked about contextual events that impacted Plan implementation, respondents replied to question in terms of how increased gas prices affected ridership. Similarly, it may be the assumption of respondents that external factors are influential on ridership, which may in turn affect the relevancy for individuals and the likelihood of support for the plan now that they have a stake in its completion. Responding to another question regarding public support, one informant's statement provides support for this notion, asserting that, "anytime you have a greater constituency it leads to more political support for implementing the plan." Making this determination is outside the scope of the study, and while the respondents reported a supportive influence on cycling, it is not possible to determine from the responses given whether there was a positive influence on implementation and what that mechanism might be.

3.1.3 Political stability

Ison and Rye (2003) note the importance of political stability in the case of road charging schemes, where many may have failed to advance beyond the initial stages because of local authority elections and a subsequent change in the political environment. Interview participants discussed their views on various political actors in the process, with some conflicting opinions presented about the role of the State and County in aiding or obstructing Plan implementation. Three interview respondents affiliated with the implementing agency noted that overall, the city is largely independent of the County and State in regard to implementation:

"The county is a presence [at the regional planning level]… as well as local municipalities who have all been supportive and are actually interested, and I think we as a larger municipality really have been influential and keep that momentum going with other municipalities. They actually have been interested in implementing the

kinds of facilities that we have, but that doesn't really speak to anything that really influences our ability to implement our plan."

A focus on the city is therefore most appropriate, with two respondents characterizing the short-term implementation period as being one with relatively few changing players, and consistent political support and stability throughout:

"…we had a favorable climate in King County. Then we had…Mayor Nickels, and then as now, a City Council that seems to be completely in sync with the Mayor's objectives and policies for making changes for the benefit of the city as well as the world for climate. To me, that has been a marvelous benefit as we don't have agencies and executives working at cross purposes."

Another respondent, while in agreement with the foregoing comment, notes that the same stable political environment makes it difficult to assess the role of stability as a factor influencing the Seattle Bicycle Master Plan, as there is no basis of comparison:

"Well, we only had one mayor during that period, so that didn't change. And there was some change in the City Council, but overall if you look at the votes and the nature of the City Council, the vote split didn't change much during that period so that was pretty stable. One [City Transportation] Director that whole period so that was pretty stable. I don't think that this is a good case study to answer that question [regarding the role of political stability]. There was no change so I would be speculating. I have seen change make things a lot better and change can make things a lot worse. I think the message is that people are important rather than whether there is change or not and people really do make a difference, whose Governor or who is Mayor, it really does make a difference day to day, that leadership."

Respondents overall reported a supportive political environment in Seattle as being an important factor in assisting implementation. The last respondent is correct in that it is impossible to tell what the magnitude of the effect of stability on SBMP effort is, as political conditions were consistently reported as conducive to plan implementation throughout the process. It is only by identifying and comparing specific variations in the political environment, with their concomitant effects on individual projects, that a researcher would be able to get a sense of both the actual mechanisms involved and the magnitude of their effect. The environment of consistent support can only lead to speculative responses regarding the importance of stability. Implicit in the responses, however, is that it was beneficial to have a consistent political environment that is as favorable as or more favorable than the one present at policy adoption.

3.1.4 Resourcing: Staff, Time, Funding and Expertise

Even when a policy is physically or politically feasible, it may fail to achieve its stated intentions if the means of implementing the policy are not adequately provided for. A common reason for implementation failure is that too much is expected too soon, especially when attitudes or behavior are involved (Hogwood and Gunn, 1984).

As the theory behind the Seattle Bicycle Master Plan is predicated on a change in behavior among city residents in response to a more conducive cycling environment, it is particularly critical that projects on the ground are not hampered by resource constraints. Gaps in the implementation of BFN projects could create a barrier to greater cycling if city residents see important destinations as inaccessible and potentially dangerous. Gaffron (2003) echoes the importance of resources in her study of British authorities implementing pedestrian and cycling policies, citing staff, time and funding as providing the greatest potential opportunities, or barriers, to implementation depending on the circumstances.

In addition to the consideration of staff, time and funding, the availability of expertise among agency staff and others charged with implementation is a critical element of this question. Charles included this criteria in his implementation framework based on Sabatier and Mazmanian's (1979) observation that policy support among implementing staff is essentially useless if not accompanied by political and managerial skill in utilizing resources. Among these skills are the ability to develop working relationships in the agency's subsystems, convince opponents and constituents that they are being treated fairly, the ability to mobilize support among latent supportive constituencies, and to make sure the program is fiscally responsible, among others.

Given that the scope of this interview question could easily occupy an entire study on its own, the purpose is only to identify and explore the extent to which given resources are seen by participants as affecting implementation outcomes. The influence of appropriate staffing, expertise and the presence of a dedicated transportation funding measure are discussed below. Discussions around funding turned to the issue of capital projects, such as bridges and multi-user trails, which were seen by participants as problematic in terms of implementation due to their complexity and associated costs.

3.1.4.a Staff

In anticipation of the increased volume of work required of SDOT's Bike Program, the SBMP recommended that an additional three full-time staff would be needed to implement the Plan during the ten-year time frame. Three respondents remarked on the importance of staffing, generally finding it to be adequate at current levels for the completion of projects prioritized during the timeframe of the study:

"I think that staffing is a bigger concern than actually the financial aspect right now. Because each year [project implementation] gets more complicated, the first few years of the Plan you are doing the easier projects and each year the projects get to be a little more challenging."

"You really need the staff support, it takes a tremendous amount of work to put in infrastructure; it is not an easy thing….there was additional staff but there certainly was a struggle to get everything done. The good news is you have a whole bucketful of money, the bad news is you have to spend that whole bucketful quickly and it's hard. They did it and they did a good job, but it was stressful and hard."

Two more responses lend support for the importance of appropriate staffing levels while noting that the declining economy is responsible for not only a staff freeze but a potential loss of staff and its associated expertise. It should be noted that a potential loss of staff was not thought to be a barrier to project implementation during the scope of this study, but as a concern weighing on the minds of those closest involved with the process, it may be assumed to represent the importance of appropriate staffing levels.

"We are also in a no hiring mode for the entire city. Because of the economic forecast and the revenue forecast I think that we are pretty much pressed staff-wise to do as much as we are doing and do it well.

"[SDOT] staffed up post Bridging the Gap and the non-motorized section has been refined a couple of times since then and now has the staff, the time, the funding and the expertise. That could all change, layoff notices went out in SDOT this year and people…there were people who were in the bike-ped program who were low people on the totem pole who could be flushed out. The staffing and resources issue could become a significant problem."

The Seattle Bicycle Master Plan's recommendation to increase the number of staff, as well as concerns from respondents that current staffing levels may become pressed due to the increasing complexity of projects and potential for cuts, testify to the importance of providing for additional positions to respond to the heavy workload associated with a BMP. Two participants made the connection that although dedicated funding for the plan was in place during the study period, a lack of staff to study and implement projects could prove a limiting factor.   What qualifies as "enough" staff will depend on a multitude of factors that affect workload and cannot therefore, be assessed. For this studies purpose, responses testify to the supportive effect appropriate staffing levels have on implementation.

3.1.4.b Funding: Bridging the Gap Levy (BtG)

In 2006, a year before the SBMP was adopted by City Council, Seattle voters passed a nine-year, $365 million transportation levy for maintenance and improvements know as Bridging the Gap (BtG). Complementing the levy are a commercial parking tax ($127.5 million) and an employee hours tax ($51.5 million). Over the life of the levy the total expected revenue from the three sources is $544 million (SDOT, 2010) The main purpose of the program is to address the maintenance backlog for paving, sidewalk development and repairs, bridge repair, rehabilitation and seismic upgrades, transit enhancements, and other maintenance work. Per the authorizing ordinance, 18% of the levy is to be used for bicycle safety and pedestrian projects. More specifically, it provided funding to support the 93 miles of bike lanes and sharrows that were installed during the 2007-2009 period of SBMP implementation.

All five interview respondents emphasized the critical role that the BtG played as a dedicated and consistent funding source that was available from the outset of Plan implementation.

"There are characteristics of effective non-motorized plans that we go around the state and train people and teach people… it has to have an implementation timeline, it has to have dedicated funding. [These] are critical components because the plan sitting on the shelf is the all too common scenario. You develop the plan and then you can never fund it and you have no prioritization scheme involved, you have no implementation schedule involved so it never goes anywhere. Eventually it becomes outdated and outmoded and so even when you refer back to the plan or use it, it isn't a worthwhile exercise."

Two more respondents agreed that the levy's concurrency with plan implementation was a critical piece, with one citing that it was likely to be the most important factor influencing successful implementation:

"[It was] probably the strongest. I mean having the plan but then really simultaneously having the funding package come through [at the same time]."

Two respondents, when given the hypothetical scenario that the BtG was never passed by voters, were emphatic that projects would likely have not been possible. One respondent discussed the likelihood that bicycle facilities would have been created along a route he rode into work:

"They wouldn't have been, there is no doubt about that. I've been cycling…since 2005 on a daily basis, it never changed in all those years and it certainly wouldn't have if the money hadn't been approved. That certainly is a tangible benefit that I have seen myself, I don't doubt that the BTG levy has in fact allowed the BMP to be implemented."

Similarly, when asked to follow up on what the potential fallout would have been for the SBMP if the levy didn't received voter approval, another respondent thought that:

"… we would have really had to rethink… about how to construct the [Seattle Bicycle Master] Plan before we sent the final draft to Council for adoption that fall if we had not had that initial revenue."

Hogwood and Gunn (1984) state that politicians sometimes will the policy "end" but not the "means", so that expenditure restrictions end up starving a program of adequate resources. It could be argued that Bridging the Gap represents the opposite end of the spectrum in this regard. As a foundational funding source throughout the majority of the ten year implementation period, a strong argument can be made based off of interview responses that Bridging the Gap is the critical element in the Seattle case for being able to implement the Seattle Bicycle Master Plan.

3.1.4.c Funding: Capital Project Cost

The presence of both Bridging the Gap transportation levy and the Complete Streets ordinance allowed for a both a consistent funding source and for greater efficiency through the routine accommodation of bicycle facilities. As such, funding was generally seen by participants as being adequate for the 2007-2009 period, with some exceptions:

"Projects that will be a problem: bridges, all the major capital projects. So for instance, building a bridge across 47th and I-5, connecting the U-District to Wallingford…even the most conservative estimate I can come up with…is $35M. $35M is more than we have spent on bike capital projects in Seattle since the plan was developed…these aren't cheap. The Ballard Bridge, even the cheap way to improve the Ballard Bridge, is a $4M project. And that's cheap. It would be a substantial improvement for very small dollars compared to the original parallel bridge proposal that was in the SBMP which could have cost as much as $50M."

The response above was shared by two other interview participants who reported the construction of bridge and trail projects as problematic in terms of implementation. Responses indicate that it was not the type of project in itself that was obstructive, but rather the prohibitively high cost associated with the construction coupled with the fact that alternatives for connecting bicycle facilities (particularly with bridges) are not readily available. Two participants noted that the construction of capital projects and trails presents a substantial opportunity cost to developing on street bicycle facilities, as one project can drain the budget or several years and miles worth of on-street bike facility construction. One participant believed the difference in costs between on-street and capital facilities justifies the need for separate financial plans:

"There was not a shortage of funding [during the short-term implementation period]. Some of the trails projects were really expensive, sort of a separate deal, those are the outliers and the ones that cost millions of dollars, some of those don't have enough money. In terms of on street system, I don't think that funding was an issue… One thing I would do differently in organizing a plan is that if you look at the plan, there is sort of [on-street facilities] and then there are these outliers that cost millions of dollars and then tend to be these bridges like the facility over Ballard Bridge and possibly something over I-5. And those are so expensive that if you look at the total cost of the plan and then look at the money spent it looks like the plan is underfunded. Which is not quite fair. What I would do now is [include] everything but those outliers and I would financially set those aside. We need to mention them because they are important to happen, but neither do you want to take twenty years of bike funding and build one bridge. That would be dumb too. On those really expensive ones you have to find an opportunity to do it with something else. For example, on Ballard, it looked like there was an opportunity to get some of the work done as part of the monorail that was going to go in there, we worked closely with the monorail people and then of course that didn't happen. So there is not funding for those mega projects, but setting those aside, there wasn't a lack of funding for the other stuff."

This current lack of funding for "mega projects" could prove to obstruct full implementation of the plan, however, study participants responses converged in characterizing the issue as problematic during the Short-term Implementation Period, as advocates and city staff worked on long-term strategies and funding solutions capable of moving these critical projects forward. The high costs of bridge and trail projects may prove to obstruct full implementation of the Plan should adequate funding not be provided for.

Table 4: Seattle bicycle Master Plan Higher Costs Projects in Areas of High Bicycle Demand

Seattle Bicycle Master Plan Higher Cost Projects
• Provide a bicycle facility connection between Downtown Seattle and the UW Campus via Eastlake Avenue N.
• Complete the Ship Canal Trail, including connection to the Fremont Bridge and Ballard Bridge
• Construct the Chief Sealth Trail Crossing of I-5 between S Spokane Street and S Lucile Street (and provide a trail on the east side of I-5 between the Chief Sealth Trail and the I-90 Trail).
• Construct the Burke-Gilman Trail section between 11th Avenue NW and 17th Avenue NW
• Construct a new bicycle and pedestrian bridge across I-5 between Wallingford and the University District
• Provide a bicycle facility connection between the I-90 Trail and Downtown Seattle
• Construct multi-purpose trail connections from the SR-20 Bridge to the UW Campus and to Downtown Seattle as a part of the bridge reconstruction project
• Improve the bicycle lanes on Alaskan Way S/E Marginal Way S between S Spokane Street and Downtown, and complete the E-3 Busway Trail between S Spokane Street and Downtown
• Either rehabilitate the existing Ballard Bridge or add a new bicycle and pedestrian bridge adjacent to the Ballard Bridge.

Source: Seattle Master Bicycle Plan, pg. 13 (SDOT, 2007)

All of the projects that appear on the SBMP's list of higher cost projects in areas of high bicycling demand (Table 4, below) consist of bridges and trail connections considered to be critical in achieving the Plan's goal of tripling ridership and increasing the safety of bicycling in Seattle.   Should funding be unavailable for these projects, outcomes over the 10 year implementation period are expected to fall short of plan goals. For these reasons, the majority of participants concern about these projects appears well justified and the high costs of capital projects should be considered a long term issue in terms of SBMP implementation.

3.1.4.d Expertise

Issues of expertise tended to focus on SDOT staff, with all three of the interview respondents who engaged the question being current or former SDOT employees. Interviews diverged somewhat from considering whether implementing agency staff expertise affected SBMP during the 2007-2009 period, to respondents providing their views on the SDOT's reorganization of its bicycle program to a matrix model. A loss of expertise due to an overreliance on one individual left agency staff in the position of needing to pick up the pieces:

"With Peter Lagerwey (former Senior Transportation Planner with SDOT) we had a pretty senior staff person with 25 years of historical knowledge who retired, so regardless of funding, staffing, that was a huge loss to implementing a bike program. So we felt it, because it takes us longer to do something that he would know, especially about a trail. We are also in a no hiring mode for the entire city, so because of the economic forecast and the revenue forecast I think that we are pretty much pressed staff-wise to do as much as we are doing and do it well…staffing is a bigger concern than the financial aspect right now."

The loss of expertise and institutional knowledge discussed above was shown to stress other resources, particularly staff, which had to quickly get up to speed in order to perform the same duties that were lost due to the vacancy of this key position. All three respondents discussed the need to disperse the knowledge and build resilience across the organization:

"In theory you shouldn't have a special bike section in a transportation department, just like you don't have a special car section. In theory the system should be integrated and institutionalized so you don't need that. I have never seen a city do that successfully 100%. One of the problems is that on paper it looks good but the people you hire don't know anything about bicycling or walking, they didn't learn it in school and they are not likely to have learned it anywhere else they have worked. For many years …we had one and a half/two people in the whole program and there was a real lack of understanding or expertise throughout the larger department and then slowly that changed by the time we started implementing the plan… in general I wouldn't say that would be a major barrier."

This emphasis on the matrix model, where responsibilities and knowledge are dispersed across the agency may ameliorate the effects of the loss of what may be deemed a "policy expert". Similar to Gaffron's (2003) statement that the presence of a policy champion may been indicative of the fact that bicycle policies are not well institutionalized, expertise concentrated in one staff position presents a problem for organizational resilience. Organizations with a separate pedestrian and/or bicycle department may be particularly susceptible to a loss of staff that hold key expertise and a lack of accountability to the Plan across programs. In the view of one participant, however, the matrix model:

"…has its pros and its cons. The biggest pro... is institutionalizing implementation of bicycle infrastructure in the city. So that the more [agency staff] who are aware of [the Seattle Bicycle Master Plan] and the more people that do it, the more eyes there are to make sure it gets done. Not everyone from what would be our Pedestrian Bicycle Neighborhood Streets program and project development group could be at every meeting so when you have people from our Traffic Operations implementation group, they can be on the lookout for things. So, theoretically, it's dispersing the knowledge across the organization so that it will help with implementation."

The cost of dispersing knowledge and responsibilities across the agency is that staff must adapt to the new model and learn about other programs they are not currently acquainted with. Another respondent notes this effect has been seen throughout SDOT, without saying explicitly that implementation was impacted as a result:

"It also has to do with a lot of education throughout the department to really institutionalize. We have the financial resources, but the human resources… it is an ongoing learning curve for folks. [Peter Lagerwey] kind of held a lot of the knowledge for many, many years and we've kind of exploded the bicycle program to be institutionalized throughout the department but there is a learning curve to that, so that is what we are experiencing now with people coming up to speed, not only in our group, but at other levels throughout the department."

A definitive conclusion on the effects on implementation cannot be reached, however, as participants overall did not comment specifically on the impact the staff loss or organizational model change had on projects during this time. Agency staff did note that there was a learning curve associated with dispersing information and responsibilities throughout the organization in the wake of a major loss of expertise, but it is assumed that they were able to cope successfully- the initial quote above supports that "it wouldn't be a major barrier". The context provided is useful, however, in identifying the important role of organizational structure in making expertise a more resilient asset within an agency.

3.1.5 Monitoring

The SBMP recommends periodic monitoring through performance measures (Action 4.13, SBMP 2007) that are to be evaluated on a bi-annual basis to ensure that they are the most appropriate and cost effective measures for assessing progress towards the Plan goals of increased safety and ridership. Monitoring the outcome of implementation efforts is seen by Ison and Rye (2003) as closely related to the question of whether the policy demonstrates a cause and effect linkage, assisting implementing staff in refining the plan to make it as effective as possible within the available resources. It is this second aspect of monitoring that we are most interested in here.

This interview question therefore looks to establish whether the performance measure data gathered simply allows for the program to provide evidence of its overall progress towards established Plan goals, or whether a feedback loop has been established that allows the outcomes to inform future implementation efforts. Study participants did not mention the SBMP's Strategic Performance Measure related to facilities, the percentage of bicycle network completed, as being particularly useful in assisting plan implementation. More important was the use of a GIS tool that is allowed for prioritization of projects based off several parameters:

" I guess the way I see [data] influencing our projects is how we select projects, we have a whole prioritization process, a GIS base, we have five categories and we assign points to different roadways or projects and we include collisions in that analysis. We also have some demand, not necessarily based on our bicycle counts, but we look at neighborhood centers and major employers and tie that in. So I think that is probably the most influential where we are trying to address high collision locations through the projects we are trying to select every year."

New data, then, can be used to queue up projects that are most likely to prevent the likelihood of accidents and fatalities, assisting in the earlier accomplishment of Plan goals. Another respondent echoes the important role of using geographically based data to increase ridership and reduce fatalities, while addressing broader social and environmental justice issues in historically underserved areas of the city.

"There is feedback. We had a soul searching moment last year… we had four fatalities in the city, a number of very serious life threatening injuries, and none this year. The

year is not over but we are really asking ourselves, "Did we do anything wrong here, is there a false sense of security?" So the metrics, the counts, crashes, fatalities, they all feed back into the (GIS) system and are instructive of how we accomplish the goals of the plan…what we asked for this Spring and got was for the city to incorporate the health inequity information that was used in the GIS modeling for the Pedestrian Master Plan into the Bicycle Master Plan so that in terms of our geographic focus, whether its low income or disadvantaged communities…communities with high crash and fatality rates… that we are accomplishing a broader set of goals. And if sedentary lifestyles are influencing health equity/health outcomes in South Seattle…because their street network is not what it is in North, Northeast, Northwest Seattle there aren't the diversity of travel options…they act as barriers they keep people from walking and bicycling, they contribute to poor health outcomes and air quality problems, they contribute to disengagement socially which we know contributes to poor health outcomes. So in incorporating that other metric we are going to better address the safety and mobility needs. By factoring those in to the GIS tool we can help prioritize the planning."

Data played a clear role in prioritization of projects that may assist in plan goals, but it says nothing of the quality of the outcomes. The same respondent notes that the dogged pursuance of more facilities, however prioritized, can lead to a short-sightedness regarding the appropriateness of facility types for a given project.

"…the downside to rigidly adhering to metrics, how many lane miles were dropping in is it can lead you to a quantity over quality approach that can be detrimental. The quality comes down to how much time you can put into really looking at configuration of interchange. If you are just trying to hammer [bicycle facilities] out …that's not helpful if their just slapping down stuff that we come back and find that there were problems with. I can't point to any really significant examples, but the early implementation of sharrows was sharrows were not located as per city instructions. On 34th at Stone Way, sharrows in the middle of the right turn lane where we thought about configuration issues and we said, "Wait a second, why aren't we moving bikes across the turn lane and queuing them up with the thru-traffic over there." There will be facilities around this town that need to be reworked."

Again, a respondent found that an exclusive focus on metrics, specifically the number of miles of bike lanes installed and crash counts, creates a problem by not addressing more complex projects that represent barriers to cycling. The resulting discontinuities in the Bicycle Facilities Network that result are seen as stemming from strong political support the Plan currently has, leading to a desire of public officials to act while the opportunity exists:

"Well, certainly they do the counts that are going to…tell you how well you are doing and not what you are doing right and what you are doing wrong. What the city has been doing is focusing on just getting miles of bike lanes and shared lane markings in, but what they haven't done is gone back and addressed spot locations that are known barriers. And if you don't address those locations, you aren't going to get a big jump in cycling…The question comes in "Do you go for those spot locations or do what they have been doing [focusing on getting lanes installed]. I would argue they are doing the right thing. And so there is a little bit of a delay in terms of realizing the benefits of what you have been doing because right now there is a window open…those windows don't stay open forever. Portland went through a period where they hardly put in any new bike lanes for a number of years. When that point comes, then you will have an opportunity to circle back and do those spot locations and remove those barriers. But you can always do that, that's not cyclical. But the massive ability to put in miles and miles of new facilities probably is. So short term, I don't think the city is getting all the benefit in terms of increasing bicycling that it could, long term. I think there is going to be an opportunity to come back and fix those spots and then you'll see a huge change. So that's the strategy and it is one I agree with but it is also not real satisfying because I think you'll find that there was an initial surge in numbers, but I suspect that it is going to plateau at this point for a bit…".

Responses fell short of converging on a singular influence for the role of data in affecting future project implementation. Responses did, however suggest that data collection could lead to positive implementation outcomes through the prioritization of projects that will accrue safety and health benefits for a greater amount of time. An overreliance on metrics in terms of getting bike lanes on the ground, while support and funding is present, may result in early successes, but respondents suggested that the long-term appropriateness of a given facility, as well as the lack of critical connections, may serve to limit the effects of the Bicycle Facilities Network overall until key barriers have been removed.

3.1.6 Leadership- Single Implementing Agency

Hogwood and Gunn (1984) specify that a necessary condition of implementation is that there is a single implementing agency which depends minimally (or ideally not at all) on other agencies for success. This view is predicated on the idea that implementation requires a complex set of conditions and linkages to ensure a successful outcome- the additional need for agreement among a wide array of participants in the process will only serve to further diminish the potential of a successful outcome. The theory holds that the number of decision points and need for consent among multiple groups may serve to obstruct full program/plan implementation. The author framed the interview question in a neutral way to avoiding assuming that the involvement of other agencies is a liability to the process- it is just as likely that the need to consult other actors for their expertise, criticism, and agreement with the implementing agency's approach may prove to be critical for predicting and preventing obstacles that may serve to derail the process down the line.

All respondents acknowledged that the construction of bicycle facilities requires, by necessity, interactions with a large number of agencies, stakeholders and the public. Participants relayed that the involvement of other groups depended on the attributes of the project itself; whether the project was a segregated bicycle lane or a sharrows, whether it affects parking or businesses, and whether the number of existing vehicle lanes would be restricted, among many others.

"There may not be a complete awareness of problems on a decision. From an agency standpoint, they are trying to accomplish a goal which is to get a road repaved and in doing so, how do they accomplish the Complete Streets [requirement]? Well that

means reducing parking. So what is the effect on business? The business owner says I need those three spaces or otherwise I won't have a business…I think that overall the process was helped, not hampered, and improved. It took more time but I think the result was better because they actually got some very good feedback and that feedback is being seriously considered as part of the implementation."

An agency insider notes that while the necessity of dealing with stakeholders is essential for the projects longer term, it is the citizen input in particular that can be problematic in terms of getting the requisite feedback and ensuring awareness about the changes to be made on the ground level:

"Seattle is a very inclusive city, politically…we are process oriented, it's just the nature of Seattle. We have to do a lot of outreach, we have to get a lot of feedback… the process that involves all the other stakeholders that we talk about, that is essential for project success. Getting citizen input is really essential for project success, as well, but that process is probably the one that you could say would maybe slow us down the most."

As established above, the conflicting opinions of affected stakeholders, in of itself, is not necessarily problematic in that previously unidentified issues can be brought to light. Indeed, disagreement on the best way to proceed may modify a project in ways that can more comprehensively benefit all user groups. Another SBMP advocate's insight into the stakeholder process may serve to refine this sentiment in noting that it is the evidentiary nature of the stakeholder input that can determine whether the influence on implementation is problematic:

"[The SBAB's] contribution insofar that they support bicycling is helpful and useful, but anecdotes in my mind don't contribute to the improvement [of projects]…But the citizen involvement is good when it eliminates things you don't know. And so citizens advisory groups are good when they can bring a perspective that the department may not have, but their challenges to technical assumptions can be counterproductive. Generally, the interaction between agency staff and an advisory group doesn't say "Well here are my three peer reviewed reports, where is your evidence?" That's not a way to facilitate a dialog. And because they only meet monthly, having to turn back around and refute assertions and assumptions can add delay and complication to the

project, and the inclination of the agency staff may be to placate the opposition…by modifying the projects in a way that isn't necessarily supported by the data. So we value citizen input, citizen advisory groups and stakeholder groups to the extent that they don't undermine sound projects that are composed around generally accepted standards and practices."

As the participant noted, balancing the ideal of data-based decision making is the need to facilitate a dialogue with outside users. Inherent in involving other affected groups in the construction of SBMP projects is the notion of accountability, which according to one participant, has the secondary effect of building long-term support for the Plan itself:

"I think it is real important when you do any plan that you build in some accountability [in terms of who approves projects], who do you report to? Late in the fall, November or December, [SDOT] went to the SBAB with a work plan and said this is what we are going to do next year and it includes a list of all the streets that are going to get bike lanes or shared lane markings and they approve it. And then at the end of the year you come back to them with a report card and say this is what we promised and this is how we did. That is an important notification...Certainly sometimes during the public process we will slow up a given project, on the other hand the only reason you get to do all the projects is because there is so much public support. So in the bigger picture, it makes things go faster. So the reason that Seattle could put in so many facilities so quickly in a given year is because I think they got the public process thing right. In the macro picture, it speeds thing up. In the micro picture, it may slow down a given project."

Another long-term effect identified by one study participant involved making city processes more efficient and streamlined through interagency consolidation. The coordination of needs, in this case, between multiple public agencies is seen as crucial to avoid affecting the quality of recently installed facilities.

"…[SDOT tries] to get everybody together in one room and in the Right of Way Improvement Manual the need to have this interagency consolidation on the project planning was seen as imperative for a lot of reasons. I mean SDOT would go out and put down brand new asphalt and will have asked City Light and Public Utilities if they needed to do anything while they were in there, and City Light and Public Utilities couldn't get the work and the analysis done in time. And then two weeks after the

fresh asphalt is down you would see the spray paint markings where SPU is going to come in and cut it back up. And then there is a big fight generally between City Light, SPU and SDOT over the quality/standard of the repair so that it has the same project life as the repaving did… So there is a turf war that goes on there, but they try to have one consolidated agency working group.

Overall, interview responses related to the public process and the necessity of dealing with multiple agencies and groups were categorized as having a mixed influence on implementation. Projects were slowed down initially, but this was considered a short-term effect. Responses ultimately contradicted Hogwood and Gunn's implementation framework by acknowledging the long-term benefits yielded due the routine involvement of diverse and relevant groups in decision making. Three of the respondents quickly qualified their initial assessments by noting that the long-term effect of this involvement is better implemented projects that more comprehensively address other public needs through the incorporation of insights that are not available to staff. Greater accountability was though to engender greater public trust and in turn support for projects, and involving groups with a stake in individual projects through an interagency working group was thought to lead to efficiencies overall. Although the responses differed in the aspects of implementing agency interactions that they touched on, the results are suggestive that coordination of groups includes an initial transaction costs that pays off in the long term by increasing public trust, reducing the risk of unknowns, and minimizing redundancies between agencies that could serve to degrade facilities.

3.1.7 Ability to Enforce Compliance

Noting that it is perhaps the least attainable condition of "perfect" implementation, in addition to being a system that most of us would not want to live or work under, Hogwood and Gunn (1984) posit that the potential for resistance to a policy is limited if there is authority to secure total and immediate compliance from others involved in the implementation process whose consent is required for the success of the program. In such extreme cases, consent would have to be understood as symbolic, and one would assume an inverse relationship between the amount of authority to demand compliance and an institutionalized flexibility to public reaction. The question used for the purposes of the survey opens up the possibility that other government entities may be able to pressure for compliance with the Plan, as well as consider whether there are consequences to overriding other actors involved with Plan whose short-term opposition may in fact facilitate better long-term outcomes.

The implementation of the W. Nickerson Street rechannelization was brought up in several instances by respondents as an example of implementation in the face of opposition. The project, recommended as a part of the SBMP, would change the lane lines on W. Nickerson Street, effectively reducing it from two travel lanes in each direction to one travel lane in each direction along with a center-turn lane. Bicycle facilities would be added in the space made available, in the form of a bike lane in one direction and a sharrows in the other. National studies show that this level of traffic could be accommodated within the proposed 3-lane configuration, it was expected to slow traffic and also reduce rear-end collisions, side-swipe and angle collision, and make pedestrian crossings more safe. (SDOT, 2009).

Yet many neighborhood residents were upset that the project would create needless congestion despite the presence of the Ship Canal Trail, a recreational trail, running directly parallel with the proposed rechannelization. In face of opposition, Mayor McGinn remained resolute in directing SDOT to complete the project. Peter Hahn, the Director of SDOT, said he had the authority to carry out the project without further Council or Mayor actions.

Tom Rasmussen, chairman of the City Council's transportation committee responded to an outcry from neighborhoods and Democrat groups, saying that the project should be delayed pending the completion of two other corridors are completed. He considered several options to stop the project a) pass a budget proviso withholding road-diet money, b) pass a recommendation for or against the plan, or c) watch what happens, perhaps adding language repealing the road diet if things went bad. Bike activists, in response, were able to successfully influence Councilmember Rasmussen and he agreed to give the project a try. (Lindblom, 2010)

Clearly, the authority of SDOT and ultimately the Mayor was not absolute, but it was substantial. It would take a veto-proof six council votes in order to stop the Mayor. One respondent points to the unlikelihood of this happening given the legitimacy of having a project in adopted plan:

"SDOT has the authority, as does the Mayor's office, and without extraordinary intervention the City Council does not. The City Council isn't the executive so they can't direct the agency. Certainly the Mayor as the executive administrator of the city had the authority to direct his department to move forward on a project that is in an

adopted plan. SDOT may also move forward so long as it is consistent with state law and other standards and [the project] is in the plan…they are the actor that can just drive over the top and say, "it is in the plan, we adopted the plan we went out we had 4,000 comments on the plan. The plan is the plan. You had an opportunity to comment on the plan and didn't."

When asked whether such a response would generate fallout, another respondent noted that for controversial projects, the city is more inclined to go through its public process:

"***On controversial project, yes, I think that that is right. But on ones that are not controversial I don't doubt the city makes a decision even if somebody complains, it's not seen as a big problem… I guess on Nickerson Street the city council was involved. I think SDOT realized the Council didn't need to be involved, the city could decide on its own to implement a project yet it wanted the council to…well I think it was more for support, do we have the support, and do we need to have the Council's blessing? No, because it has been budgeted. SDOT has the ability, probably legally to make the decision without the Council saying yay or nay on it. I think it made sense almost as a way to…process, say, what are the concerns of individual, and use the City Council forum as a way to provide that feedback to the city and make the best decision. So I think they went out and sought that feedback, to me that was fairly extraordinary and it was smart too."***

Yet these two comment plays down the fact that an "extraordinary intervention" of a City Council is still possible under the right conditions, such as overwhelming opposition from affected stakeholders that makes the agency and Mayor's position untenable. Respondents tended to support the view that what allows project implementation to move forward was not so much the legal structure, but the political will and backing of elected officials to allow SDOT to move forward in the face of opposition:

"I think it is important to remember that plans are not laws and there is no obligation to do everything in a plan… It's not a legal issue, it is a political will issue. In most big projects there are one or two people who really don't want it. What I have seen is towns where they allow one percent of the population to stop something, are towns that don't get much done. So when I said figuring out that public process, part of that

is figuring out how to deal with the 1% of the population who will always be negative…. [Political will] gives you permission to take the political risks and upset one or two people because you also know there is a very well organized group out there that represents thousands of people that have another opinion. That just gets down to things like the Cascade Bike Club and let everybody know that you are well connected."

When two of the respondents were asked what would happen if opposition continued to pursue using anecdotal evidence not supported by the data in order to uphold a project, they similarly pointed to political will as being a key element for obtaining compliance with the plan:

"That's where political support is the key issue when we as the worker bees say, "Do the management and elected officials have our back.". We are used to it. It's how much we get the political backing with our projects."

Both respondents replied that it was absolutely critical to have political backing, which operates through support and trust in the implementing agency on the part of elected officials who do have the power to obstruct or delay projects, if need be:

"We have had incredibly great management as well as political support for the projects so if someone writes to the Mayor and say "I'm opposed to this project.", the Mayor's office, instead of responding, will say "SDOT, I want you to send your standard response, thank you for your input, your input is very valuable." Maybe some past administrations would have wanted to go into every detail and answer every question but this administration has been very supportive of saying we have a process, we understand SDOT's process and we are supportive of that process."

Convergence of opinion in the Seattle case demonstrates that political will is the crucial element influencing implementation outcomes in the face of an opposition that can serve to delay, halt, or substantially change recommended projects in the Plan. Responses from implementation staff suggest an additional condition to Hogwood and Gunn's original formulation of the framework be taken into account- that those with the formal authority to demand co-operation may only be able to use that power in instances where public support and the will of elected officials is sufficient to overcome opposition.

3.1.8 Agreement on Objectives to be Achieved: Mix of Facilities

Hogwood and Gunn (1984) compare examples of policy objectives in the theory of planning, which we are told should be clearly defined, specific, mutually compatible and supportive, against research studies that show that "real life" policy objectives are often difficult to identify, may not be compatible with each other, or are vague and evasive. Identifying whether aspects of the SBMP have been contentious due to a lack of agreement on what the stated objectives are is therefore crucial; even if there is legitimate discourse over the meaning of objectives in the Plan, it may serve to delay projects or diminish the original intentions of the Plan in important ways.

The Seattle Master Bicycle Plan states the importance of providing a mix of bicycle facilities. This view is predicated on the idea that different types of facilities are appropriate depending on surrounding land use characteristics, available right-of-way space, traffic volume and speed, and other roadway characteristics. Equal consideration is given to individual bicyclists' level of experience, in which some bikeways are more preferred than others. Newer bicyclists, the Plan holds, often prefer off-road multi-purpose trails and quiet neighborhood streets, while more experienced bicyclists prefer bike lanes, wide curb lanes, paved shoulders, etc. (SBMP 2007) The issue of providing for a mix of facility types came up consistently in interviews in response to the implementation frameworks requirement for agreement on objectives.

The goals of tripling ridership and decreasing the number of bicycle accidents by one-third are explicit in the SBMP, and may meet Hogwood and Gunn's criteria of having consensus and understanding of the overarching policy objectives to be achieved. Yet it is the authors contention that implicit in these goals are assumptions about what user groups should be served and what design treatments are effective. This is in line with Charles' inclusion in Hogwood and Gunn's implementation framework of the need for policies to contain unambiguous directives that structure the implementation process to maximize success, as a lack of agreement on *how* to achieve broadly conceived objectives may serve to unnecessarily hold up plan implementation. Responses varied and no consistent effect on implementation was discernable. The issue of determining the mix of facilities deserves development due to the presence of a convergent theme across all interviews.

One respondent who was a key player in the initial creation of the Seattle Bicycle Master Plan notes that even with consensus around the two Plan goals of increasing ridership and decreasing accidents, methods for achieving those goals was a source of debate from the inception of the plan all the way through current efforts:

"There was disagreement during the development of the plan on the composition and mix of facilities. There were people who were particularly traffic adverse who were offering up some pretty loony ideas about dropping jersey barriers down to segregate the bicycle facilities…it was a small number, but it was a vocal minority. And then on the other side you had a particularly vocal group of vehicular cyclists… they claim it's all education, that we don't need any [separation of bicycle lanes]. And they say that it's just a form of segregation and second class citizenship for bicyclists, that all you need to do is take the lane, in a 40 mph, 59,000 car [environment]… So we had the complete segregation folks and the no facilities folks."

Another respondent that provided guidance for the initial planning stages of the SBMP similarly noted that underlying the consensus on objectives, broader philosophical disagreements existed as to how to increase ridership and decrease accidents.

"First of all, when we did the plan we had a bike advisory group that worked with us and they unanimously supported those two goals which were really important. Obviously in terms of how you reach those goals, there are a lot of different ways to do that and that is why every year the work plan is taken to the SBAB and they approve it by unanimous consent. Does that mean that everybody agrees with every little thing in it? No. But it means there is an overall consensus. The Cascade Bicycle Club always participates, they always have one or two people there at the Seattle Bicycle Advisory Board meetings and they have been very helpful and supportive of the whole thing. Having said that, can you find disgruntled people out there? Of course you can. There has always been a small group of bicyclists who don't want any bicycle facilities...some of them like shared lane markings and some don't."

Debate and disagreement on how to reach objectives may simply represent the demand of bicycle riders at various levels of proficiency advocating for a plan tailored to their unique preferences and level of comfort while riding adjacent to motor vehicle traffic. Another respondent discusses his experience on the Seattle Bicycle Advisory Board,

"The SBAB did hear public comment. People come in and talk about their personal experience, what they like and don't like, the Board hears that and any members of SDOT hear that. We have also heard feedback from the city that they would like to deemphasize sharrows and emphasize other facilities in the coming years. I think that certainly the Board agrees with that, again I don't speak for the Board, but my point of view is that that would be consistent with what we would like. So that has been a change."

While there is no convergence in responses, the above two quotes suggest that by requiring consensus through the creation of a yearly work plan that is in turn dependent on the approval by the Bicycle Advisory Board, Plan implementation can successfully move forward by incorporating public comment while eliminating the disproportionate influence of what may be termed “vocal minorities”. The potential exists for implementation to be held up by disagreement over how to meet objectives, yet interview responses are suggestive of the importance of having an accepted public process that takes debate into consideration over how to meet the needs of diverse users, ultimately being responsible for making a final decision.

Participants identified two other areas where changing understanding on how to meet plan objectives may be necessary, and ultimately benefit implementation overall. Again, while there was no convergence in responses, interviews suggested that innovations that have taken place since Plan adoption may change the individual facilities treatments that streets receive:

“And there has been a little bit of evolution as well since we have adopted the plan… really the goals were to get facilities on major streets and arterials, as well as some residential streets but its very arterial focused. Both in Seattle and other cities throughout the U.S have been doing different kinds of facility types such as separated facilities and cycle tracks and that is something that we are kind of adding to the plan. And so just the backup a little bit, we take recommendations in the plan which we take as recommendations in our design process we look at more of the details, and that is maybe where, if there is any friction with those groups that sat in our planning process, it’s in the details, its making those decisions as to “This is recommended” but really when we get out there and measure the roadway and see what the options are, our final design can vary from that initial recommendation. And occasionally that means we can put in a facility that is not even in the plan.”

Finally, one respondent identified the need to change facility types from what was originally outlined in the Plan in order to adjust to costs, when projects were determined to be more expensive than originally thought.

While responses were not convergent on the influence on implementation, a common thread that ran through all responses consisted of the need to adjust the mix of facilities implemented due to changing conditions external to the Plan in order to maximize the intended outcomes. Despite consensus on overall plan goals, implementation actions will necessarily need to respond to user preferences as bicyclists become acquainted with individual facilities treatments and attempt to address their preferences through the public process. As cities increasingly experiment with new road treatments such as bike boxes and cycle tracks, current BMPs will likely adjust their recommended facilities to incorporate successes. The implementation framework suggests that the lack of agreement on how to reach objectives may serve to hinder implementation short-term until a consensus can be achieved, but it is just as likely that the adjusting to new realities and changing user preferences will lead to better outcomes overall.

3.1.9 Leadership: Policy Champion

Ison and Rye (2003) argue that an important influence on successful implementation is the availability of what they call a "policy champion". The role of the policy champion is to provide leadership and direction during the implementation process when a diverse range of stakeholders are involved and where alliances can often be fragile. Indeed, Gaffron's study (2003) of implementation of walking and cycling policy in British authorities cites the presence of a local champion as often sufficient to influence policy implementation. The study is quick to note that while this may be a benefit to pedestrians and cyclists, it may cut both ways- the importance of individuals means that a highly motivated actors or opposition groups may have an undue restrictive influence on implementation efforts. The importance of a single actor may also be an indicator that cycling policy implementation is not well embedded in existing administrative and political structures and cultures. (Gaffron, 2003) The interview question, unlike Ison and Rye's brief treatment of the topic, allows for the possibility that there may be consequences to a structure that grants one person disproportionate influence over policy or plan outcomes.

Overall, the implementation framework proved useful in that the interview respondents were readily able to identify champions whom they felt were pivotal in affecting the implementation process. All respondents mentioned Cascade Bicycle Club, or their advocacy and executive director, as policy champions that played a critical role in successful implementation of the Plan:

"David Hiller (Advocacy Director at CBC) is probably the single most visible advocate for cycling in the city and he is very knowledgeable and very active and very energetic and very impressive. Now he doesn't always create a single minded approach, he sometimes has to take an approach that he feels is different than others are taking so he has to raise objections when he feels it's necessary. It's championing bicycling, but it's not necessarily getting everybody on board with him in accomplishing that result. But he is very good, very knowledgeable and I am very impressed by his experience and commitment."

Obtaining dedicated funding for the Plan, already identified as one of the major pieces of policy implementation, was also attributed to the leadership of CBC:

"I think in the beginning Cascade Bicycle Club was a big [policy champion] that supported and really got the funding to do the Plan…"

Part of CBC's ability to position itself as a champion of the Plan lie in its political ties, large constituency and increasing resources. One interview respondent, testifying to Cascade influence and effectiveness in creating a political climate friendly to bicyclists, remarked:

"… I know Cascade Bicycle Club was huge and lobbied to get certain people elected on the advocacy level. I know people who ask "How is CBC voting" and that is how they vote."

This is more than simple anecdote- CBC is widely credited as having helped elect Councilmember Mike O'Brien in his first run for elected office in 2009 and current Mayor Mike McGinn. The organization's influence has led candidates to seek its endorsement and Club members have given thousands of dollars to its political-action committee to elect pro-bicycle candidates. (Hefter, 2010b)

As the Club has transitioned from riding club to a professional advocacy organization, its membership has tripled in under a decade from 3,700 members in 2001 to a current membership of over 13,000 in the Puget Sound area, and its influence continues to grow. Boasting such a large and devoted constituency has earned the organization monthly access to the Seattle City Council "bike caucus", consisting of four Councilmembers who hope to advance bicycle-friendly policies and prioritize funding for bicycling initiatives. (Heffter, 2010) One staff member testified to this support as crucial for its policy champion role in advancing implementation of the SBMP:

"…I think that this organization has been the most critical component on the implementation side and it is because it is a major focus of ours and we have the resources to do it…and we have the constituency we can leverage. Where they lead we follow but we educate them on where to go."

Responses readily lend themselves to placing Cascade Bicycle Club in the category of being a critical influence to overall Plan implementation. While respondents could clearly identify policy champions that were supportive of positive implementation outcomes, what emerged from the interview responses, taken together, were strong advocates and leaders at all levels of government, advocacy and research, affecting change either as professionals or as citizens at the neighborhood level. While neighborhood activists may not be defined as champions of the overall SBMP policy implementation, their role in assisting in the implementation of individual projects was seen as crucial:

"Every project has unique players involved… and you have some key citizens involved with really promoting the projects. With implementation overall, it is generally "We are doing this." There is a lot of buy-in and I think when you get to every specific project you have had someone who is very helpful and influential."

An important factor emerged, however, in the need to not rely too heavily on champions and what may be its corollary, the importance of knowledge and expertise being institutionalized into processes. This requires at minimum, buy-in by organizations (and therefore individuals), and a commitment to building resilience within organizations to buffer the loss of any one champion. Noting the importance of institutionalizing buy-in and ensuring a commitment throughout an organization, one SDOT staff member remarked that:

"The SBMP is an accepted city document with high levels of accountability- so at all levels of management there are huge levels of support. I am sure that every person who works at SDOT has read the SBMP- it is pretty amazing. I think if you said Transportation Strategic Plan or Comprehensive Plan there would be a lot of people who have never heard of that."

A board member echoed this sentiment in regard to SDOT:

"What I have observed in general is SDOT as an agency is very committed so it is not a person but an agency to me that is even better than a single champion because we have an agency that wants to accomplish this."

One respondent who has assisted bicycle planning efforts in several capacities discussed the need to build resilience into the implementing organization to buffer inevitable changes that could unduly affect implementation efforts.

"I would say Seattle is kind of in the middle. Individuals still make a big difference, but it is not institutionalized to the point where they don't make a difference. I would also say that there is a lot of depth here so that we can recover from one or two people leaving pretty good usually. We've recovered with a new mayor, we have recovered with a new director and things are going forward as much as ever….you have to build depth in your organization. Then you will survive these ups and downs of being overly dependent on one champion… you need to develop depth in your organization so that it isn't reliant on just a few people, because they move, they get married, they have kids, life changes. And that will happen to everyone guaranteed."

The results above suggest that, in the Seattle case, both Ison and Rye (2003) and Gaffron (2003) are correct in identifying the role of policy champion as a critical component of implementation success. Respondents were able to readily identify champions at both the individual and organizational level and consistently characterized the involvement as a supportive influence on implementation. Yet the respondents were clear that institutionalization leads to greater resilience and is a critical component to avoiding the risks inherent in relying on the leadership, motivation, and expertise of the well-positioned few. The results do not lend themselves readily either way in regard to Gaffron's (2003) sentiment that the importance of a policy champion may indicate that cycling policy implementation is not well embedded in existing structures and cultures.

3.1.10 Support- Flexible attitude toward public reaction

"Seattle is known for its public process so that is the closest I can come to in terms of ensuring that we had some flexibility…insofar that we can meet those needs and address local concerns, the city through its public input process and through its planning process, they go out and door hanger. When a new facility is coming to a neighborhood, they're going to every house, they hold an open house, they hold meetings, they've got comment forms, and they have an online approach. They don't hide these things from folks."

The above statement was typical of interview responses received regarding flexibility in regard to public reaction. All five study participants agreed that flexibility to public reaction was an integral element to the SBMP plan implementation process, in terms of openness to new information brought about by local knowledge and the ability to adjust projects accordingly. This was without exception related to Seattle's public process, which incorporates a high degree of public input through public meetings, outreach and survey research. Part of the flexibility is being able to adapt the outreach process commensurate with the complexity and potential impact of a given project:

"I would say there is a lot of flexibility, for each project there is a slight difference in public outreach, there are standard thresholds for public projects, but if it is known to be a challenging project in the neighborhood then you do a lot more public process, a lot more meetings."

This flexibility extended not just to the amount of public process the City goes through for a given project, but into decision making that affects actual implementation outcomes. One respondent outside the City notes that the flexibility is,

"…more in how it is carried out as opposed to some sort of a planned flexibility. What I see in projects being implemented, especially ones that are major or controversial, is that there is that effort being done to get that valuable information from people and actually consider it, not just as a process. If it was just a process, then I would say here is our checklist yes, we called a meeting, yes we invited reaction, yes we are going to make the same decision, I haven't seen that...A good example of that would be the Capitol Hill Community Council saying "we really want this street car"…. the city was

very keen on that and very much aware of that and took it very seriously and actually made a better decision. It seems to me that the flexibility is there even if it is not a checkbox. They are actually doing it."

City staff echoed the sentiment that the value of the adapting a project to local knowledge may play a large part in of the quality of the project,

"When we go out to the community and we get feedback, it often does make a project better…You get so much good feedback from people who live out there actually know the road and it will make you think about something you didn't consider and you can tweak the design. That outreach and input is actually very valuable."

Yet the flexibility toward public reaction was not without its setbacks in terms of implementation. Participants relayed that, while leading to more successful outcomes, flexibility towards public reaction can be burdensome and have a negative impact on project implementation due to the workload involved and administrative needs. It is not the value of the process that was problematic, but the degree:

"It would be fair to say that that process takes up tons of staff time where we could be working on projects. Our own process hampers us from implementing. You can't double the number of lanes we do next year, but you can double the number we have studied. We couldn't do that next year, [the public process] is so time intensive."

Delving further into the topic, the same respondent relayed that after a certain threshold was reached, additional input from the public was unlikely to bring new information to light that had yet to be considered.

"I just think that sometimes it is overboard. Could we have sufficed with 50 comments, or 100 comments, is 400 that much better? Most of those have very similar trends. The people that are thoughtful and provide really good input about a project, when you get into the 400 range you are not getting 400 of those comments."

Separate from the burden on staff time, the process can also serve to hold up individual projects as citizens contested the objective studies with local knowledge of varying merit:

"Stone Way was a really good example. We did more study and public process on that one then many other comparable projects just because it was a big deal….that was a pretty straightforward project and we knew ahead of time that it would work, it had standard numbers, there is things that clearly fit within a normal range, and there was "were not quite sure if it will work or not". This one was a slam dunker. But the community wasn't convinced that it would work, so we collected the numbers very impartially and they showed what we knew they would … you don't need to overly test everything if you know what the outcome is."

Yet the same respondent noted that even in cases where the outcome was good, the incorporation of public comment has the ability to greatly hold up the project.

"Another one I worked on that really had a good outcome… a lot of neighborhood issues, and other neighborhood cut through issues, and we just had to meet and meet and meet. And even though it wasn't that complicated of a project, it took us over 2 years to get it in because it was such an important connection."

Given the views of study participants outlined above, Ison and Rye's inclusion of the need for a flexible and open attitude toward public reaction appears to be justified. Yet there is a mixed influence on implementation. Overall, study participants believed that local knowledge is taken into consideration throughout the implementation process and has been shown to directly influence the final outcome of several projects. While administrative burden associated with the public process was believed to hamper outcomes, it is possible that this aspect is an indicator of a lack of systems capable of handling what has become a routine part of the workload. One staff member discussed how another city streamlined the public comment process through the use of a simple online survey tool:

"We have to track every single comment and it is a lot of cutting and pasting into spreadsheets. The City of Vancouver for example made it very clear as to how people can comment and they had to actually fill out a survey on Survey Monkey- it does it for you, it spits out graphs and in some ways analyzes the answers. You have people entering their information and really getting something digestible out of it without having the time commitment [of staff] to reenter it."

It would seem appropriate for the implementation framework to consider an agencies data needs, and corresponding systems in its analysis of whether adequate resources exist. As the above example show, the need for timely data and routine analysis that could just as easily be handled by databases and survey software can be a drain on staff and expertise better spent working on other aspects of project implementation.

Yet the need for public meetings, as discussed, still has the potential to significantly slow down the more contentious or complex bicycle facilities projects. Higher quality outcomes may be a product, as well as better coordination with community and other agency needs while contributing to the public trust. The fact remains, however, that the public process is inherently time-intensive and this unfortunate by-product needs to be taken into account in the implementation theory. For these reasons, flexible process for public opinion reaction should be considered as having a mixed effect in terms of implementation: constricting in terms of resources (staff and time) and beneficial in terms of data and creating public trust.

3.1.11 Support- Public Trust, Support and Opposition

Ison and Rye (2003) supplement Hogwood and Gunn's original implementation framework with the inclusion of public trust, which is considered to be a critical element in the introduction of any new policy. Fundamental to this idea is that with the whole process must be considered above reproach if it is to avoid widespread opposition.

Distrust in the implementing agency, it may be assumed, will hamper the implementation process through the medium of public opposition if the program is seen as benefitting special interests at the public's expense, or if the public process is not inclusive and transparent. The idea of public trust in regards to the SBMP incorporates a sense of confidence in the ability of SDOT and the city of Seattle to take into account public opinion and act faithfully and with full disclosure in executing their duties to the benefit of the public overall.

Participants confirmed the support of constituency groups as either a critical or very supportive factor influencing implementation of the plan and ultimately, affecting SBMP goal outcomes:

"Anytime you have a greater constituency it leads to more political support for implementing the plan, so we have seen ridership numbers go up quite a bit."

One advocate well acquainted with the Plan deemed the role of public support for projects as "key", supporting the statement of a consultant familiar with bicycle plans across the country that that, "if it wasn't for public support, the plan wouldn't happen, it is as simple as that." Responses were notable for their self-evident quality characterized by little elaboration. Public support was simply seen as the backbone of a strong implementation effort and the convergence of views lend credit to its significance.

Four participants responded specifically to the term "public trust", with three agreeing that Seattle's flexible and responsive public process played a supportive role in engendering that trust. One respondent details his own experience as a Seattle Bicycle Advisory Board member:

"When citizens come in [to SBAB meetings] and say there is a problem…we try to include that information as best we can. The SBAB can only advise. We can't make decisions so we try to act as a conduit so the city can actually consider that feedback. So from our view, really, we do as much as we can to make people feel that when they come and talk- it is not just that they talk and it is over with. It is not just a venting session, we actually try to do what we can to facilitate input from citizens. And just from the people I have met from SDOT who have come to talk to us, I think they are very sincere in taking information from citizens as best they can. I have never felt that there was an unwillingness to seriously listen to what the public would like to be considered".

Following up on this sentiment, the same participant notes that a key element of the process was its flexibility in responding to new data and public opinion, which may be suggestive of a linkage between the creation of public trust and having a flexible response to public opinion- another of Ison and Rye's criteria covered above. Two current city employees agreed with the board members opinion that the city doesn't just collect comments, but is responsive to public the public by incorporation comments into actual decisions made:

"We do actually respond to everyone who comments and we take it really seriously. Correspondence is huge and we do so much outreach and I think over time…at the local level you have a lot of trust…people have worked with us and been through some of these issues with SDOT and they have been involved in projects. It is just our whole entire outreach."

The public process not only has a receptive element through the incorporation of public comment, but allows the City to engage the public proactively with information that leads to greater transparency and trust, while dispelling myths that may be perpetuated by opponents:

"It is really based on our structure, it is neighborhood based, it is just inherent in so many of our practices. I would say that we approach each project differently in some respects. I think using people who are well connected in the community, using community councils, blogs and those sorts of outreach tools are really helpful, at least for getting a constituency developed before the plan [implementation] really hits. And

also in messaging the project so neighbors are talking to neighbors and the word is getting out about what your actual intentions are, that is really helpful."

One conflicting view was offered by an advocate stating that public trust may be a more critical component in the policy adoption, rather than implementation, phase:

"I don't know that public trust component was as important or critical in plan implementation. The public, or the engaged activist public, tends to be oppositional on almost anything, change is bad…The public, insofar that they are voting to support [the Plan and related measures] is conveying a certain amount of public trust, but I think it is being driven largely by the stakeholders and the advocates in terms of keeping implementation on track. I think there was public trust on the part of allowing the city to do the plan…and the public trust in voting for the Bridging the Gap streets levy, that we would meet the commitments set out in the financing package the public trust."

Responses by interview participants overall lends support in the Seattle case to the notion that the creation of public trust is a supportive influence on plan implementation.

The inverse of public support, public opposition, played a part as well, with three participants responses centering around their view that the perception of bicyclists as routinely breaking laws or obstructing traffic leads to complaints about bicycle facilities. One respondent reported that the perception of reckless cyclists is,

"… one of the primary complaints, that bicyclists are an unusual other. Virtually everywhere. And then the anecdotes, "Bicyclists don't follow the law." When you pivot on that and say, "Well I was just at a red light the other day and, "Bam!", the light changed and three cars kept going through it. Should we ban cars from the roads?" We need better compliance in terms of this public ambassador standpoint of the small percentage of total trips, the 4% of total trips in the city of Seattle that are done by bike."

This response suggests that the real or perceived transgressions of city traffic ordinances by the users of bicycle infrastructure can provide fodder for the opposition to frame the user group as operating from a sense of entitlement. As the "unusual other", law abiding cyclists are in the sensitive position of being readily perceived as infringing on long dominant modes of transportation (automobiles and buses), rather than being incorporated into roadway users' schemas about what is an acceptable and safe form of transportation. Two respondents agreed that opposition to projects and perceptions of disobeying traffic laws may be due to a lack of education regarding new facilities types and cyclists rights to the road:

"Probably the only other factor that we didn't talk a whole lot about, probably because we are not involved, is education… I would say that one of the number one letters we get has to do with rude or reckless cyclists… people have to understand why a bicyclist would ride in a center lane. That is a whole different level of education. It is trying to not get people so polarized one way or another from the motorist perspective or the bicyclist perspective. You have these fringes that create huge amounts of angst. Now if we have someone write to the Mayor about rude cycling behavior, we have this standard response. There are so many people who think that the bicycle community has a sense of entitlement."

Echoing off this comment, an agency staff member laments the lack of education that should have been provided concurrently with new projects unveiled during the Short-Term Implementation Period:

"You really can't expect to put a sharrow down on a street and expect people to know what that means. Although now that they have been adopted at the national level, you are seeing more and more of them. But I think that that is something we could have done a better job on, but in the transportation department we don't do advertising all that well."

The three participants who identified opposition due to the perception of cyclists and infrastructure as impinging on existing roadway space were the most likely to have to contend with opposition on a daily basis. As advocates and agency staff, they identified these views as the number one complaint received from constituents. Educating roadway users on how to interact in relation to new facility types and increasing numbers of cyclists on the road was viewed by the study participants as necessary to avoid confusion that may create backlash against future projects outlined in the SBMP.

3.2 Factors Influencing the Decision to Bicycle

The previous section identified a broad range of contextual factors thought by interview participants to be important for successful implementation of recommended bicycle facilities in the SBMP. An assessment of implementation only, however, would fail to address whether the Plan is likely to have the intended effect of increasing bicycle ridership. As the Bicycle Facilities Network is a core aspect of the Plan, it is reasonable to expect that the costs and resources dedicated to providing infrastructure would be justified by empirical evidence showing that increased access to bikeways is sufficient to induce some people to ride their bicycle for utilitarian trips. Evidence that fails to support this theory may ultimately prove to be problematic in terms of implementation, as a policy based upon an inadequate understanding of a problem to be solved may result in failure. In such a case, the underlying theory may be at fault rather than execution of the policy (Hogwood and Gunn, 1984) and investing in improving bicycling infrastructure may present an opportunity cost for more successful interventions, ignoring the more complex interplay of factors that influence an individuals' choice to engage in non-motorized travel in favor of a policy prescription that is popular with advocates, governments and current cyclists.

To answer the second study question regarding bicycle facilities effects on ridership, a review of models in the literature that incorporate bicycle facilities as an independent variable as an influence on ridership are presented. Analysis will be conducted in terms of the policy implementation framework's requirement for a valid supporting theory with a direct causal relationship and few intervening links. It is also necessary to critique the studies themselves, as the results may not be generalizable outside the population of the study, measures may be problematic, or the results may reflect response bias due to a low response rate or limitations of the study design.

As identified in the Introduction, a dramatic rise in facility provision and bicycle transportation planning has taken place at all levels of government, with increases in both the adoption of both BMPs and funding dedicated to facilities provision. Both supporting and possibly stemming from the growth of these large public commitments to cycling is a growing body of literature in both the public health and transportation planning fields that focuses on the relative influences on an individual's choice to use the bicycle for both utilitarian and recreational purposes. An analysis of the literature is provided to establish the strength of the available evidence to support the claim that infrastructure investments, in the form of lanes and multi-purpose trails, will influence on bicycle use.

The theory that creating bicycle facilities induces a change in behavior in non-cyclists and cyclists alike must be supported by a valid theory of implementation if outcomes are to be successful. In order to organize analysis of influences on human behavior, researchers in the public health and physical activity fields have suggested the use of ecological models of behavior to understand and identify targets for physical activity programs and policies.   Ecological models have increasingly been utilized by researchers to gain a greater understanding of the relative influence of the social and physical environment, and policies on physical activity (Pikora, et al. 2003). Proponents of ecological models of behavior hold that environments restrict the range of a given behavior by promoting and sometimes demanding certain actions and by discouraging or prohibiting other behaviors; the implication is that environmental and policy variables can add explanatory value above that provided by intrapersonal and interpersonal factors (Sallis et al., 1998). This is not to say that environmental factors are the only important variable to be considered- ecological models emphasize that behaviors have multiple levels of influence and that a combination of these variables is necessary to influence physical activity. (Saelens et al., 2003)

Ecological models have been used specifically in the literature regarding influences on bicycle use, either stated explicitly or implicitly through frameworks that are in many cases functionally identical. For example, Xing et al. (2008) employ an ecological model in their cross-sectional analysis of the relative influence of individual factors, social-environmental factors and physical-environmental factors on both bicycle ownership and use in six small U.S cities in California. Explanatory variables are grouped into these three categories, with individual factors being subdivided into both socio-demographic and attitudinal factors. T. Pikora et al. (2003), interview experts using a Delphi panel study to inform an ecological model for understanding the potential relative importance of environmental influences on walking and cycling. Claiming that the evidence to date for the influence of the physical environment on physical activity is sparse, the authors focus on developing four key themes that fall under the umbrella of physical environmental factors: functional, safety, aesthetic, and destination. It should be noted that the Delphi study did not examine the statistical associations of these factors with increases in bicycling or walking. The purpose of the study was to create a consensus of expert opinion regarding the relative potential importance of environmental factors to aid in the development of an ecological framework. Rietveld and Daniel (2004) likewise provide a general framework of factors that have a potential impact on bicycle use as a basis for an econometric analysis of bicycle use in Dutch municipalities. While not explicitly an ecological model, the framework shares nearly identical categories such as individual features, socio-cultural factors, and local authority initiative and policy variables that encompass what other models identify as environmental factors.

The ecological model confirms that considering a wide array of factors is necessary to determine if the provision of a network of bicycle facilities is likely to significantly impact an individual's choice to start cycling, and what other factors may constrict or support preferred behavioral outcomes. Should another factor prove to have a stronger influence, supporting a rival or alternative theory (and therefore policy approach) may be necessary. For example, individual preference and demographic factors, such as age, environmental concern, income and educational level, are in some cases be found to be more important predictors in explaining bicycle use. Findings such as these would suggest that increases in cycling may be attributed more to self-selection, such as an influx of young, educated, and middle-class residents who already bicycle and are attracted to a city's amenities and pro-bike policies or marketing, rather than access to infrastructure.

Using the ecological model as a general framework, the following sections will use empirical research to provide evidence of the impact of bicycle infrastructure, environmental, socio-demographic, and individual or attitudinal factors, and their relationship to various measures of bicycle ridership.

3.2.1 Influence of Bicycle Lanes and Pathways on Bicycle Ridership

In what is widely considered the first study to test the relationship between facilities provision and bicycle use, Nelson and Allen (1997) analyzed cross-sectional data of 18 U.S. cities and established that there is a significant positive correlation between the number of bicycle pathway miles and the percentage of commuters using bicycles in their journey-to-work. Each additional mile of bikeway per 100,000 residents was found to be associated with a 0.075% increase in commuters using bicycles.

Building on the research of Nelson and Allen and lending strength to their findings, Dill and Carr (2003) employ a regression model using new data to identify factors associated with the percentage of workers commuting by bicycle in 33 U.S. cities with populations over 250,000. The number of miles of Type II lanes per square mile was found both significant and positive, with each additional mile of bike lane per square mile associated with a roughly one percent increase in the share of workers commuting by bicycle. As one potential explanation, also put forth by Nelson and

Allen, policy makers may be providing bicycle lanes in response to a large number of cyclists in these cities.

Observing that from a policy perspective it is not clear what policy makers can do to promote more bicycling, Rietveld and Daniel (2004) provide a quantitative analysis in order to explain variations between municipal bicycle use for trips shorter than 7.5km. An important aspect of this study is that it confines itself to only one country, the Netherlands, where variations in bicycle use are less likely to be confounded by cultural differences and more likely to result from variations in municipal policy. Route-related environmental factors that had both significant and positive effect on bicycle use included the speed of the trip (compared to the car), less stops per kilometer for a given trip, fewer hindrances on a trip per kilometer. Safety, objectively measured through victims of serious accidents, is an element that is also found to be important for increasing bicycle use. Despite a negative correlation, it should be pointed out that this study cannot attribute particular environmental interventions to promote cycling as the cause of less serious accidents, only that accidents are negatively associated with increased bicycle usage. Based on these findings, however, Rietveld and Daniel provide support for the claim that both bicycle speed and convenience are essential elements in promoting use. The authors conclude that the spatial design of networks that provide direct routes with minimal stops for cyclists represents an effective policy that should be used to increase bicycle use.

Parkin, et al. (2008) used aggregate data from the UK 2001 census to provide evidence for the determinants of the choice to use a bicycle for work related trips.

Positive effects that were found to be significant in the model included the proportion of the bicycle route that is off road, however, the elasticity was small, suggesting that the creation of a large quantity of off-road facilities would only succeed in creating a small increase in bicycle commuting. The proportion of route that has bicycle and bus lanes did not have significant coefficient and was eliminated from the final model.

One study, often cited as evidence for the positive role infrastructure (bicycle lanes, paths, and bicycle boulevards) may play in encouraging bicycling provides little support for the conclusion that "infrastructure appears necessary to encourage bicycling for everyday travel." (Dill, 2009) Using GPS (global position system) trackers to monitor a convenience sample of interested cyclists, the study provides evidence that the distribution of bicycle travel differs significantly from that of the transportation network. Utilitarian cycling travel during the study was 13% on bicycle/multi-use paths, 15% on secondary roads with bicycle lanes, and 10% on boulevards, compared to the fact that these infrastructure categories represented 2%, 2% and 1% of the total network, respectively. Overall, participants used bicycle infrastructure for about half their travel, indicating that bicyclists are probably traveling out of their way to use these facilities.

Several studies contradicted the findings that environmental influences were positively associated with an individual's choice to bicycle. Moudon, et al. (2005), in a disaggregate cross-sectional study of urbanized King County, looked at the role of both individual and environmental factors (both perceived and objectively measured, through surveys and GIS respectively) thought to influence bicycling. The authors were able to conclude that cycling mostly takes place irrespective of environmental prompts or barriers, having more significant associations with personal factors. Objectively measured route-related variables, such as the percentage of streets lined with bicycle lanes, traffic speed and volume, number of vehicle lanes, topographical conditions and street block size all were found to be insignificant in binary logit models. Only the distance of an individual to the closest trail, measured both objectively and subjectively, had a significant positive correlation with cycling.

de Geus et al. (2008) similarly found that the perceived environment was not a significant predictor of cycling for transportation in areas with adequate cycling infrastructure. Based on a self-reported survey of both cyclists and non-cyclists in Flanders, Belgium (a cyclist being defined as cycling at least once a week to work in the last 6 months), the results suggest that individual and social factors play a larger role than environmental factors. The authors tested subjectively reported cycle lanes that were present and in good condition, which were found to be insignificant.

Another study (Xing, et al. 2008) used cross-section survey data to identify the relative importance of factors influencing both bicycle ownership and use while controlling for the possibility of self-selection. Self-selection is an issue in correlational studies where residents of a city choose to live in a particular area because it is perceived as a supportive bicycling environment. This effect may erroneously attribute increased bicycle use to physical or environmental interventions when in fact it should be attributed to demographic changes in an area- people who already bicycle simply moved to the area.

The influence of perceived infrastructure in the built environment showed no significant effect on bicycle use or bicycling in the final model, including such facilities as major streets with bike lanes, streets without bike lanes being wide enough to bike on, well lit bike paths, networks of off-street bike paths, and bike lanes free of obstacles. While there were significant associations of bicycle use and frequency with the perception of the safety of bicycling to select destinations, this does not provide a basis for the author's suggestions that this may be an indirect role of infrastructure. No evidence is provided as a basis for this assertion and other factors, such as lower traffic intensity, may be responsible

Citing the field's overreliance on cross-sectional studies as problematic for establishing causality, Krizek et al. (2009) provide what may be the sole longitudinal study to date. In investigating the impact of bicycle lanes established during the 1990's on subsequent bicycle use in Minneapolis and St. Paul, Minnesota, the authors are able to conclude that bicycle facilities significantly impacted levels of bicycle commuting. While a more nuanced treatment of the results is warranted, in general, the study found that both for traffic analysis zones within defined buffers and outside of buffers associated with bicycle facilities, increase in bicycle use took place during the period, with areas inside the buffers showing a larger increase. The share of residents commuting by bicycle living within defined buffers around individual facilities was likewise found to be significant in almost all cases, except for near the University area, where the initial rate was already very high. In some cases bicycle modal shares doubled in areas with low bicycling, suggesting that there may be a diminishing marginal return effect. Bridge improvements likewise were found to have significantly affected commuters' willingness to use bicycles to cross the Mississippi River, even though they already had a relatively high bicycle mode share. Finally, the study found mixed results in its analysis of the impact of facilities on final trip destination. As mentioned before, model share for residents around the University of Minnesota did not change significantly over the 10 year period, however, the share of trip did significantly increase at this trip endpoint, suggesting that the facilities may have provided more benefit to commuters coming from outside the area. Contrasted with this is the very slight increase and decrease in final trip destinations in Minneapolis and St. Paul, respectively, where as discussed earlier, residents in these areas were found to have increased their share of cycling overall.

3.2.2 Influence of Socio-demographic Characteristics on Bicycle Ridership

A comprehensive analysis of factors influencing an individual's choice to use a bicycle for utilitarian trips would be inadequate if it only considered the influences bicycle lanes and pathways. In keeping with the ecological model, socio-demographic variables, such as age, sex, income, and related household characteristics have proven to be significant and sometimes stronger correlates than environmental factors in determining a person's willingness to engage in non-motorized transport. Studies that examine socio-demographic factors will be discussed in turn for their association with increasing various measures of bicycle ridership.

3.2.2.a Gender

Studies reviewed consistently show that gender is significant predictor of cycling rates, with males being much more likely to cycle then females in every study considered. Through the use of data gleaned from the 2001 American Housing Survey, Plaut (2005) was able to determine that for renters and homeowners identifying as female, a negative correlation exists with the log of the probability of using a bicycle for commuting divided by the relative to the probability of using a car. Gender was found to be highly significant in two models that predict the number of times a week a person bicycled for any reason, with males having odds ratios just over three times that of women (Moudon 2006) . Cervero and Duncan (2003) similarly found a correlation between male gender and the probability of choosing a bicycle for traveling. Troped et al. (2001), found a correlation between the use of a community rail trail and respondent identifying as male.

3.2.2.b Race

Race was found to be a strong predictor of cycling in several studies. Baltes' (1996) aggregate study of 284 Metropolitan Statistical Areas found that the percentage of the total population in an MSA that is Asian is a strong predictor of the percentage of work trips taken by bicycle in 1990 in several regions. The percentage of the MSA that is non-white was found to be negatively correlated with cycling trips, supporting one study's findings that non-white workers who both rent and own their homes were less likely to use a bicycle for commuting rather than a car (Plaut, 2005) and another study that showed that the percentage of non-whites were negatively associated with the proportion of individuals in a ward cycling to work (Parkin, et al. 2008). A study of King County, Washington, found that respondents identifying as White have odds ratios between 3.5 to 5 times higher than non-whites in relation to the # of times a week the individual chooses to bicycle for any reason (Moudon et al., 2005).

3.2.2.c Age

Age was found to be negatively correlated (Troped et al., 2001; Xing et al., 2008) or a not significant predictor (Parkin, et al., 2008; Plaut, 2005) of various dependent variables related to cycling across several studies. Rietveld and Daniel (2004) found a correlation at the aggregate level between the proportion of young adults (ages 15-19) in Dutch cities and the share of bicycle use. Moudon found a curvilinear relationship showing that respondents in the age category of 25-45 as more likely to bicycle than the youngest age category, 18-21.

3.2.2.d Education Level

Education level was strongly associated with the likelihood of bicycling across the majority of academic studies considered. A study of five comparison communities in California found a highly significant correlation between education level and whether one chose to bike in the last seven days or not (Xing, et al., 2008) Both renters and homeowners who were college graduates or have postgraduate schooling were found to be more likely to choose a bicycle. (Plaut, 2005) An aggregate level study of

Metropolitan Statistical Areas (MSAs) found that when considering all MSAs in one model, or stratifying MSA's by region, the percentage of the population age 18-24 enrolled in school was significantly correlated with the percentage of work trips by bicycle. Across several studies, education level and levels of enrollment can be shown to have a high degree to association with a variety of cycling related variables.

3.2.2.e Income, Employment and Workforce Characteristics

The effect of income was found to be insignificant in one study looking at whether one chose to bike or not bike in a given week, and how frequently (Xing et al., 2008) This association appear again in an aggregate study comparing median family income and its relation to work trips in metropolitan areas (Baltes, 1996). Baltes (1996), in a model of Western U.S. MSA's, was able to demonstrate that the percentage of families living below the poverty level is negatively associated with the percentage of work trips completed by bicycle. Parkin et al. (2008) similarly found that the index of deprivation income score (a proxy of income) of both Welsh and English wards was found to be negatively correlated to the proportion of individuals cycling to work-this can be interpreted as the higher the rate of poverty, the less likely the individual was to cycle.   Plaut (2005) contradicted this effect in her study of commuting trends from the American Housing Survey, finding that the salary of a worker was negatively associated with the probability of using a bicycle over a car.   While these results may suggest a non-linear relationship in which those under poverty level and those with higher incomes are less likely to bicycle, study results did not provide enough evidence to support this conclusion.

Employment characteristics of individuals were also identified as a possible influence on bicycle ridership, with two studies including employment related variables in their final models. Moudon et al. (2005) found similar results in two models that having less weekly work hours was positively associated with the number of times a week a person bicycled for any reason. An aggregate study (Baltes, 1996) of all U.S. MSA's, stratified later into separate models by region, consistently found that the percentage of the population that was unemployed was a strong and positive predictor of the percentage of work trips by bicycle.

The percentage of various occupational categories represented in MSA's were found to be significantly associated with bicycling in several cases (Appendix C), with no clear trend to explain why some are more likely to be associated with cycling outcomes over others. The abundance of factors tested and the inconsistency of effects of factors tested across studies do not readily lend support to the influences of income or employment for the purposes of this study.

3.2.2.f Housing Characteristics

Plaut's study (2005) of non-motorized community analyzed data from the 2001 American Housing Survey in order to see how commuting decisions are affected by, or made jointly by, housing choices. The value of the owned units was associated with a decrease in the probability of using a bicycle and the value of the rental payment was associated with an increase in the chance of using a bicycle. Plaut found that the number of persons in the household was insignificant in determining cycling outcomes, while Xing et al. (2008) tested the same variable across several models, finding a significant negative correlation affecting those who biked frequently as opposed to moderately. In this study, housing size was found insignificant in determining who bicycled and who didn't. Finally, Plaut was able to predict a negative effect on choosing a bicycle for transport with newer housing and rental properties. Many other aspects of housing were found not to be significant predictors of choosing a bicycle over a car for transport, including whether a parking space was available, if commercials properties were nearby (i.e, a mixed-use neighborhood), the presence of green areas, and the square foot/space of the unit.

3.2.3 Influence of Individual and Attitudinal Factors on Bicycle Ridership

The following section considers the influence of Individual and attitudinal factors on bicycle use. Variables are represented that were included in models of bicycle use that are associated with individual preference and are not due, primarily, to an individual's position in society.

3.2.3.a Bicycle Ownership

Bicycle ownership, as a prerequisite of bicycling and an indicator of interest in cycling was positively and significantly associated with bicycling in the three studies that included it as a factor. A study of 608 randomly selected adults in King County found that ownership of a bicycle was significantly associated with the number of times bicycling in a week, with two models resulting in odds ratios of 180:1 and 163:1 compared to those who don't own a bicycle. (Moudon et al., 2005). Cevero and Duncan's (2003) study of two day travel activity for 15,066 randomly selected households also found a positive correlation between the number of bicycles per household and the probability of a person choosing bicycling for travel. Xing, et al. Buehler's (2008) study provides models on factors influencing who owns a bicycle based on both individual and socio-demographic factors. Among those found to be significant, those reporting that they are in good health and enjoy bicycling were more likely to own a bicycle as opposed to those who reported that they need a car, like taking public transit, and surprisingly, those that are pro-exercise. The results of these models, however, should be cautiously interpreted as surveys received only had a 12.6% response rate.

3.2.3.b Car Ownership and Attitudes Towards Motor Vehicles

The majority of studies reviewed found a highly significant negative relationship between ownership of one or more motor vehicles and the likelihood of cycling. Another recent study (Xing et al., 2008) found car ownership to be an insignificant variable in the determining who bicycled and who didn't bicycle, but found that it was significant in determining who biked frequently vs. moderately. An aggregate study of Dutch municipalities found that the number of cars per capita had a negative effect on the share of bicycle use, mirroring a similar look in the U.S. by Baltes (1996) that found a negative correlation when all MSA's were considered on the percentage of bicycle trips to work. Similar results were found in a study to determine the factors that determine the probability of choosing a bicycle of using a motor vehicle, with both renters and homeowners being more likely to do so if no car is available at the household (Plaut 2005). Plaut similarly found that owning homeowners with two or more cars had a negative effect on bicycle choice, but the effect was not found to be significant for those who were renters. Owning exactly one car per adult in King County Washington was associated with a negative effect on the number of times a cyclist rode each week for any reason (Moudon et al., 2005).

Attitudes towards motor vehicle ownership were of mixed importance for determining the probability of cycling. Those that reported needing a car for transportation were found in two models predicting the likelihood of whether one bicycled or not in five California comparison cities were not found to be significant (Xing et al., 2008). This variable did have a negative impact, however, on the likelihood of one biking frequently as opposed to moderately, defined as five to seven days versus one to four days a week.

3.2.3.d External Support

Only one study incorporated external support and reinforcement from friends and family in its modeling of factors that influence cycling for transport to work at least once a week (de Geus et al., 2008). While no other studies incorporated psychosocial factors into their study, and thus they cannot be corroborated, the results of this study of 343 Flemish adults discovered that those who reported high external self-efficacy, having a partner or someone who cycles with them, and have someone who provides a positive model of cycling behavior, were significantly more likely to have bike at least once a week over the six months prior to the study. The results, while not conclusive, show that a social element may be at play in influencing cycling rates, and that increased cycling may in turn generate more cycling through positive modeling and reinforcement.

3.2.3.e Attitudes Cycling, Transit and Walking

Perhaps unsurprisingly, a lack of interest in cycling significantly decreases the probability of a respondent cycling at least once a week (de Geus et al., 2008). The inverse was explored in another study (Xing et al., 2008) that integrated attitudinal factors into its final models, finding that respondents who agreed strongly with the statement “I like biking” were more likely to bicycle and to bicycle more frequently. The same study found that survey recipients who favorably responded to the statement “I like walking” were less likely to bicycle, but this was not a significant factor in regard to the frequency with which the individuals cycled. Similarly, those who agreed strongly with the statement “I like taking transit”, were more likely to bike moderately rather than frequently, with no significant difference between those who bike and those who do not. This could be seen as suggesting that walking and transit are competitive modes with cycling, however, interpretation is difficult given the generality of the statements, the lack of other studies that corroborate the relationship, and the low response rate of the specific study in question. Complicating the analysis further, a study of King County, Washington (Moudon et al., 2005) that incorporated transit users in two of its models found them to be both insignificant (GIS Network Model) and positive (GIS Airline Model) influences on the number of times a week the person cycled for any reason. As can be seen, the mixed results of the few studies related to attitudes and behavior in regard to alternatives to the automobile do not allow for a definitive answer on their effect on bicycling rates.

Another attitudinal factor that was briefly explored in the Xing et al., (2008) concerned the view that "Most bicyclists look like they are too poor to own a car". Responses in the affirmative were significantly correlated with the respondent not bicycling. This influence on bicycling suggests that the unwarranted image of cycling as a "fringe mode" may inhibit greater ridership numbers, no other study looked at this variable and it cannot, therefore, be corroborated.

3.2.3.f Individuals' Health/Attitudes Towards Exercise

An individual's health, as a self-reported assessment, and attitudes about exercise and the benefits of physical activity were found to be significantly related across a variety of studies on cycling. Temporary illnesses/injuries were not found to impact the use of a community rail trail, yet long term illnesses/injuries were found to decrease the odds of using the trail to 0.43 compared to those that did not report an illness or injury (Troped et al., 2001). Adult respondents in King County, Washington (Moudon et al., 2005) who exercise at home were found more likely to bicycle more during the week, mirroring an association in a study of five communities in California that show that those who report being pro-exercise are more likely to have bike in the previous seven days. (Xing et al., 2008). Contrary to these findings, de Gues, et al. (2008) found no significant connection between self-reported physical well-being and only a moderately significant influence of body image on the choice to cycle for transportation at least once a week during the six months preceding the study. Moudon's study further contributes to an understanding of the influence of attitudes in that those who strongly disagree with the benefit of physical activity, or reported no vigorous physical activity, were less likely to bicycle during the week for either commuting or recreation. Overall, the results of the four studies above support a positive role for attitudes about health in regard to a variety of bicycle related outcomes.

3.2.3.g Environmental/Economic Awareness

Two studies considered the impact of attitudes towards the environment in the decision to bicycle at least once during the week. Environmental concern did not factor into the final models of one study that considered bicycle ownership, bicycle riders, and the frequency of which bicycles are ridden. (Xing et al., 2008) Ecological and economic awareness was found by de Geus et al. (2008) as a significant predictor of biking to work during the week, with an odds ratio of 1.71 compared to those who didn't cycle. Xing et al. (2008) also found a significant correlation between those who try to limit driving as much as possible and those who cycle. Across models, those who self-reported constraining their driving were found to be strongly associated with those who biked versus those who didn't, and those who bicycled frequently versus those who did so only moderately.

3.2.4 Influence of Environmental Factors on Bicycle Ridership

The results of models that tested the influence of environmental factors are explored below, with several significant effects on bicycle use present. Environmental factors include variables related to geography, climate and urban design, including population density, traffic density, neighborhood characteristics, and weather, among others.

3.2.4.a High Traffic Densities/Presence of Automobiles

High traffic densities in neighborhoods and the presence of automobiles were factors considered in five models reviewed for this study, both objectively and subjectively measured. Troped et al. (2001) found that survey respondents were more likely to use a community bikeway when they self-reported that no busy street barrier existed en route to the bikeway. An objective assessment showing a busy street barrier did not prove to be significant however, suggesting that what constitutes a busy street and risky conditions are more likely to be a matter of perception. Another predictive model looking at factors that influence the proportion of individuals in an area that cycle to work found that the transport demand intensity, defined as the number of employees for the area divided by road length, negatively influenced the outcome. Other studies that looked at motorized traffic noise (Rietveld and Daniel, 2004), traffic danger and traffic safety in neighborhoods (de Geus et al., 2008) found no significant association. One King County, Washington study (Moudon et al., 2005) relating bicycle rates to the presence of motor vehicles and motor vehicle facilities found not a negative influence, but a curvilinear one. The non-linear association suggested to the authors that having a moderate level of traffic and auto-oriented facilities is more desirable for cycling, compared to having too few or too much of them. The explanation offered was that these conditions may offer a diversity of activities of interest to cyclists in the form of sensory or visual stimuli.

<u>3.2.4.b Weather Related Variables</u>

Rainfall measured as number of days during the year rain exceeding 1/10th of an inch for 18 U.S. cities and rainfall per year in millimeters in British wards were found to have significantly negative effect on cycling when measured at the aggregate level in two models (Nelson and Allen, 1997; Parkin et al., 2008). This same effect was only found to be significant in one model that measured days of rain for 33 U.S. cities, but only when D.C. and NYC were removed as outliers (Dill and Carr, 2003). A study of the effect of rainfall as measured in millimeters on the cycling rates of Dutch cities was found to be insignificant. The authors do note that there is less spatial variation for precipitation across the Netherlands and it tends to rain evenly over the whole country.

Wind speed was a variable in two studies reviewed (Rietveld and Daniel, 2004; Parkin et al., Wardman, and Page 2008) thought to negatively influence cycling by increasing the effort the cyclist must make to ride against it. Both studies did not find the variable to be significant in explaining cycling levels in the areas of study and it did not make it into final models.

While studies considered other factors such as mean temperature and the total annual hours of sunshine for the year in order to detect an outcome on cycling, weather variables have not been explored to any great extent in the literature. From the above review, we can conclude with reasonable confidence that rainfall will have an inhibiting effect on cycling outcomes.

3.2.4.c Geographical Factors: City Population and Density

Plaut (2005), in her study of U.S. Metropolitan Statistical Areas (MSA), was able to show a strong association between those that live in central cities of the MSA on the West Coast of the U.S., and the log of the probability of using a bicycle over the probability of using a motor vehicle. In line with this, a negative correlation was detected for those who lived in rural areas and those who lived in secondary urban areas in a given MSA. Baltes (1996) study of U.S. MSA's found that the percentage of population living in central cities was negatively associated with the percentage of work trips made by bicycle.

Population density was found to significantly influence the proportion of individuals cycling to work in a study of British wards (Parkin et al., 2008), but was not significant in a model using 284 MSAs in the U.S. An increase in the population (in thousands) was found to be associated with a decrease in the share of bicycle use in Dutch cities, but the impact of total population was not measured in any other study reviewed.

3.2.4.d Neighborhood Level Characteristics: Trip Origins

The influence of urban design, land-use diversity and density patterns on the choice to use a bicycle was explored by Cervero and Duncan (2003) using a combination of data on the built-environment in the nine county San Francisco Bay Area and travel survey data detailing two days of household trip information for over 7000 households. To deal with the issue of multicollinearity that will cause interrelated built environment variables to contaminate the final predictive model, the authors use factor analysis to extract two variables: a pedestrian/bike friendly factor (small blocks, four way intersections, and five or more way intersections) for both trip origins and trip destinations and a land use diversity factor, again for trip origins and trip destinations. The land-use diversity factor, a measure of mixed land uses, employed residents to retail/services balance, residential balance, and other related factors, was found to have a moderately significant (probability 0.088) effect on the choice to cycle when considered as a destination. Overall, the study found that demographic characteristics of trip makers were far stronger predictors of bicycling choice than built-environment factors. Moudon et al. (2005) found that the presence of convenience stores had a negative impact on cycling in both models tested when captured as total parcel areas rather than count. The authors suggest that larger convenience stores tend to be those combined with gas stations, which may be explain their role as a possible detractor of cycling.

Access to transit within a five minute walk from home was found to be an important determinant in two models that predicted who bicycled in the previous seven days, but it was not a relevant factor in a model determining the frequency of which they biked (Xing et al., 2008). de Geus et al. (2008) found that the time predicted to go to a bus, tram or metro stop was not associated with cycling for transport.

3.2.4.e Trip-specific Variables: Distance and Destinations

A variety of variables specific to individual trips was presented in the literature with two consistent themes: trip distance and trip purpose.

Trip distance was found to be negatively correlated with the proportion of individuals cycling to work in British wards, with an increasing coefficient distance to work increased in the variable ranges of 2km-5km to 5km-20km (Parkin et al., 2008). Another study (Cervero and Duncan, 2003), using disaggregate travel data on individual trip characteristics in its modeling, found a similar negative result when comparing trip distance in miles to the probability of a person choosing a bicycle for traveling in the San Francisco Bay Area.

Trip purpose was also considered by Cervero and Duncan (2003) in their study of how land-use diversity dimensions of built environments affects walking and cycling. Recreational/ entertainment purposes and social purposes were found to have a positive effect on cycling, in addition to the presence of food shops at the destination. Weekend trips and those that involved shopping were found to be positive, but not significant predictors, of traveling by bicycle. Xing et al. (2008) found that the average self-reported rating of safety to various destinations such as grocery stores, post offices, restaurants and elementary schools was found to significantly and positively correlated in models that tested the factor against who biked and how frequently.

3.2.4.f Slope

Slope (rise/run) was found to be a significant factor influencing the use of a bikeway in Massachussett's, with survey respondents nearly twice as likely (Odds ratio 1.90) to use a trail when no steep hill barrier was objectively present (Troped et al., 2001). Subjective reporting of a steep hill on the route to the bikeway, however, was not found to be significant. The proportion of 1km squares with slopes 3% or steeper was found be associated with a lower proportion of individuals cycling to work in British wards (Parkin, Wardman, and Page, 2008), and the presence of slopes was found to be a negative influence on the share of bicycles use in relatively flat Dutch cities (Rietveld and Daniel, 2004). A study of the hilly San Francisco Bay Area contradicted these results by finding that objectively measured average slope, calculated off of trip origins in destinations, was not significant. Overall, studies reviewed support an expected negative or insignificant effect of hilly areas on cycling.

3.2.4.g Road quality

Only two of the studies reviewed considered the effect of road conditions on cycling, with both being aggregate measures that are not specific to the experiences of individual cyclists and non-cyclists. One study of Dutch municipalities found that the effect of pavement vibrations was either insignificant and had issues of multicollinearity with other factors, and did not make it into the final study model (Rietveld and Daniel, 2004). The proportion of principal and non-principal roads with negative residual life were both found to negatively affect the proportion of individuals in British wards who cycled to work (Parkin et al., 2008). Xing et al. (2008) found that respondents' assessments of the average comfort of biking on various street classifications was not a significant predictor of who did or did not cycle, but these same perceptions do have a significant positive effect on who does and does not own a bicycle. With only two studies showing significant relationship for a subjective and objective measure of road quality, the effect of this factor is presently indeterminable.

3.2.5 Influence of Policy level Variables on Bicycle Ridership

A broad category that could be termed "policy level" variables, was the focus of the (2004) Rietveld and Daniel study, "Determinants of bicycle use: do municipal policies matter?" The authors were able to determine that parking costs, measured in eurocents per hour, had a positive effect on the aggregate share of bicycle use in Dutch cities. The speed of cycling when compared with the car was found to be a positive influence, with stop frequency for cyclists being negative. These results suggest that one element that needs to be considered in making cycling a more attractive mode is that it is able to compete favorably with other modes- in this example high parking costs and a low stop frequency can be expected to make motor vehicles less appealing and bicycles more so. As Rietveld and Daniel state, “this combination of push and pull policies is a rather general result found in transportation research, and it also appears to apply to bicycle use.” The only other finding of significance was related to an aggregate measure of the degree of satisfaction in the study areas with bicycle policies, provisions, etc. This had a significant positive influence on cycling as a larger portion of the modal share, and may be somewhat corroborated with Dill and Carr’s (2003) model showing that state spending per capita on bicycle and pedestrian improvements was significantly related to the bicycle rates in 33 U.S. cities (when D.C. and NYC, are excluded).

The limited studies available that consider policies, coupled with the wide variety of proxy measures that are used as indicators of municipal incentives and supportive policies for cycling, proves problematic in terms of assessing the importance of variables at this level. While there may not be agreement on what is relevant to measure, the significant relationship between cycling outcomes and the variables presented should be noted.

3.3 Assessment of Models in Relation to Implementation Framework

The ability to prove a causal relationship between bicycle facilities and increased levels of bicycling has remained elusive in much of the existing research. Four of the recent studies reviewed, (Nelson and Allen (1997); Dill and Carr (2003); Rietveld and

Daniel (2004); Parkin et al.,(2008)) often held up as providing evidence for the role of lanes in inducing bike ridership, use cross-sectional or aggregate models that test factor associations with the dependent variable at a single point in time. Three of the four studies found statistically significant relationships between various measures of bicycle facilities, with Rietveld and Daniel (2004) finding no significant relationship to a bike network, and Parkin et al. (2008) only finding a relationship for off-road facilities (such as bike trails). What may seem like favorable results overall is limited when taking into account the inherent deficiencies of aggregate modeling- foremost is the inability to prove causality in favor of statistically significant correlations that may be spurious or misleading. One major issue identified in the literature is that of self-selection, in which a correlation masks a causal relationship that move opposite of the intended direction. In such a case, residents may have based their locational decisions in response to a supportive bicycling environment and in turn create more demand for bicycle lanes. This is separate from true causality, where bicycle lanes induce more to ride by making utilitarian cycling more accessible to those who previously wouldn't have considered it.

Disaggregate studies that rely on surveys and the subjective measures of the presence of bicycle lanes are also present in the literature. These studies may prove problematic in that there is no way of assessing the extent to which actual bicycle lanes are present. Xing et al. (2008) found no significant relationship when respondents were asked their perception on the presence of bicycle lanes, but were found to have a marginally statistically significant ($p=0.10$) relationship when aggregate objective miles bicycle lanes per square mile were modeled. These results do not pass the causality test for the same reason elucidated above regarding aggregate studies. de Geus et al. (2008) similarly used the presence of subjectively reported or perceived bicycle lanes and found no significance.

Two studies attempted to remedy the problematic nature of self-reporting in surveys supplemented respondents answers with objectively reported disaggregate variables matched through GIS to the respondent's location. Moudon et al. (2005) found that the subjectively reported presence of bicycle lanes showed a highly significant positive relationship with the number of times cycling a week for any reason, while an objective measure of the percentage of streets lined with bicycle lanes, which were not significant. Objective distance to the closest trail, however, did show a positive relationship with bicycling. Troped et al. (2001) used a similar hybrid design using a mixture of self-reported and objectively measured variables gathered through a GIS tool, finding that distance to the nearest trail was negatively associated with the use of a community rail trail- the closer the distance the person lived, the more likely they were to make use of it.

Only one longitudinal study was identified that analyzed the effect of bicycle facilities on mode share over time, with the explicit purpose of attempting to address causality given the predominance of cross-sectional/correlational studies (Krizek et al., 2009). Using aggregate U.S. Census data, the study identifies specific bicycle facilities that were installed in Minneapolis and St. Paul during the study period of 1990-2000, and test for effects using two different buffering techniques to define proximity. While self-selection remains an issue, and the authors caution against any interpretation inferring causality, the results are suggestive of the significant positive impact of bicycle facilities on bicycle commuting. While these results may seem particularly promising given the longitudinal study design, it is still appropriate to be cautious when inferring causality. Yet the authors are able to reasonably conclude that self-selection is not the case- a prior study conducted by Barnes and Krizek (2005) allows them to conclude that even if all the "right type" of persons (affluent, male, between the ages of 18 and 40) lived in one area and were absent from another, the difference in rates should only differ by a factor of two. The differing rates of bicycle use between 1990 and 2000 were, however, many times that amount. While still falling short of showing a causal relationship, these results are promising nonetheless for the positive role bicycle facilities may plan in increasing ridership.

The foregoing discussion establishes a predominately positive correlation between bicycle lanes and bicycle ridership across several models, with a few exceptions showing no significance.   Providing a study design that demonstrates a causal relationship has been elusive given the reliance on cross-sectional study designs and aggregate data. From the evidence provided, the overall relationship between bicycle facilities and increased ridership can best be defined as a statistically significant positive correlational relationship.

Hogwood and Gunn's implementation framework requires that the relationship between cause and effect be direct, as too many linkages will provide additional opportunities for a break in the chain. The use of ecological models of behavior was determined in the above review of literature to be well justified given the strong associations many socio-demographic and attitudinal factors have on bicycle ridership. The significance of these factors, however, may be problematic if they serve to mitigate the effects of bicycle lanes.   Overall, models found a significant correlation between the presence of a high percentage of white, young, college educated males living in urban areas that own a bicycle and are inclined to limit driving, and a higher proportion of bicycle trips. Rainfall, road quality, and hills, on the other hand, may cancel out the effects of bicycle lanes. Parkin, et al. (2008), Moudon, et al. (2005) , and de Geus et al. (2008) all conclude that socio-demographic or individual factors played a stronger role in predicting bicycle mode shares or the number of times a bicycle was ridden per week than physical factors, and Xing et al. (2008) and Rietveld and Daniel (2004) do not show significance for the effect of bicycle infrastructure, in comparison to many attitudinal, socio-demographic and other environmental factors with significant and at time larger coefficients.   While it could be said that a direct causal linkage is to be taken as an ideal, the factors that influence increases in bicycle modal share are numerous, correlational, and at times contradictory. The evidence based off the literature presented clearly shows that a policy intervention aimed at increasing bicycling modal share will be impacted by numerous factors outside of its control.

The inability to show causality coupled with a large number of factors that may serve to mitigate the potential impact of bicycle facilities may prove problematic for meeting the SBMP goal of tripling ridership. Absent the provision of a well-accepted model of bicycle use, predicting the outcome of the provision of bicycle infrastructure will continue to prove difficult. Seattle precipitous climate and hilly landscape may serve to mitigate the effects of bicycle lanes, while demographic factors may prove favorable, adding an element of self-selection that increases ridership. While further studies are required, the theory underlying the SBMP shows limited strength in comparison to the framework's ideal requirements for direct causality, and should at best be interpreted as a significant positive correlational relationship.

4. Analysis and Conclusions

The study concludes by considering the implications of the study findings for other cities engaged in Bicycle Master Plan implementation based off of the experiences of implementation staff in the Seattle case. Refinements to the implementation framework are offered based on evidence provided by interview participants that contradicted the frameworks premises of elements required for ideal policy execution. The limitations of the study findings are then addressed in light of the study design, and suggestions are made for future research to assist in the development of an empirically based understanding of the actual potential to increase ridership through the use of bicycle facilities.

The use of the implementation framework devised by Hogwood and Gunn was successful in assisting interview respondents in the identification of major factors influencing the construction of bicycle facilities in Seattle, Washington over the 2007-2009 study period. Overall, the interview instrument employed was successful in identifying factors of varying influence on Bicycle Facilities Network implementation efforts. All interview questions based on Charles' iteration of the framework generated responses, with five framework categories (Context, Resourcing, Compliance, Leadership, and Support, see Table 1 above) of eight having converged on responses for one or more factors. These findings justify the use of the framework in both the current and future case studies of BMP implementation.

Influences on Plan execution were found to be critical, supportive, neutral, or problematic for implementation outcomes, yet no factors were determined to be barriers to implementation of bicycle facilities in the Seattle case. This finding is not surprising as respondents identified that enough funding was provided for during the 2007-2009 period and all projects prioritized were completed during this time. It is reasonable to believe that factors exist that may serve to hold projects up, or the absence of factors that were deemed critical to implementation in the current study may serve to stall projects indefinitely. While these factors were not identified in the Seattle case, future case studies of cities that have not been successful in meeting recommended facilities goals may assist in a more comprehensive understanding of factors that can hamper projects and lead to implementation failure.

The Bridging the Gap transportation package, a voter approved levy, was determined by participants to be the most crucial factor in implementation of the Seattle Bicycle Master Plan. Perhaps its two most defining attributes are that the levy runs concurrently with the Plan and it mandates providing a percentage of funds to non-motorized transportation projects. Just as notable was the passage of a self-imposed levy, which indicates a wide degree of popular support beyond the control of any one politician or group to block. Findings from the Seattle case suggests that dedicated funding, in whatever form, is a necessary component of BMPs, the absence of which will likely obstruct any implementation efforts.

In response to Hogwood and Gunn's inclusion of the need for the ability to enforce compliance in the face of opposition to a policy, interviews revealed a more fundamental factor at play. The missing ingredient of political will was identified by study participants, and its presence should be considered crucial for implementation when dealing with opposition to projects the agency wishes to pursue in line with the SBMP. The authority to enforce compliance takes place in the context of a pluralistic system of governance where power shifts depend on the political will of elected officials and the relative support of constituency groups. A well organized opposition or a Mayor or City Council less amenable to championing the Plan and lacking the will to act on agreed upon objectives could severely hamper the implementation process, all within the same legal context. With this qualification in mind, it can be concluded that in the Seattle case, SDOT has the ability to enforce compliance with the Plan due only to the political will of actors such as the Mayor and City Council, themselves subject to the political support of their constituents. This finding suggests that case studies should consider whether the legal authority exists to follow through with the Plan, and if political leaders that can exercise such authority are likely to support implementation efforts in the face of adversity.

A convergence in opinions exists among study respondents that the adoption of a Complete Streets policy was a critical piece of the policy framework necessary for implementing the SBMP. The passage of the Complete Streets was the product of years of advocacy and work with elected officials. Its adoption, first as a City Resolution, and later as an Ordinance, could be seen as suggestive of a confluence of factors more fundamental to the creation of a policy that mandates a divergence from a focus on infrastructure provision primarily for the benefit of motor vehicles. While it is outside the scope of this study to determine what these factors are, the adoption and subsequent passage of the Complete Streets Ordinance by unanimous votes of City Council suggests broad and sustained public support over a four year period, coupled with an advocacy boasting the expertise, resources, and influence to affect the opinions of elected officials. Its defining characteristic is institutionalizing the consideration of bicycle facilities when any transportation projects are considered, ensuring that players in the planning process do not push an underserved mode into the margins. The possibility remains that cities may accomplish the goals of routine accommodation of projects in a BMP without an explicit “Complete Streets” policy- cases studies should consider the level of institutionalization of bicycle planning efforts in the absence of a Complete Streets ordinance.

The support of constituency groups and the public was considered a final critical factor that positively influences implementation. The inclusion of this factor in the critical category is not surprising, and can be assumed to have an effect across the board in many different aspects of implementation- notable are the passage of the Bridging the Gap levy, the Complete Streets Ordinance, and as a foundational force in the creation of political will among elected officials, all of which were identified above as critical factors in implementation.

A clear policy champion was present in the form of Cascade Bicycle Club, whose advocacy efforts were considered highly supportive of implementation efforts. By rallying support around the Bridging the Gap levy, the Complete Streets Policy, and creating political will, again, all found to be critical factors for implementation in this study, Cascade Bicycle Club used the strength of its membership, its expertise, and its connections with City staff to influence processes to provide a conducive environment for the Plan to become adopted and realized on the ground. While the importance of institutionalizing bicycle planning efforts in existing processes should be of paramount importance, the Seattle case suggests that a well-positioned advocacy group can have significant sway over events that will ultimately benefit implementation efforts overall. Future research should consider the role that bicycle advocacy groups play in creating support for Plan adoption, the technical assistance they provide to city staff and the maintenance of support during actual policy execution.

The question of timing, defined by the author as contextual events that influenced implementation that were not willed by policy actors, was found to influence project implementation in the case of increased gasoline prices in the summer of 2008. Interestingly, respondents discussed the influence in terms of increasing ridership, which may have the indirect effect of increasing support for the SBMP as a greater constituency has a stake in successful Plan outcomes. This relationship could not be determined, yet the ability for events to affect the mood and subsequent support for projects suggests a linkage between the implementation frameworks requirement for timing and political support. The influence of timing may prove difficult to establish in future case studies of bicycle facilities provision as the concept is broad enough to apply to any contextual event that occurred during the scope of the study. The concept could benefit from better operationalization more specific to bicycle use to reduce the possibility of it being a catch all for factors not specifically outlined in the framework.

Environmental concern, either at the attitudinal level that may influence bicycle use and possibly support for Plan implementation, or as embodied in adopted City documents such as the Seattle Climate Action Plan, were determined to have no direct effect on implementation outcomes. Interview responses do suggest an important indirect effect in that environmental strategy documents may serve to frame the need for bicycle facilities in terms of larger overarching values, thus building upon latent constituencies of support. Despite the finding of a neutral effect, future research into BMP facilities implementation should consider this effect not just for environmental strategies and values, but also those related to public health, energy reduction, and providing options for low-income individuals.

A lack of streets space, or the presence of competing uses that confined the optimal project option, was considered a problematic factor influencing implementation. This could result in the overdevelopment of one type of facility, depending on a city's geographical characteristics. The SBMP states that "Depending upon an individual bicyclist's level of experience, some types of bikeways are preferred over others…new bicyclists tend to prefer off-road multi-purpose trails and quiet neighborhood streets. More experienced bicyclists prefer on-road bicycle facilities such as bike lanes, wide curb lanes, paved shoulders, etc." (SBMP, 2007) As discussed earlier, sharrows were widely considered confusing and not an ideal facility type for beginning bicyclists in discussions during SBAB meetings. Attracting only those comfortable sharing a lane with motor vehicles may ultimately serve to hamper implementation outcomes by not providing the necessary environment to induce new cyclists to ride. Responses suggest that the constraining effect of street space on project implementation may be mitigated by an effort to obtain more detailed data regarding constraints during plan development, considering both data on street characteristics and potential conflicts with competing uses. The issue becomes less one of a lack of street space and more one of having accurate data to reduce unseen conflicts later on during implementation. The ability to get high quality front-end data will inevitably be constrained by the plan development budget, time, and staff availability, but may allow for smoother project provision by increasing awareness of issues inherent to contested spaces, ultimately allowing for adjustment before the plan is adopted. Future research should consider the extent to which high quality data is gathered at the front end and is consistent with realities present at the time of actual implementation.

Funding of capital projects (specifically bridges and trails) was considered problematic during the Short-Term Implementation Period primary due to the high expense associated with their construction. While speculative, these large projects may act as a potential barrier to full implementation of the Plan if resources are not forthcoming, leaving critical gaps in the Bicycle Facilities Network. The Seattle case demonstrates that these projects should be considered separately in order to avoid funding issues where the construction of a larger project presents an opportunity costs for developing on street bicycle facilities. The identification of this factor points to the appropriateness of considering individual facility types and projects as the units of analyses appropriate for case study research into factors influencing implementation. The construction of large projects is likely to face a different set of barriers compared to on-street bicycle lanes due to their size and complexity, and should receive a separate treatment to ensure that important differences are not glossed over.

Responses regarding the importance of a single implementing largely contradicted the requirement of Hogwood and Gunn that successful implementation depends on the ability of an agency to operate in an environment with minimal decision points outside of its control. Study findings regarding Ison and Rye's (2003) requirement for a flexible public process found a similar effect in the opposite direction, showing that the need for public comment could serve to hamper project provision in the short-term. Common to both of these was that the need to coordinate with other stakeholders and the public initially slowed projects down, sometimes for extended periods of time, but the end results was thought to be better implemented projects that generated public trust in city processes, reducing opposition and creating buy-in as a result. Hogwood and Gunn's largely top-down approach for a single implementing agency does not take into account the long-term benefits associated with coordination with multiple interests that may allow for piggybacking on other projects, the avoidance of inefficiencies between departments or groups, and increased data gathering that may impact the quality of projects implemented. Interview responses suggested that streamlining data gathering and the public process through survey tools, databases, and requirements for coordinated stakeholder meetings may mitigate any detrimental effects on project execution.

Assessing the effects of political stability on implementation outcomes proves difficult in the Seattle case given the consistent political support for the Plan by elected officials. Participants readily identified that the political support was important to implementation outcomes, but stability could not be assessed as participants noted that there were only minor changes at the city level and they were not able to assess the importance of the effect on overall Plan efforts. While it is likely that political stability played a part in Seattle's successful execution of recommended projects in the SBMP, future research efforts are needed to determine the impact of a change in executive branch leadership or City Council vote composition on BMP facilities implementation. A comparison of cities that experienced significant leadership changes to those that have experienced relative stability may provide evidence for the effect of political stability on facilities provision as envisioned in a BMP.

The role of data in Plan implementation outcomes was ambiguous, as Ison and Rye's inclusion of the requirement for monitoring outcomes provided little guidance on what aspects of data to consider. The purpose of the interview question was to determine whether the performance-based measures currently recommended for assessing Plan implementation progress, or some other data, allowed for feedback that assisted in developing bicycle facilities. The performance measure in the SBMP monitors progress through a metric of bicycle facilities produced, with studies of individual facilities outcomes being produced ad hoc, largely in response to public opposition. While it is important to monitor overall progress in creating new facilities and meeting Plan goals, future case studies could benefit from considering data collection and monitoring more specific to bicycle planning that will allow for feedback and course correction. Aspects of data found to be important by implementing staff that should be specifically considered include creating a scheme to prioritize a list of recommended projects, and the impact of metrics on project decisions. It may also be appropriate to consider an agencies data needs and corresponding systems capacity in its analysis of whether adequate resources exist. As respondents identified in the Seattle case, the need for timely data and routine analysis that could just as easily be handled by databases and survey software can be a drain on staff and expertise better spent working on other aspects of project implementation. The consideration of technology in the resources category could be an important addition the existing policy implementation framework.

Several limitations to the study conclusions must be taken into account that are directly related to the research design employed: a single case study analysis of data from qualitative interviews of key participants. Foremost is that the study results are necessarily limited by the single case research design, which is analogous to a single experiment. The single case study design was necessary due to the scope of the research project and resources available, and did not meet any of Yin's (2003) criteria to justify the appropriateness for the method, specifically that the case be critical, unique, representative, revelatory or longitudinal. The possibility remains that contextual events specific to the City of Seattle either before or during the study period are responsible for implementation outcomes, or that an interplay of several factors were necessary to produce the influence identified by study participants. Absent multiple case studies that replicate the same study methodology for another city, it is impossible to determine the extent to which the study results are determined by such an effect.

The choice of an implementation framework may also have driven the results in important ways, as the categories in the framework influenced the construction of the interview instrument and ultimately the contextual factors that participants focused on. This does not invalidate the responses of interview participants, who were free to identify factors and contradict or support the assumptions of the framework. The issue remains, however, that factors specific to transportation planning or bicycling that were not accounted for by the framework remain unidentified, and that a different implementation framework and interview instrument may achieve different results. The final interview question was intended to mitigate this possibility by allowing for the respondent to consider any other factors thought to be important for implementation outcomes. The author believes that overall the framework employed was successful in identifying the major influences on SBMP implementation, with many of the responses for the final non-structured interview question being readily categorized into the existing implementation framework.

The choice of key participants in SBMP implementation was appropriate for the research questions and study design, as responses needed to reflect the expertise and insight of those most closely involved in the process. Yet this reliance on key participants with a stake in the Plan's ultimate success creates the possibility that responses are biased toward participants' downplaying aspects of the Plan that do not meet expectations, or reflect professional assumptions that may not be borne out by evidence. The need to keep interview participants identity's confidential may again mitigate this effect to some extent by allowing for an honest assessment of the obstacles and shortcoming affecting Plan implementation without fear of contradicting the attitudes of their peer groups. The corroboration of factors identified serves to strengthen the study results by adding weight to the inherently subjective and anecdotal nature of interview responses. Future case studies that incorporate individual projects as the unit of analysis may be better suited for identifying specific groups outside implementing staff that can corroborate or refute accounts based on their unique perspectives.

Finally, the unit of analysis chosen, projects recommended in the SBMP as a part of the Bicycle Facilities Network, may obscure important differences in implementation between facilities types. Responses from study participants may be seen as supportive of this view in that some bicycle facilities, such as sharrows, were not as constrained by factors such as space, parking issues, conflicts with existing uses, or the need to go through an extended public process. Capital projects such as bridges or multi-user trails that are more complicated and expensive may be more problematic to implement in terms of expertise, funding, opposition, and political will.

The identification of a wide range of factors influencing implementation of the SBMP provides a starting point for analyzing other cases to provide support for the findings of this study. Future research should consider a multiple case study design stratified by project type across a range of cities of similar size and characteristics to allow for a more robust theory on the influences on bicycle facilities implementation. A more detailed look at individual projects can identify specific mechanisms of support and opposition, as well as barriers that affect various facilities types, bringing to light important differences that may further assist localities in identifying opportunities to provide a more supportive environment for Plan and project execution.

In regard to influences on bicycle use, researchers should focus on study designs that can provide additional support for the theory that the creation of bicycle facilities will have a positive effect on ridership. Longitudinal studies of specific facilities that can control for demographic changes are particularly well suited for this endeavor given that they can suggest the direction of relationship and not just correlation. Such research will assist advocates in making the case for increasing cycling should the data support the creation of facilities to increase cycling, or allow for a better allocation of scarce resources should findings show that self-selection is the driver of bicycle ridership. The incorporation of ecological models that take into account attitudinal and socio-demographic factors will be crucial in providing evidence for the relationship, with greater consistency in metrics and definitions across studies adding to the strength of the findings.

Finally, a clear role is established for researchers in providing evidence that can aid municipalities in managing the risk associated with developing a BMP. Generating more successful BMPs through a front-end assessment of the strengths and weaknesses of a cities' ability to affect a positive implementation outcome will provide positive modeling to other localities hesitant to commit to BMP development. The results suggest that positive steps can be taken before adoption of a BMP to increase the chances of successful implementation. Advocacy groups are well positioned to mobilize supporters and lobby local officials to establish a supportive policy framework and dedicated funding source well in advance of the policy implementation period. Only through a combination of political will and the development of effective strategies founded on verifiable theories of bicycle use and implementation can increases in bicycling be expected in the coming years, supplanting short trips by automobile to make a small, but necessary impact on climate change.

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Appendices

Appendix A. Background: Goals and objectives of the Seattle Bicycle Master Plan

The Seattle Bicycle Master Plan (SBMP) consists of two main goals that encompass all activities of the City of Seattle related to bicycling, providing a basis for the Plan's recommendations. The first of these broad goals is to triple the share of bicycling in Seattle for all trip purposes during the period of 2007-2017. The second goal is to increase the overall safety of bicyclists in the City, with the aim of reducing the rate of bicycle crashes by one third during the same period (2007-2017).

In service of the goals of increasing bicycle trips and safety in Seattle, specific action items are organized under four broad objectives identified by the city that establish the framework for the rest of the SBMP. These include:

- **Objective #1: Develop and maintain a safe, connected, and attractive network of bicycle facilities throughout the city.**
- **Objective #2: Provide supporting facilities to make bicycle transportation more convenient.**
- **Objective #3: Identify partners to provide bicycle education, enforcement, and encouragement programs.**
- **Objective #4- Secure funding and implement bicycle improvements.**

It is with Objectives #1 and Objectives #4 that this paper is most concerned. The effort to create a network of connected bicycle facilities in Seattle is central to understanding the context of a local environmental intervention to increase cycling and is therefore most relevant to the scope of a case study on implementation. Second, Objectives #2 and #3, while important aspects of the Plan, are not directly related to the scope of this paper and will therefore not be considered.

A diverse array of recommended facilities is provided for in the Seattle Bicycle Master Plan's Bicycle Facility Network (BFN), with individual treatments depending on both environmental level factors (land use characteristics, available right of way space, traffic volume, etc.) and individual level factors (rider preferences and level of experience). The Plan cites the lack of facilities on arterial streets as preventing more people from considering bicycling as a viable transportation option, and suggests that improvements on these routes, which tend to be characterized by gentle grades, will make conditions more comfortable and conducive to bicycle travel (Action 1.1). Following this, nearly one-third (32%, see Table 5 below) of the total recommended bicycle facilities are directed toward the creation of on-street bicycle and climbing lanes on core arterial streets that offer the most direct routes to workplaces, shopping areas, schools and transit hubs. Additional on-road facilities also contribute to the BFN, including shared lane markings, paved shoulders, and shared bus-bike lanes, bringing the total designated on-road bicycle facilities recommended to 295 miles of arterial roadway, representing roughly two-thirds (65%) or all recommended facility miles.

Separate rights-of way from motorized traffic (i.e., off-road bicycle facilities and recreational multi-use trails) represent another infrastructure component of the Network objective (Action 1.2), with completion of The Urban Trails System, adopted in the 2005 Seattle Department of Transportation (SDOT) Transportation Strategic Plan, being a key action item. Several gaps in the existing Urban Trails System are identified as requiring completion if a continuous and connected BFN is to be realized.

Table 5. Mile of Recommended Facilities

Miles of Recommended Facilities			
Facility Type	Existing	Short-term 2007-2009 (includes existing)	Total 2007-2016 (includes existing)
Bicycle lanes/climbing lanes	25.5	63.7	143.3
Shared lane pavement markings	0.3	54.2	110.5
Bicycle boulevards	0	7.6	18.1
Other on-road bicycle facilities	2.2	4.2	46.1
Signed local street connections	0	28.6	75.9
Multi-use trails	39.4	41.9	58.2
Other off-road bicycle facilities	0.2	1	2.6
TOTAL NETWORK	67.6 miles	201.2 miles	454.7 miles

Source: Seattle Bicycle Master Plan pg. 16 (SDOT, 2007)

Additional action items that serve to supplement or facilitate implementation of bicycle facilities involve making operation improvements to complete connections (Action 1.6) in the BFN and improving complex corridors and focus areas (areas with right of way constraints, potential conflicts between multiple user groups, and multiple alternatives for providing bicycle facilities, etc.) (Action 1.5). The need to improve complex corridors is purposefully vague in the Plan, which may result from the fact that a specific treatment needed for a given site will depend on a variety of factors. The Plan cites the need to consider public input, trade-offs among other user groups, additional design development, cost, and future opportunities as important considerations to take into account in these highly contentious areas.

Appendix B. Seattle Bicycle Master Plan Thesis Interview Questions

1.) In what ways was the policy framework surrounding the Plan supportive/constricting of projects recommended as a part of the Bicycle Facilities Network?

2.) How did the timing of the program influence implementation? (By timing, I am referring to the larger contextual events from 2007-2009, not intentionally willed by policy actors, which impacted plan implementation. For example, changes in economic climate, demand for bicycle infrastructure due to increasing environmental consciousness etc.?)

3.) Has political stability/change at the municipal/county/state level been important in contributing to implementation success or failure? In what ways?

4.) What role did resources (staff, time, funding, expertise etc.) play in facilitating or hampering the implementation of bicycle infrastructure projects?

5.) Have the performance-based measures currently recommended for assessing plan implementation progress allowed for feedback that assisted in developing bicycle facilities? If not, has other data accomplished this? Or, what data would have been useful?

6.) What organizations/division/groups are required to be consulted before implementation of a project can occur?

- Overall, does the necessity of dealing with multiple agencies hamper the process or does a multi-agency approach lead to more successful outcomes?

7.) What is the capacity of any one actor involved in the process (the agency, Mayor's office, City Council, etc.) to demand compliance if substantial opposition exists to a recommended project?

- If there is the capacity, has it been used?
- What have been the consequences in cases where the opposition has been overridden?

8.) In regard to the Bicycle Facilities Network, has there been agreement among groups involved in how objectives of the Plan are to be achieved?

- If yes, what allowed these conditions to persist?
- If no, did it hinder facilities implementation, or was it an appropriate response to changing conditions?

9.) Do one or more agreed upon policy champion(s) exist?

- What is his or her role in influencing the BFN implementation process?
- If no champion exists, can the respondent identify times when one would have been useful?

10.) How have organizations involved with plan implementation ensured a flexible attitude to public reaction?

- If they have, has this hindered the plan in cases where there was strong opposition or obstructionists? (This question is more about the institutionalized processes that have been incorporated into the implementation process for reacting to constituents, not about how constituents feel)

11.) What role did public trust (a transparent and inclusive process) and the support of constituency groups play in Plan implementation? Was it significant enough to move individual projects along more effectively than if it wasn't there?

12.) During the course of your involvement with the Plan, what other factors not covered earlier do you believe were important in determining both successful and unsuccessful implementation outcomes?

Appendix C. Predictive Models in the Literature: Attitudinal, Socio-demographic, Environmental and Policy Level Factors Associated with Bicycle Use

positive and significant	+			< 0.05 signfcance
negative and signficant	-			0.05<p< 0.10 significance
not applicable or not signficant	n/a		ns	not significant

Sex

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Gender	+	0.588	0.002	probability of person n choosing bicycle for travelling between origin and destination
Moudon, et al (2005)	Airline Model	gender (male)	+	3.124 (odds ratio)	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	gender (male)	+	3.196 (odds ratio)	0.01	# of times a week bicycling for any reason
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of employees who are male	+	2.8284	(t-stat) 12.59	proportion of individuals in ward x cycling to work
Plaut (2005)	Cyclists to work who own their home	Dummy for female	-	-1.012	23.57 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy for female	-	-1.768	38.05 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Troped, et al (2001)	Self reported env. Variable model	Sex (male)	+	(Odds Ratio) 1.91	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	sex (male)	+	(Odds Ratio) 1.99	pg 197 for 95% CI	Use of a community rail trail

Race						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Baltes, M. (1996)	All MSAs	% of population that is Asian	+	0.098	0.05	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	North Central	% of population that is Asian	+	0.489	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	South	% of population that is Asian	+	0.288	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of population that is Black	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	North Central	% of population that is non-White	-	-0.173	0.05	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of population that is of Hispanic origin	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Northeast	% of population between ages 16 and 29	+	0.757	0.01	% of work trips in 1990 by bicycle in each MSA
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	African American		0.854	0.071	probability of person n choosing mode I for travelling between origin and destination
Moudon, et al (2005)	Airline Model	race (white)	+	4.938 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	race (white)	+	3.626 (odds ratio)	0.1	# of times a week bicycling for any reason
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of population non-white	-	-1.1708	(t-stat) - 11.93	proportion of individuals in ward x cycling to work
Plaut (2005)	Cyclists to work who own their home	Dummy if worker is Non-White	-	-0.703	4.98 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if worker is Non-White	-	-0.576	4.91 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Proportion of non-native residents	-	-0.625	(t-value) - 1.91	Share of bicycle use in Dutch cities
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	white	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	white	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	White	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)

Age						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Moudon, et al (2005)	Airline Model	Age	(curvilinear, see page 254)		?	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	Age	(curvilinear, see page 254)		?	# of times a week bicycling for any reason
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of employees in the bands "16-24", "25-34", "35-49', "50-59", "60-64" and "65-74"	n/a	/	ns	proportion of individuals in ward x cycling to work
Plaut (2005)	Cyclists to work who own their home	Age	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	age	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Proportion of young (15-19) years	+	4.19	(t-value) - 2.10	Share of bicycle use in Dutch cities
Troped, et al (2001)	GIS environmental variable model	age	-	(Odds Ratio) 0.71	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	Self reported env. Variable model	Age (10 year increase)	-	(Odds Ratio) 0.67	pg 197 for 95% CI	Use of a community rail trail
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Age	-	-0.029	0.01	Owns a bike
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	age	-	-0.02	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	age	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Age	-	-0.029	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Age	-	-0.019	0.05	Biked in previous 7 days (vs. did not bike)

Marital Status						
Moudon, et al (2005)	Airline Model	martial status (vs. never married)	+	2.519 (odds ratio)	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	martial status (vs. never married)	n/a		not significan t	# of times a week bicycling for any reason

Education Level

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Education level	n/a	/	ns	Owns a bike (vs. not own a bike)
Troped, et al (2001)	Self reported env. Variable model	Educational level	n/a	/	ns	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	educational level	+	(Odds Ratio) 2.19	pg 197 for 95% CI	Use of a community rail trail
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	educational level	+	0.231	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	educational level	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Educational Level	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Educational level	+	0.198	0.05	Biked in previous 7 days (vs. did not bike)
Plaut (2005)	Cyclists to work who own their home	College graduate	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy for college graduate	+	0.955	10.98 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if have postgraduate schooling beyond BA	+	1.108	17.54 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if have postgraduate schooling beyond BA	+	1.4	15.28 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Baltes, M. (1996)	All MSAs	% of pop. age 18-24 enrolled in school	+	0.415	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	West	% of pop. age 18-24 enrolled in school	+	0.807	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	North Central	% of pop. age 18-24 enrolled in school	+	0.386	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	South	% of pop. Age 18-24 enrolled in school	+	0.676	0.01	% of work trips in 1990 by bicycle in each MSA
Nelson and Allen (1997)	Final model	% college students residing in city	+	0.071	less than .10	% of commuters using bicycles in their journey-to-work in city
Baltes, M. (1996)	Not significant in any model	% of population in high school	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA

Income Level

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Baltes, M. (1996)	Not significant in any model	Median family income, 1990	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	West	% of families below the poverty level	-	/	0.01	% of work trips in 1990 by bicycle in each MSA
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	index of deprivation income score-English	-	-2.22	(t-stat) - 16.49	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	index of deprivation income score-Welsh	-	-0.0159	(t-stat) - 5.39	proportion of individuals in ward x cycling to work
Plaut (2005)	Cyclists to work who own their home	Log of salary of worker	-	-0.291	21.00 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Log of salary of worker	-	-0.291	10.64 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Level of disposable income	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Income	+	0.016	0.01	Owns a bike
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	income	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	income	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Income	+	0.015	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Income	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)

Employment & Workforce

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Moudon, et al (2005)	Airline Model	weekly work hours	-	0.643 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	weekly work hours (less than 40, 40, more than 40 hours)	-	0.642 (odds ratio)	0.01	# of times a week bicycling for any reason
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	proportion in higher managerial & professional in larger organisation	-	-4.7724	(t-stat) -10.14	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	proportion in higher professional	+	5.7281	(t-stat) 24.44	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	proportion in intermediate occupations	-	-2.4663	(t-stat) -8.75	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	proportion in lower managerial and professional	-	-2.5041	(t-stat) -11.32	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of all employees aged 16-74 with higher level qualifications	n/a	/	ns	proportion of individuals in ward x cycling to work
Baltes, M. (1996)	All MSAs	% of pop that is unemployed	+	0.431	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	West	% of pop that is unemployed	+	0.566	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	South	% of pop that is unemployed	+	0.508	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	All MSAs	% of pop. Employed in agriculture	+	0.103	0.05	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	West	% of pop. Employed in agriculture	+	0.236	0.05	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of workers in central city	n/a		ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	All MSAs	% of workers living in central city	+	0.797	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of workers working in place of residence	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of workers working outside place of residence	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Northeast	% of population employed in agriculture	+	0.232	0.01	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Northeast	% of population employed in manufacturing	-	-0.224	0.05	% of work trips in 1990 by bicycle in each MSA
Baltes, M. (1996)	Not significant in any model	% of population in the armed forces	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA

Household Characteristics

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Baltes, M. (1996)	All MSAs	% of housing units occupied by the owner	-	-0.274	0.01	% of work trips in 1990 by bicycle in each MSA
Plaut (2005)	Cyclists to work who own their home	Dummy if commercial properties nearby	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if commercial properties nearby	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if green area near unit	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if green area near unit	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if unit has garage	-	-0.559	6.49 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if unit has garage	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if unit has parking space included	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if unit has parking space included	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Log of home owners insurance premium	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Log of home owners insurance premium	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Log of property tax	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.

Household Characteristics-continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Plaut (2005)	Cyclists to work who rent their home	Log of property tax	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Log of rental payment	+	0.312	1.97 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Log of rental payment	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Log of square foot floor space of unit	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Log of square foot floor space of unit	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Log of value of unit owned	-	-0.128	Wald chi-square 2.103	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	# of bathrooms in unit	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	# of person in household	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	# of persons in household	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.

Household Characteristics-continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Plaut (2005)	Cyclists to work who own their home	Year unit built	-	-0.017	17.83 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Year unit built	-	-0.017	12.1 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Number of bathrooms in the unit	-	-0.59	2.38 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Household size	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	Household size	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	household size	-	-0.262	0.05	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	household size	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)

Bicycle owership

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Moudon, et al (2005)	Airline Model	owns a bicycle	+	179.648 (odds ratio)	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	owns a bicycle (vs. not owning a bicycle)	+	163.204 (odds ratio)	0.01	# of times a week bicycling for any reason
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Number of bicycles in household	+	0.345	0	probability of person n choosing mode I for travelling between origin and destination
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	bikers poor	-	-0.264	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Bikers poor	-	-0.201	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	bikers spend	-	-0.208	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Bikers spend	-	-0.241	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	car ownership	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	good health	+	0.361	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	good health	+	0.351	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Like biking	+	1.166	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Like Biking	+	1.17	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	like transit	-	-0.216	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Like Transit	-	-0.231	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	like walking	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Like walking	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	need car	-	-0.329	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Need Car	-	-0.306	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	pro-exercise	-	-0.438	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	pro-exercise	-	-0.447	0.01	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	race (white)	+	0.507	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	race (white)	+	0.513	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	transit access	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	transit access	n/a	/	ns	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Household size	n/a	/	ns	Owns a bike (vs. not own a bike)

Car Ownership

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	car ownership	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	car ownership	-	-1.602	0.1	Biked frequently (vs. biked moderately)
Plaut (2005)	Cyclists to work who own their home	Dummy if own no cars	+	1.048	10.56 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if own no cars	+	3.061	178.6 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if own three or more cars	-	-0.632	4.40 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if own three or more cars	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if own two cars	-	-0.629	7.41 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if own two cars	n/a	/	ns	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Number of cars per capita	-	-0.26	(t-value) - 1.95	Share of bicycle use in Dutch cities
Moudon, et al (2005)	Airline Model	exactly 1 car per adult (vs. more than 1 car)	-	0.407 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	exactly 1 car per adult (vs. more than 1 car)	-	0.438 (odds ratio)	0.1	# of times a week bicycling for any reason
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Number of cars per employee	-	-0.9758	(t-stat) - 22.90	proportion of individuals in ward x cycling to work

Car Ownership-continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	need car	n/a	/	ns	Biked vs. did not bike
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	need car	-	-0.389	0.05	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Need car	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Dill & Carr (2003)	Model 1 (D.C. excluded)	Vehicles per household	n/a	-0.698	0.208	% commuting by bicycle
Dill & Carr (2003)	Model 3	Vehicles per household	n/a	/	ns	% commuting by bicycle
Dill & Carr (2003)	Model 4 (D.C and NYC excluded)	Vehicles per household	-	-1.52	0.02	% commuting by bicycle
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Number of vehicles in household	-	-0.629	0	probability of person n choosing mode I for travelling between origin and destination
Baltes, M. (1996)	All MSAs	% of households with no vehicle available	-	-0.259	0.01	% of work trips in 1990 by bicycle in each MSA

Interest in Walking

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	like walking	-	-0.602	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	like walking	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Like walking	-	-0.626	0.01	Biked in previous 7 days (vs. did not bike)

Transit Preference

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	like transit	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	like transit	-	-0.237	0.05	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Like Transit	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Moudon, et al (2005)	Airline Model	uses transit	+	2.965 (odds ratio)	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	uses transit	+	2.702 (odds ratio)	0.1	# of times a week bicycling for any reason

Attitudes toward Cycling and Cyclists						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	like biking	+	1.252	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	Like biking	+	1.045	0.01	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Like Biking	+	1.26	0.01	Biked in previous 7 days (vs. did not bike)
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	lack of interest	-	(Odds Ratio) 0.45	0.003	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	bikers poor	-	-0.373	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	bikers poor	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Bikers poor	-	-0.311	0.05	Biked in previous 7 days (vs. did not bike)
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Probability of acceptability of cycling	n/a	/	ns	proportion of individuals in ward x cycling to work
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Internal self-efficacy		(Odds Ratio) 0.61	0.078	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	bikers spend	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	bikers spend	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Bikers spend	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	lack of time	-	(Odds Ratio) 0.26	0.001	Cycling for Transport at least once a week to work in the last 6 months prior to start of study

Individual's health/attitudes

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Body image	-	(Odds Ratio) 0.63	0.08	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	good health	n/a	/	ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	good health	-	-0.333	0.05	Biked frequently (vs. biked moderately)
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Lack of skills and health	n/a	/	ns	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Moudon, et al (2005)	Airline Model	attitude factor on knowledge of phys benefits	-	0.502 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	attitude factor on knowledge of phys benefits	-	0.548 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Airline Model	exercise at home	+	2.134 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	exercise at home	+	3.626 (odds ratio)	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	no (vs. sufficient) vigourous phys activity	-	0.231 (odds ratio)	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Airline Model	no (vs. sufficient) vigourous phy sactivity	-	0.225 (odds ratio)	0.01	# of times a week bicycling for any reason
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	pro exercise	+	0.244	0.05	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	pro exercise	n/a	/	ns	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Pro-exercise	+	0.247	0.05	Biked in previous 7 days (vs. did not bike)
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Physical well-being	n/a	(Odds Ratio) 1.05	0.845	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Moudon, et al (2005)	Airline Model	moderate (vs. sufficient) phys active		0.527(odds ratio)	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Airline Model	moderate (vs. sufficient) physical activity	n/a	/	ns	# of times a week bicycling for any reason
Troped, et al (2001)	Self reported env. Variable model	Temporary illness/injury	+	(Odds Ratio) 1.66	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	Self reported env. Variable model	Long term illness/injury	-	(Odds Ratio) 0.43	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	Long term illness/injury	n/a	/	ns	Use of a community rail trail

External Support						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	External self-efficacy	+	(Odds Ratio) 0.32	0.001	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Social support: accompany	+	(Odds Ratio) 2.26	0.012	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Social support: encourage	n/a	(Odds Ratio) 0.66	0.183	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Modeling	+	(Odds Ratio) 1.83	0.043	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Social norm	n/a	(Odds Ratio) 1.30	0.377	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Social influence	n/a	(Odds Ratio) 0.98	0.94	Cycling for Transport at least once a week to work in the last 6 months prior to start of study

Bicycle lanes and infrastructure						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Bicycle lanes (neighborhood)	n/a	(Odds Ratio) 0.70	0.13	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Bicycle lanes (road to work)	n/a	(Odds Ratio) 1.48	0.12	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Bicycle network	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Bicycle parks	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Brownson, et al (2001)	Associations between perceived environmental variables and physical activity bheavior in the US 1999-2000	Bicycle paths	/	(odds ratio) 1.19 (0.85, 1.67)	0.05	Physical activity behavior (defined as meeting public health recommendations for moderate or vigorous activity)
Nelson and Allen (1997)	Final model	bicycle pathways per 100,000 residents in 1992	+	0.754+0.069x	less than .10	% of commuters using bicycles in their journey-to-work in city
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Battle Creek	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Cedar Lake-Kenilworth	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Park-Portland	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Phalen	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Shepard	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Summit	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000

Bicycle lanes and infrastructure-continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Krizek, Barnes and Thompson (2009)	Table 3- Bicycle Commute Share in Buffer Analysis Areas, 1990-2000	Change in bicycle commuters in facility buffer Univ. of Minnesota	n/a	longitudinal study	0 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in Minneapolis TAZs in Buffer 1	+	longitudinal study	1 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in Minneapolis TAZs in Buffer 2	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in Minneapolis, 1990-2000	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in St Paul, 1990-2000	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in St. Paul TAZs in Buffer 1	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in St. Paul TAZs in Buffer 2	/	longitudinal study	0 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in zones outside buffers Minneapolis	+	longitudinal study	1 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 2- Minneapolis and St. Paul Bicycle Commute Share, 1990-2000	Change in bicycle commuters in zones outside buffers St. Paul	+	longitudinal study	1 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 5- Major Destination Commute Share	Change in bicycle commuters trips to major employment/activity centers Downtown Minneapolis	+	longitudinal study	1 std dev	change in bicycle mode share 1990-2000

Bicycle lanes and infrastructure-continued						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Krizek, Barnes and Thompson (2009)	Table 5- Major Destination Commute Share	Change in bicycle commuters trips to major employment/activity centers St. Paul	-	longitudinal study	std dev (-1)	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 5- Major Destination Commute Share	Change in bicycle commuters trips to major employment/activity centers Univ. of Minnesota	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 4- River Crossing Bicycle Commute Share, 1990-2000	Trips crossing south flowing portion of Mississippi River	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 4- River Crossing Bicycle Commute Share, 1990-2002	Trips originating and terminating east of the Mississippi River	+	longitudinal study	2 std dev	change in bicycle mode share 1990-2000
Krizek, Barnes and Thompson (2009)	Table 4- River Crossing Bicycle Commute Share, 1990-2001	Trips originating and terminating west of the Mississippi River	+	longitudinal study	1 std dev	change in bicycle mode share 1990-2000
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of off-road route	+	12.5162	(t-stat) 18.72	proportion of individuals in ward x cycling to work
Troped, et al (2001)	Self reported env. Variable model	Distance to bikeway (.25 mile increase)	-	(Odds Ratio) 0.65	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	distance to bikeway via road network (.25 mile increase)	-	(Odds Ratio) 0.58	pg 197 for 95% CI	Use of a community rail trail
Moudon, et al (2005)	Airline Model	distance to closest trail	-	0.801	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	distance to closest trail	-	0.728	0.01	# of times a week bicycling for any reason

Bicycle lanes and infrastructure-continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Miles of bike lanes per square mile (objectively measured)	+	0.044	0.1	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Miles of bike lanes per square mile (objectively measured)	+	0.046	0.1	Biked in previous 7 days (vs. did not bike)
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of road that has a bicycle or bus lane	n/a	/	ns	proportion of individuals in ward x cycling to work
Dill & Carr (2003)	Model 1 (D.C. excluded)	Type 2 lanes per square mile	+	0.892	0.008	% commuting by bicycle
Dill & Carr (2003)	Model 2 (D.C. excluded)	Type 2 lanes per square mile	+	0.888	0.006	% commuting by bicycle
Dill & Carr (2003)	Model 3	Type 2 lanes per square mile	+	0.861	0.007	% commuting by bicycle
Dill & Carr (2003)	Model 4 (D.C and NYC excluded)	Type 2 lanes per square mile	+	0.998	0.002	% commuting by bicycle
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion of cycle route that is adjacent to the road	n/a	/	ns	proportion of individuals in ward x cycling to work
Moudon, et al (2005)	Airline Model	subjectively measured presence of cycling trails and lanes	+	1.704	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	subjectively measured presence of cycling trails and lanes	+	1.729	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Airline Model	% of streets lined with bicycle lanes	n/a	/	ns	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	% of streets lined with bicycle lanes	n/a	/	ns	# of times a week bicycling for any reason

Weather/environment

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Mean temperature in degrees centigrade	+	0.0782	(t-stat) 7.87	proportion of individuals in ward x cycling to work
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Average temperature	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Potential wind speed	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Basic wind speed for sructural design for the district	n/a	/	ns	proportion of individuals in ward x cycling to work
Nelson and Allen (1997)	Final model	number of days during the year rain exceeds 1/10th an inch	-	-0.008	less than .10	% of commuters using bicycles in their journey-to-work in city
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Total annual rainfall in millimetres	-	-0.0006	(t-stat) -17.40	proportion of individuals in ward x cycling to work
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	rainfall (mm)	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Dill & Carr (2003)	Model 4	Days of rain	n/a	/	ns	% commuting by bicycle
Dill & Carr (2003)	Model 4 (D.C and NYC excluded)	Days of rain	-	-0.008	0.02	% commuting by bicycle
Dill & Carr (2003)	Model 1 (D.C. excluded)	Days on rain	n/a	-0.005	0.206	% commuting by bicycle
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	dark (before sunrise or after sunset)	-	-0.721	0.022	probability of person n choosing mode I for travelling between origin and destination
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Total annual hours of sunshine for the year May 2000 to April 2001 for the weather region	n/a	/	ns	proportion of individuals in ward x cycling to work

Busy Streets/Presence of Automobiles

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Troped, et al (2001)	Self reported env. Variable model	Busy street barrier (no)	+	(Odds Ratio) 2.01	pg 197 for 95% CI	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	Busy street barrier (no)	n/a	/	ns	Use of a community rail trail
Moudon, et al (2005)	Airline Model	problems- auto faciliites in neighborhoods	(curvilinear, see page 254)	/	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	problems- auto faciliites in neighborhoods	(curvilinear, see page 254)	/	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Airline Model	problems- auto in neighborhood	(curvilinear, see page 254)	/	0.05	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	problems- auto in neighborhood	(curvilinear, see page 254)	/	0.05	# of times a week bicycling for any reason
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Motorised traffic noise	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Traffic danger (neighborhood)	n/a	(Odds Ratio) 1.02	0.93	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Traffic danger (road to work)	n/a	(Odds Ratio) 1.30	0.26	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Traffic safety (neighborhood)	n/a	(Odds Ratio) 1.27	0.36	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Transport demand intensity (employees dvided by road length)	-	-0.0373	(t-stat) -17.74	proportion of individuals in ward x cycling to work

City Level/Population Size						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Human activity indicator	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Population (thousands)	-	-0.000829	(t-value) -3.90	Share of bicycle use in Dutch cities
Baltes, M. (1996)	Not significant in any model	Population density (persons per square mile)	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Population density (population divided by area)	+	0.0001	(t-stat) 9.11	proportion of individuals in ward x cycling to work
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Density of Human Activity (addresses per square kilometre)	-	-0.00669	(t-value) -3.00	Share of bicycle use in Dutch cities
Baltes, M. (1996)	Not significant in any model	Inverse of MSA population	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Safety level (number of victims of serious accidents per 100 million bicycle-kilometres)	+	0.0109	(t-value) 1.83	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	School for Higher Vocational Training	+	0.0742	(t-value) 2.32	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Presence of a university	n/a	/	multicollinearity or ns	Share of bicycle use in Dutch cities

Attitudes of restraint/environmental attitudes

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Ecological-economic awareness	+	(Odds Ratio) 1.71	0.029	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	limit driving	n/a	/	ns	owns a bike (vs. does not own a bike)
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	limit driving	+	0.312	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	limit driving	+	0.606	0.01	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Limit driving	+	0.313	0.01	Biked in previous 7 days (vs. did not bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	limit driving	n/a	/	ns	owns a bike (vs. does not own a bike)
Xin, Handy and Buehler (2008)	All models	Environmental concern	n/a	/	ns	Bike ownership, biking in previous 7 days, and biked frequently

Slope

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion 1km squares with slope 3% or steeper	-	-1.392	(t-stat) - 50.93	proportion of individuals in ward x cycling to work
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	relief (hills and slopes)	-	-0.745	(t-value) - 10.76	Share of bicycle use in Dutch cities
Troped, et al (2001)	Self reported env. Variable model	Steep hill	n/a	/	ns	Use of a community rail trail
Troped, et al (2001)	GIS environmental variable model	steep hill barrier (no)	+	(Odds Ratio) 1.9	pg 197 for 95% CI	Use of a community rail trail
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Slope (rise/run)	n/a	-7.796	0.187	probability of person n choosing mode I for travelling between origin and destination

Geographical factors

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Plaut (2005)	Cyclists to work who own their home	Dummy for West Coast	+	1.216	34.15 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy for West Coast	+	0.517	5.01 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if live in central city of the MSA	+	0.131	0.259 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if live in central city of the MSA	+	0.178	0.301 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if live in rural area of MSA	-	-1.03	5.8 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if live in rural area of MSA	-	-0.818	1.59 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who own their home	Dummy if live in secondary urban area in MSA	-	-0.517	3.56 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Plaut (2005)	Cyclists to work who rent their home	Dummy if live in secondary urban area in MSA	-	-0.802	4.68 Wald chi-square	The logit or log of the probability of using biccyle commutting divided by the probability of using car commuting.
Baltes, M. (1996)	All MSAs	% of population living in central city	-	-0.683	0.05	% of work trips in 1990 by bicycle in each MSA

Trip specific variables

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	directness of trip	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	delays	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion in the distance band "2km to less than 5km"	-	-0.6916	(t-stat) -8.53	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion in the distance band "5km to less than 20km"	-	-1.6556	(t-stat) -20.49	proportion of individuals in ward x cycling to work
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Trip distance (miles)	-	-0.291	0.001	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Shop purpose		0.443	0.256	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Recreation/entertainment purpose	+	0.602	0.001	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Weekend trip		0.226	0.301	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Social purpose	+	0.861	0.002	probability of person n choosing mode I for travelling between origin and destination
Baltes, M. (1996)	Not significant in any model	% of travel time to work <10 minutes	n/a		ns	% of work trips in 1990 by bicycle in each MSA
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	One riding behind the other	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Priority	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities

Trip specific variables- continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	slowdowns	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Turns off	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Destinations food shops	+	(Odds Ratio) 0.60	0.058	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Destinations other shops		(Odds Ratio) 0.75	0.278	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Destinations work		(Odds Ratio) 0.77	0.293	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	safe destinations	+	0.617	0.01	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	safe destinations	+	0.338	0.01	Biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	safe destinations	n/a		ns	Owns a bike (vs. does not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	safe destinations	+	0.601	0.01	Biked in previous 7 days (vs. did not bike)
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	safe destinations	n/a		ns	Owns a bike (vs. does not own a bike)
Moudon, et al (2005)	Airline Model	presence of destinations (grocery stores and schools)	-	0.702	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	presence of destinations (grocery stores and schools)	-	0.718	0.1	# of times a week bicycling for any reason
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Facilities for cyclists at the workplace	+	(Odds Ratio) 0.28	0.001	Cycling for Transport at least once a week to work in the last 6 months prior to start of study

Neighborhoods- Origins and Destinations						
Study	**Model name**	**Independent Variable**	**Association**	**Coefficient**	**Significance**	**Dependent variable**
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Land-use diversity factor, origin	n/a	0.156	0.112	probability of person n choosing mode I for travelling between origin and destination
Moudon, et al (2005)	Airline Model	Smaller total area of convenience store parcels within 3km buffer	-	0.822	0.01	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	Smaller total area of convenience store parcels within 3km buffer	-	0.784	0.01	# of times a week bicycling for any reason
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Pedestrian/bike friendly design factor, origin	n/a	0.234	0.122	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Retail/service density: # of retail/service jobs per net comercial acre within 1 mile of orgiin	n/a	0.005	0.114	probability of person n choosing mode I for travelling between origin and destination
Moudon, et al (2005)	Airline Model	more parcels within the closest (NC10) (office fast food hospital clinic)	+	1.16	0.1	# of times a week bicycling for any reason
Moudon, et al (2005)	Network Model	more parcels within the closest (NC10) (office fast food hospital clinic)	+	1.238	0.05	# of times a week bicycling for any reason
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Crime (neighborhood)		(Odds Ratio) 0.63	0.14	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	transit access	+	0.694	0.05	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	Transit Access	n/a		ns	Biked frequently (vs biked moderately)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	transit access	+	0.664	0.05	Biked within last seven days (vs. did not bike within the last seven days)
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Bus, tram or metro stop	n/a	(Odds Ratio) 0.83	0.494	Cycling for Transport at least once a week to work in the last 6 months prior to start of study

Neighborhoods- Origins and Destinations- continued

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	low-income neighborhood (proportion of households within 1 mile of orgin and destination with annual incomes<$25,00	n/a	-1.657	0.175	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Land-use diversity factor, destination	n/a	0.056	0.57	probability of person n choosing mode I for travelling between origin and destination
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Pedestrian/bike friendly design factor, destination	+	0.193	0.088	probability of person n choosing mode I for travelling between origin and destination

Road Quality

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Pavement vibrations	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion non-principal roads with negative residual life	-	-0.783	(t-stat) - 8.25	proportion of individuals in ward x cycling to work
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Proportion principal roads with negative residual life	-	-0.3493	(t-stat) - 3.87	proportion of individuals in ward x cycling to work
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	Biking comfort	+	0.72	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	biking comfort	n/a		ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	Biking Comfort	+	0.718	0.05	Owns a bike (vs. not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	Biking Comfort	n/a		ns	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	bike comfort	n/a		ns	biked frequently (vs. biked moderately)

Policy Level

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Municipal budget	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	municipal incentives	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Dill & Carr (2003)	Model 1 (D.C. excluded)	State spending per capita on bke/pedestrian	n/a	0.771	0.144	% commuting by bicycle
Dill & Carr (2003)	Model 2	State spending per capita on bke/pedestrian	n/a	0.427	0.328	% commuting by bicycle
Dill & Carr (2003)	Model 4 (D.C and NYC excluded)	State spending per capita on bke/pedestrian	+	1.021	0.047	% commuting by bicycle
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Parking costs (policy) (eurocents per hour)	+	0.0522	(t-value) 4.13	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Speed (compared with the car) (policy)	+	0.03392	(t-value) 4.41	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Stop frequency (policy) (cyclists stops per kilometre)	-	-0.0499	(t-value) -3.63	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Degree of satisifcation (with bicycle policies, provisions, etc.)	+	0.0509	(t-value) 3.50	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Proportion of VVD voters (main liberal party)	-	-0.753	(t-value) -3.27	Share of bicycle use in Dutch cities

Employment & Workforce

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Baltes, M. (1996)	Not significant in any model	% of females age 16 and over in the work force	n/a	/	ns	% of work trips in 1990 by bicycle in each MSA
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	proportion of small employers & own account workers	-	-4.1446	(t-stat) - 13.63	proportion of individuals in ward x cycling to work
Baltes, M. (1996)	Not significant in any model	Percent of males age 16 and over in the work force	n/a		ns	% of work trips in 1990 by bicycle in each MSA
Cervero and Duncan (2003)	Bicycle-Choice Model for predicting that a trip will be made by bicycle	Employment accessibility: number o jobs (in 10 000s) within 5 miles of origin	n/a	-0.017	0.106	probability of person n choosing mode I for travelling between origin and destination

Self Selection

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Xin, Handy and Buehler (2008)	Model 1 (own a bike vs. not own a bike)	self selection	n/a		ns	owns a bike (vs. does not own a bike)
Xin, Handy and Buehler (2008)	Model 2 (biked vs. did not bike)	self selection	+	0.524	0.05	Biked within last seven days (vs. did not bike within the last seven days)
Xin, Handy and Buehler (2008)	Model 3 (biked frequently vs. moderately)	self selection	n/a		ns	biked frequently (vs. biked moderately)
Xin, Handy and Buehler (2008)	Model 4 (own a bike vs. not own a bike)	self selection	n/a		ns	owns a bike (vs. does not own a bike)
Xin, Handy and Buehler (2008)	Model 5 (Biked vs. did not bike)	self selection	n/a	0.508	0.1	Biked in previous 7 days (vs. did not bike)

Other Factors

Study	Model name	Independent Variable	Association	Coefficient	Significance	Dependent variable
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Gain of time	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Hindrance frequency (policy)	-	-0.0126	(t-value) - 2.22	Share of bicycle use in Dutch cities
Rietveld and Daniel (2004)	Semi-log linear regression model, explaining the share of bicycle use in cities	Insurance premium	n/a		multicollinearity or ns	Share of bicycle use in Dutch cities
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Psychosocial	n/a	(Odds Ratio) 1.25	0.388	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	External obstacles	n/a	(Odds Ratio) 1.03	0.916	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Bas de Geus et al (2008)	Differences between Cyclists and Non-cyclists	Crime (road to work)	n/a	(Odds Ratio) 1.06	0.8	Cycling for Transport at least once a week to work in the last 6 months prior to start of study
Parkin, Wardman, Page (2008)	Model of variation in use of the bicycle for England and Wales	Dichotomous variable for non-mapped wards	+	0.9376	(t-stat) 18.78	proportion of individuals in ward x cycling to work
Baltes, M. (1996)	Not significant in any model	Inverse of MSA land area	n/a		ns	% of work trips in 1990 by bicycle in each MSA