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Planning for Cycling in the Dispersed City:
Establishing a Hierarchy of Effectiveness of Municipal Cycling Policies

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ABSTRACT

Urban utility cycling is increasing in many countries and is being promoted widely due to various health, social, economic and environmental benefits understood to be attainable. This study seeks to identify and quantify which municipal-level policies and exogenous factors are most influential in efforts to induce increased utility cycling mode share and improve the real and perceived cycling safety in low-cycling urban centres. This is achieved by identifying the relevant key issues and by establishing a hierarchy of effectiveness of municipal cycling policies.

Data was collected through interviews with a panel of experts who also completed a Delphi study, in which policies and external factors were scored in a theoretical policy framework according to their perceived relative influence.

The results show that a foundation of safe, high quality infrastructure is a prerequisite for inducing utility cycling mode share. Other factors that were perceived to have a strong influence are the relative attractiveness of cycling to travel by car; wider governmental policy, political dimensions of cycle policy decisions, and the need to shape nascent cycling systems around non-cyclists.

It is concluded that a holistic, long term, integrated perspective is required to induce mainstream cycling in dispersed, car-oriented cities. An emphasis on physical infrastructure provision, strong awareness of external factors and the implementation of politically strategic solutions improve the potential for success.

INTRODUCTION

Cycling for transport is on the rise internationally and along with it academic, policy and practice interests have followed (Pucher and Buehler, 2012a; Harms, Bertolini and Te Brömmelstroet, 2014; Herder, 2015). It is widely understood that cycling as a means of everyday transport or 'utility cycling' offers a host of diverse and profound benefits to both society at large and individuals, including health, economic, social and environmental aspects (Pucher and Buehler, 2012a; Pucher, Dill and Handy, 2010; Blue, 2013).

In the context of growth in the need for and interest in utility cycling, this study contributes to the growing body of knowledge about fostering cycling in the dispersed city by attempting to establish a consensus on the optimal hierarchy of municipal cycling policies. The dispersed city is defined by a large proportion of its population living in low density suburban housing and a high commuting to employment/education mode share by car, typically accommodated by car-oriented transport planning. For the purposes of this study, all cities in New Zealand (NZ) are considered to display these characteristics, while all Dutch cities are considered to have distinct urban form, including generally higher densities.

The focus of this study is to understand what the most effective municipal-level measures are to increase cycling mode share and improve real and perceived cycling safety in dispersed, low-cycling urban centres.

The study's objectives are:

- To identify the key issues being discussed on encouraging utility cycling in academic, policy and practice circles.
- To establish a theoretical hierarchy of effectiveness of municipal cycling policies through building a consensus among a panel of experts from the Netherlands NZ.

Knowledge from the Netherlands and NZ is drawn on as two countries at opposite ends of the spectrum of levels urban cycling to compare the perspectives of professionals operating in contrasting cycling contexts. It aims to test whether experience from high-cycling countries such as the Netherlands (with average adult commuting to employment/education mode shares of greater than or equal to 15%) can be gainfully applied to low-cycling countries such as NZ (with average adult commuting to employment/education mode shares of less than 5%), and if so, what the most

important lessons are. The study is theoretical in nature in order to maintain broad relevance to the dispersed city context and on methodological grounds.

LITERATURE REVIEW

Whilst a number of studies have been conducted into the effectiveness of municipal cycling policy, in general, academic research on the issue is limited. Most existing studies evaluate a particular intervention in a particular setting, which restricts potential for generalisation (Harms, Bertolini and Te Brömmelstroet, 2016).

The literature review has revealed that the structure set out by Harms, Bertolini and Te Brömmelstroet (2016) is most suited to the purpose of this study which is to understand the impacts of various types of policies and the socio-spatial context. The policy system is organised into policy inputs, policy outputs and policy outcomes, as outlined below.

- Policy inputs, or 'orgware' is thought of as the governmental setting in which policies are formulated (Harms, Bertolini and Te Brömmelstroet, 2016).
- Policy outputs are divided into two sub-categories:
  - 'Hardware': Physical infrastructure, including cycling-specific provision, which improves conditions of cycling (Harms, Bertolini and Te Brömmelstroet, 2016).
  - 'Software': Measures aimed at altering perceptions, beliefs and attitudes which could induce a voluntary change of transport mode (Harms, Bertolini and Te Brömmelstroet, 2016).
- Policy outcomes represent measures of success of municipal cycling policy. For the purpose of this study, two of the definitions of success from Harms, Bertolini and Te Brömmelstroet (2016) are adapted to the low-cycling environment and taken forward:
  - Cycling mode share: the proportion of journeys to work and education made by bicycle.
  - Cycling safety: real safety (in terms of the number of people killed or seriously injured per million kilometres cycled) as well as perceived safety (as measured by surveying cyclists as well as non-cyclists).
- The policy inputs, outputs and outcomes were conceived to occur within a socio-spatial context (conceived as exogenous factors in this study).

Overview

An overarching theme in the literature is that no single solution (or 'silver bullet') suffices to induce increased utility cycling mode share (Pucher and Buehler 2012b; Pucher, Dill and Handy, 2010; Forsyth and Krizek, 2010). Successful programmes commonly employ a coordinated, integrated suite of cycling-specific, land use, urban form and transport planning interventions which influence the relative attractiveness of modes (Pucher and Buehler 2012b; Forsyth and Krizek, 2010). Pucher, Dill and Handy (2010) observed that isolating the impacts of individual policy interventions is almost impossible and recommended that pro-cycling policies should be designed to interact with one another and leverage synergies.

Hardware

Numerous studies have been carried out which set out the range of physical infrastructure interventions which can be made to improve conditions for cycling. Hardware is often divided into those factors which increase the attractiveness of cycling ('pull conditions') and those that decrease the attractiveness of alternatives to cycling ('push conditions'). In the context of this study the latter

refers principally to the reduction of travel by private automobile as opposed to public transport use, walking and other non-motorised modes.

There is a consensus in studies in mature cycling countries such as the Netherlands that a combination of pull and push conditions must be applied in order to increase cycling mode share and improve real and perceived safety of cycling (Harms, Bertolini and Te Brömmelstroet, 2016; Pucher and Buehler, 2008). Recommendations are commonly made to transpose this approach to the low-cycling environment.

Software

Measures designed to increase utility cycling mode share through software are promoted by several authors as being important facets of a cycling policy package. Software includes a wide variety of initiatives at the local level, including providing education, awareness-raising, information and promotion of cycling at different scales. Software measures intend to induce psychological changes in individuals and encourage positive social interaction and learning associated with the bicycle (Harms, Bertolini and Te Brömmelstroet 2016; Forsyth and Krizek, 2010). Conclusions on the effectiveness of software measures vary, although it is generally recognised that the impacts of software programmes are not often thoroughly and systematically evaluated (Pucher and Buehler, 2012b; Pucher, Dill and Handy, 2010; Forsyth and Krizek, 2010; Pucher, Garrard and Greaves, 2011).

Orgware

Several studies postulate that the success of municipal cycling policy is influenced by the governmental setting in which policy is formulated, funded and delivered. Orgware can be seen as being made up of policy formulation, funding and implementation, the involvement of external stakeholders and strong leadership (see Pucher, Garrard and Greaves, 2011; Harms, Bertolini and Te Brömmelstroet, 2016; and Pucher and Buehler, 2008).

Exogenous factors

Exogenous factors are socio-spatial contextual factors that have an influence on cycling mode share. For the purposes of this study they are divided into two categories and defined as follows:

- Policy amenable factors: aspects that can be influenced by some level of policy, although are typically outside of the remit of municipal cycling policies.
- Non-policy amenable factors: physical environment and climate variables that cannot reasonably be impacted by any policy.

METHODOLOGY

Data for this study was collected by two means: a series of semi-structured interviews with members of an expert panel and a Delphi study.

Collection of data

Participants

The expert panel from which data was collected was made up of 28 individuals based in the Netherlands and NZ. The panel members have experience in research, professional practice, policy and advocacy related to utility cycling.

Interviews

The interviews were carried out in a semi-structured, conversational style. While each of the questions was asked in all interviews, the sequence of the questions changed as responses were provided to allow the conversation to flow and new themes to emerge organically. The seven interview questions were developed based on the salient themes identified in the literature review and were designed to stimulate broader conversation. Themes included modal segregation, real and

perceived safety and cycling culture.

Theoretical policy framework and the Delphi study

The second method of data collection was through a Delphi study which asked panel members to enter scores into a theoretical policy framework ('the framework') for cycling policies in low-cycling cities. This was based on their experience and intuition.

The Delphi study was conducted in three rounds: framework validation, framework scoring and scoring review and amendments. In the second and third rounds, at each level of the framework, it was requested that a total score of 100 be distributed according to the relative importance of different factors in the participant's opinion, as follows.

- At the first level, scores were distributed across six features:
  - Feature A: Hardware-pull factors
  - Feature B: Hardware-push factors
  - Feature C: Software
  - Feature D: Orgware
  - Feature E: Exogenous factors-policy amenable
  - Feature F: Exogenous factors-non-policy amenable
- At the second level, scores were distributed across elements under each feature (between one and four in number).

Approach to analysis

The qualitative data collected in the interviews was analysed in a three-step process: transcription of key messages and two-phase coding. A summary of responses is provided in the results section.

After the three rounds of the Delphi study were completed, the quantitative data gathered was collated and a statistical analysis was carried out. This comprised calculation of mean and interquartile range of the scores entered at each level of the framework. Detailed characteristics of the results were also distilled by calculating the mean scores of the responses according to the country of location (the Netherlands or NZ) and the professional backgrounds (research, practice, policy or advocacy) of the panellists.

RESULTS

This section sets out results of the interviews and the Delphi study.

Interviews

The interviewees' responses suggested a broad categorisation of issues influencing cycling mode share in low-cycling urban environments. The six categories have been defined largely following the structure used in the Delphi study.

Hardware

Overall, there was a consensus of the panellists on the importance of providing a basic level of safe, high quality infrastructure as an essential starting point for inducing utility cycling mode share. It followed that without this, changes in other measures and exogenous factors would make little difference.

Safety was a constant theme present through many of the interviews, especially prevalent in discussions regarding the provision of physical infrastructure. Aspects such as the concept of 'safety in numbers' and social safety were referred to.

Other themes included strategies for developing a network of cycling infrastructure, segregating modes, integrating with public transport to overcome large distances and re-purposing disused transport infrastructure.

Software

The conversation around software measures made frequent references to understanding the perspectives of people who do not cycle for transport and catering to their needs. This is seen as crucial to broadening the appeal of utility cycling to a broad spectrum of people with different backgrounds and motivations.

To increase mode share, attention needs to be paid to utility cycling familiarisation, marketing and messages being emitted through policy decisions. Initiatives include cycling education, social seeding, cycle-based tourism and 'ciclovía' type events (temporary weekend closures of roads to motor traffic to allow carriageway use by pedestrians and cyclists (also known as 'open streets')).

Orgware

The expert panel members demonstrated strong awareness of the importance of the formulation and crucially the implementation of policies, with references frequently being made to the political nature of road space re-allocations in particular. It was acknowledged that a specific approach and a fundamental shift in policy direction is required by municipalities to induce a step change in utility cycling from a low base toward normalisation and mainstreaming. This could be achieved by building up a critical mass of cycle infrastructure and leveraging off the positive feedback loops created as mode share increases to allow an increasingly diverse cycling culture to develop. This requires a holistic view of the relative attractiveness of each mode for particular trip distances and types.

Recurring themes included political will, courage and capital, social capital, funding and the economy of interventions. Broadly it was agreed that behaviour change would most likely be achieved by applying incentives for cycling in combination with disincentives for car use, with the incentives employed first. Equity was raised as an important issue with regard to the geographical distribution of cycling policy interventions, for example the favouring of higher income suburbs associated with predominantly European ethnicity.

Exogenous factors

The context sensitivity required to formulate and implement effective cycling policy was mentioned in a number of interviews. The socio-demographic and the physical characteristics of an urban centre in particular were deemed to have a significant influence on levels of utility cycling according to a number of participants. Some underlined the importance of proximity for a cycling system and consequently referred to urban planning policy levers. Others cited data which demonstrated that trip distances in dispersed city environments often remain comfortably within most people's range when travelling by bicycle. Physical environment factors which have an impact on cycling mode share were mentioned, particularly topography in the context of the potential for the increased usefulness and popularity of power-assisted bicycles (e-bikes).

Socio-cultural factors

Social and cultural factors were often woven in across different topics of conversation. Social and cultural norms and acceptance of cycling was seen as an important factor, both through interview responses and in feedback on the content of the theoretical policy framework used in the Delphi study. Physical interventions should be carefully implemented to exploit the symbolic value of public bodies providing for cycling as well as the practical benefits. Other topics covered included cyclist-motorist relationships; the role of confident, assertive cyclists; encouraging cultural diversity perceived biases within the cycling community and profession; and providing for utility cycling as opposed to recreational cycling.

Individual factors

Emotions, rational considerations, attitudes and beliefs at the individual level gained some attention

during the interviews. These were thought to influence the amenability to modal switch to cycling. Themes covered included the comfort and convenience of cycling infrastructure; the relative attractiveness of available modes; safety and risk aversion; and feelings of freedom and individuality.

Delphi study

Overview

The Delphi study polled opinions of a panel of 28 experts through the scoring of a theoretical policy framework. The response rates for the three rounds of the Delphi study were 64%, 68% and 68% respectively, as summarised in Table 1.

Table 1: Summary of Delphi study response rates

	Country		
Country	Netherlands	NZ	**Total**
Round 1 - framework validation	8	10	**18**
Round 2 - framework scoring	9	10	**19**
Round 3 - scoring review and amendments	9	10	**19**

Of the participants who responded to Round 1 of the Delphi study, 56% (n = 10) did not make any recommendations for changes to the framework, while 44% (n = 8) made recommendations ranging from suggesting the addition of a small number of items through to a comprehensive review of its contents. As a result of the recommendations, a total of 27 amendments were made.

General characteristics

Table 2 and Figure 1 show that at the features level, hardware attracts almost half (47.35%) of the weighting. This comprises two features. A mean score of 26.47% was attributed to 'hardware-pull factors', and 20.88% to 'hardware-push factors'. This represents a significant divergence from the expected scores, which are defined as the scores resulting from equal weighting across all features/elements considered (Pikora et al, 2003). Software and orgware were attributed relatively low scores with means of 11.03% and 14.56% respectively, though the latter is close to the expected score. A moderate level of importance was placed on exogenous factors, with a combined score of 27.06%. Within this figure, a far greater proportion corresponds to policy amenable aspects (18.53%) than to non-policy amenable aspects (8.53%). Levels of consensus at this highest level of the framework were generally high, with four of the six features' scores having an interquartile range (IQR) of below 10 and two equal to 10.

At the elements level, scoring was analysed in an absolute sense across all features as well as within each feature. Figure 2 shows the elements on which most importance was placed across all elements in the framework. The elements which received the greatest weighting were within the two hardware features. 'Linear components' (A1) and 'network quality, completeness and integration' (A4) were valued as the most important aspects of physical infrastructure provision as well as 'relative network speed interventions' (B1).

Under the software and orgware features, mean elements scores closely reflected expected scores. Orgware demonstrated very low IQRs and therefore high levels of consensus in scoring its four constituent elements, while overall very low levels of consensus were reached under software.

Elements that make up the 'exogenous factors-policy amenable' feature diverged somewhat more from expected scores and had varying and generally high levels of consensus. 'Spatial characteristics' (34.94%) and 'quality of provision and cost of alternatives to cycling' (30.17%) were given the greatest weight in this category.

Table 2: Delphi study results

Comp-onent code	Component title	Relative weighting (%)	Con-sesus level
A	**Hardware-pull factors**	**26.47**	****
1	Linear components	29.64	***
2	Nodal components	21.69	***
3	Discrete components	15.39	*
4	Network quality, completeness and integration	33.28	***
B	**Hardware-push factors**	**20.88**	****
1	Relative network speed interventions	44.44	**
2	Private motor vehicle 'system' supply	26.67	**
3	Changes to the cost of travel by car	28.89	*
C	**Software**	**11.03**	****
1	Education	33.00	*
2	Information and promotional campaigns	28.50	***
3	Traffic laws and police presence	38.50	*
D	**Orgware**	**14.56**	****
1	Policy formation	27.11	***
2	Policy implementation	24.94	***
3	Involvement of stakeholders	21.28	***
4	Strong leadership	26.67	***
E	**Exogenous factors-policy amenable**	**18.53**	****
1	Socio-demographic and household characteristics	12.67	***
2	Spatial characteristics	34.94	**
3	Quality of provision and cost of alternatives to cycling	30.17	***
4	Media and social dynamics [a]	22.22	***
F	**Exogenous factors-non-policy amenable**	**8.53**	****
1	Physical environment and climate	100.00[b]	-

N.B. *Feature* weightings are in bold, *element* weightings are not bolded.
*** High level of consensus (IQR < 10); ** moderate level of consensus (IQR = 10); * low level of consensus (IQR > 10).
[a] Referred to as socio-cultural factors in the Delphi study.
[b] No weighting assigned as only one element included i.e. weight = 100.00.

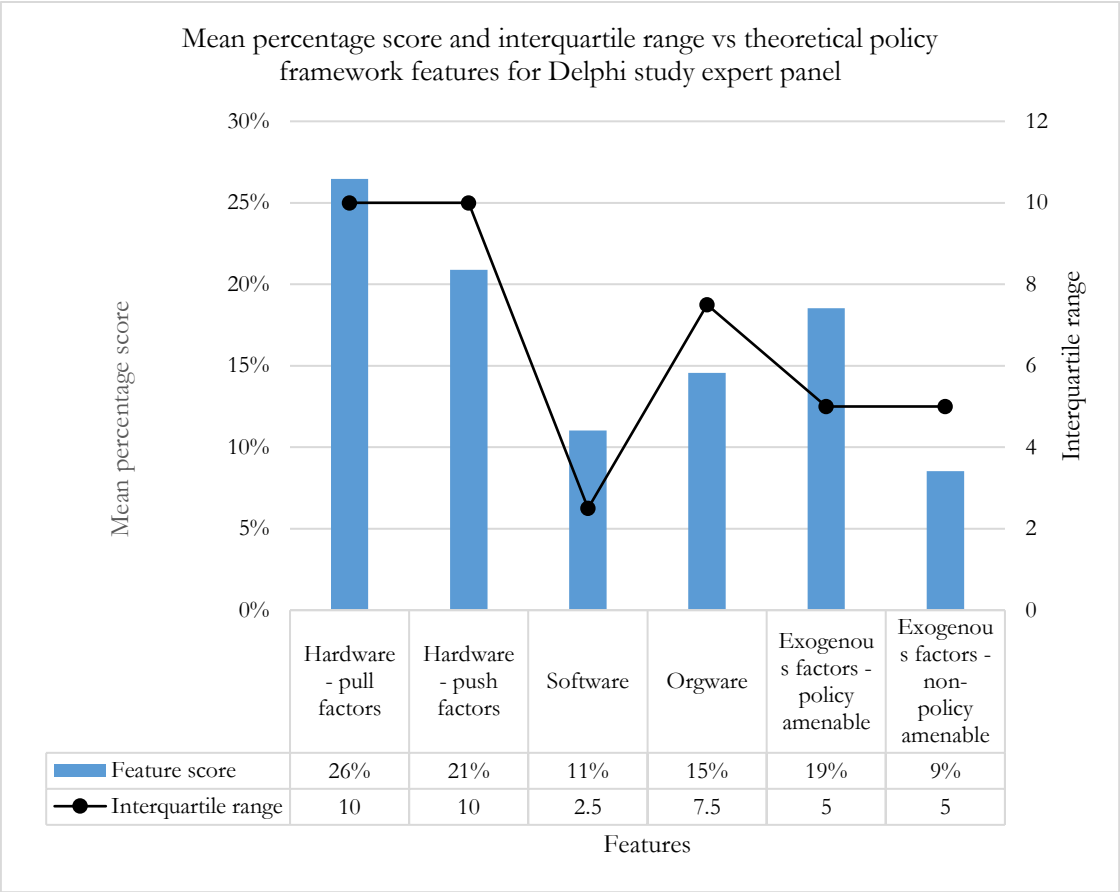

Figure 1: Mean percentage score and interquartile range vs theoretical policy framework features for Delphi study expert panel

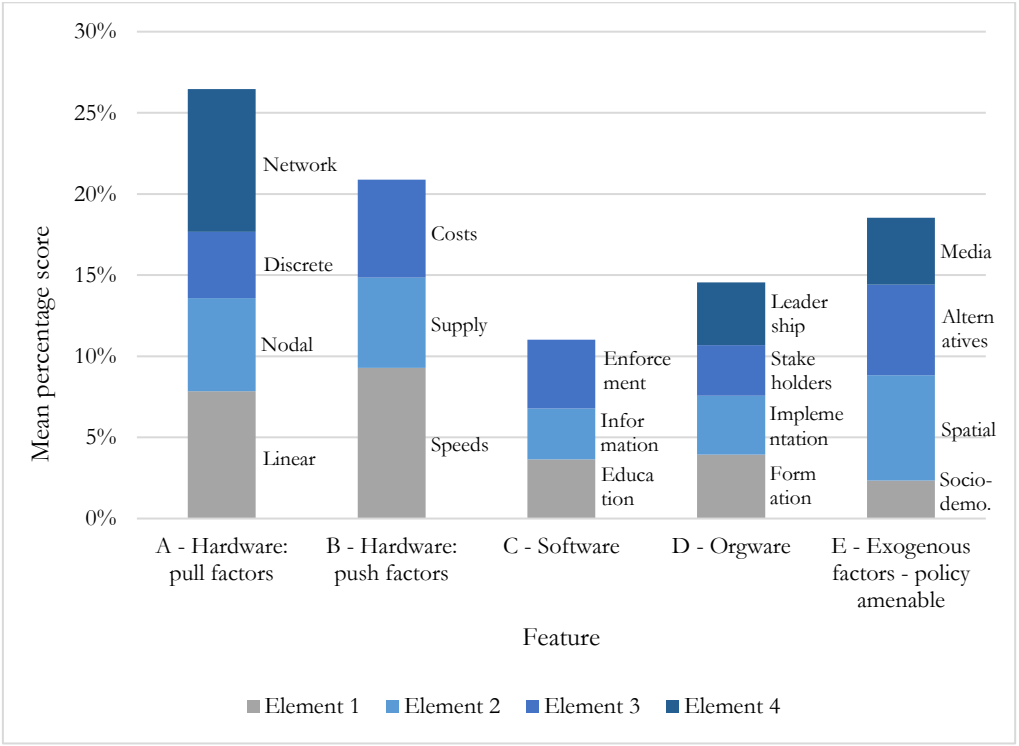

Figure 2: Mean percentage scores vs theoretical policy framework features and elements for Delphi study expert panel (abbreviated element titles included for quick reference – refer Table 2 for full titles)

DISCUSSION

This section examines the results of this study, reflects on research problems and limitations and evaluates the methodology employed.

Summary of findings

The results of this study demonstrate a number of themes in municipal cycling policy and go some way to quantifying the relative effectiveness of various strategies for increasing cycling mode share in low-cycling urban centres. Key themes in the results include:

- Safety: strong emphasis was placed on real and perceived safety and the importance of physical infrastructure in influencing safety in both interviews and the Delphi study.
- Infrastructure: it was mostly agreed that a basic level of infrastructure, is a prerequisite for inducing utility cycling mode share. This included facilities segregated from motor traffic where traffic speeds and volumes necessitate and low speed, shared streets elsewhere. Effective implementation strategies were discussed.
- Context dependency: the importance of responding to local conditions was emphasised, particularly the physical characteristics of urban centres, such as topography, local variations population density and degree of land use mixing. Generalisation in formulating and implementing cycling policy, for example the simple copying of infrastructure design, was cautioned against.
- Political dimensions: the expert panel demonstrated strong awareness to the political aspects of cycling policy formulation and outputs, although this was not reflected in the scoring of the framework. A holistic view which sought to improve the attractiveness of cycling relative to travel by car and is integrated with other policy areas was agreed to be the optimal approach.
- Cycling cultures and sub-cultures: the majority view was that the cycling system needs to be shaped around the needs and sensitivities of those who do not currently cycle for utility purposes in order to encourage more diversity in cycling.

Relevance to the research question, literature and conceptual framework

A response to the research question and objectives is outlined below according to the structure set by the conceptual framework, with reference to the literature reviewed. A conceptual framework is shown in Figure 3. It shows principally that policy outputs (hardware and software) and exogenous factors (the socio-spatial context) exert the highest degree of influence on policy outcomes.

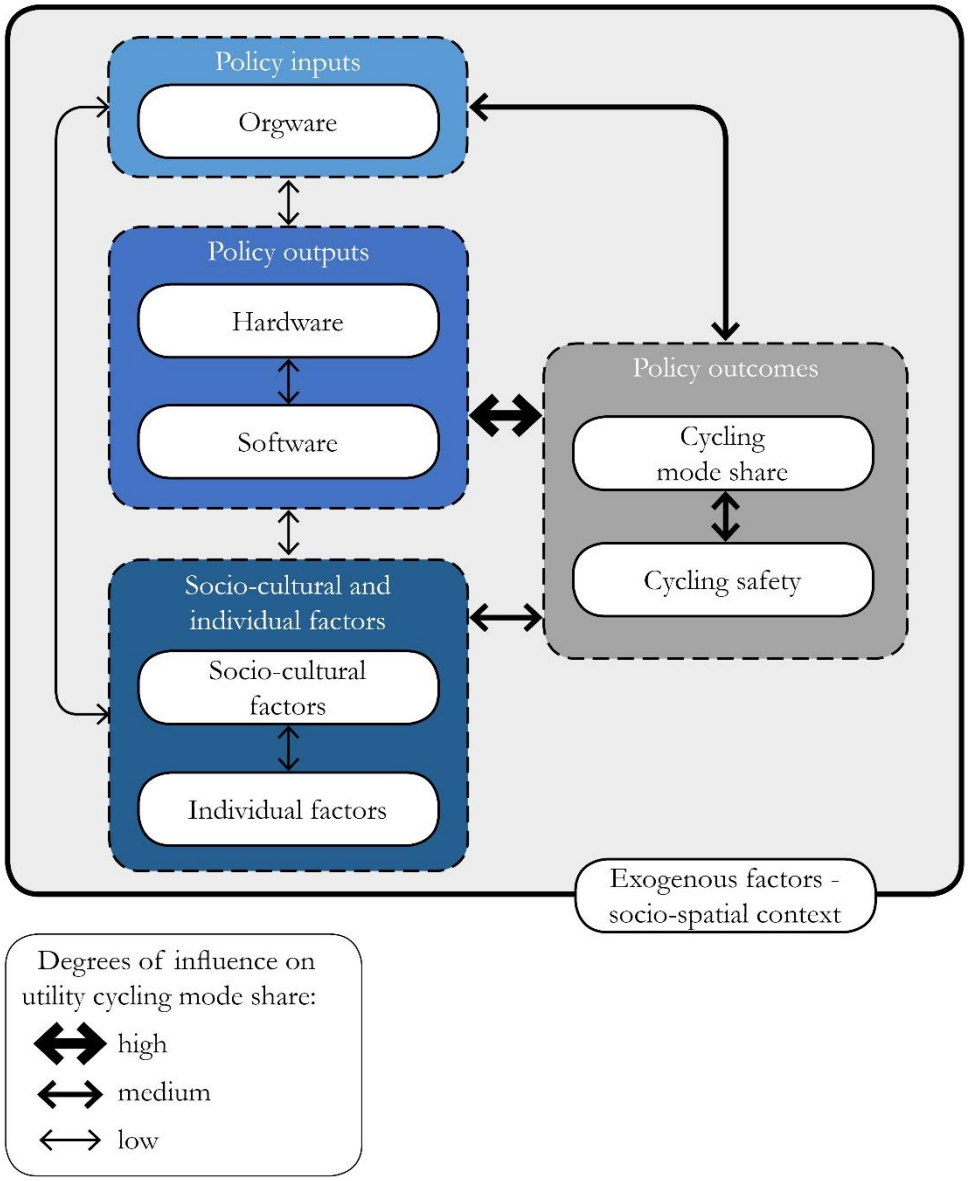

Figure 3: Revised conceptual framework

Policy outputs

The provision of physical infrastructure is emphasised as an indispensable starting point for inducing increases in cycling mode share. This functions principally through improving the real and perceived safety of cycling, and also increasing the level of convenience and comfort of the facilities, especially as a means of increasing competition with the automobile. A combination of 'carrot' and 'stick' approaches tailored to local conditions are seen as both necessary and effective. Broadly speaking, these findings are aligned to the literature (refer Pucher and Buehler, 2008; Buehler and Dill, 2016 and Pucher, Dill and Handy, 2010)

Software measures also received significant attention in the literature but in contrast to hardware were given relatively little weight in the results of this study. The majority of studies conclude that elements of software have a some to play in successful cycling policy packages, although the success of such programmes is not often systematically evaluated (refer Harms, Bertolini and Te Brömmelstroet, 2016; Pucher, Dill and Handy, 2010; and Pucher and Buehler 2012b; Forsyth and Krizek, 2010; Pucher, Garrard and Greaves, 2011).

The findings of this study support the prioritisation of physical infrastructure interventions in policy making. Software measures are cast as a complementary but less critical success factor which may have a positive influence under certain circumstances.

Exogenous factors

The socio-spatial context of municipal cycling policy is given significant weight in the results of this study. Awareness of such factors is also notable selected studies in the literature, which point to the significance of factors such as socio-demographics and the built and natural environments (refer Harms, Bertolini and Te Brömmelstroet, 2014; Pucher and Buehler, 2006; and Heinen, van Wee and Maat, 2010). This evidence suggests that an understanding of the local context in which municipal cycling policies are implemented is crucial to their success.

Policy inputs

Policy inputs or orgware is recognised as being influential in selected areas of the literature (see Pucher, Garrard and Greaves, 2011; Harms, Bertolini and Te Brömmelstroet, 2016; and Pucher and Buehler, 2008). The results of this study reinforce the need for municipal cycling policies to be formulated and implemented in a politically strategic manner. The critical obstacle to implementing cycling infrastructure in the low-cycling environment is seen as principally political in nature rather than technical or financial.

Socio-cultural and individual factors

Socio-cultural and individual factors received significant attention during the interviews and have been focused on in selected previous studies, notably Heinen and Handy (2012). Although not included in this study, interview data gathered suggests that a thorough understanding of local socio-cultural conditions and prevalent norms, attitudes and beliefs is an essential part of the formulation of successful cycling policy. It was also recognised that socio-cultural and individual factors are influenced by other policy initiatives to induce utility cycling mode share.

Policy outcomes

Utility cycling mode share and cycling safety were conceptualised as coupled with policy outcomes for the purposes of this study, with reference to Harms, Bertolini and Te Brömmelstroet (2016). This is supported by the results of this study through the position that municipalities cannot expect to see improvements in utility cycling numbers until real and crucially perceived safety is increased to such a level that safety is no longer the main barrier to cycling for the majority of the population.

Research difficulties and limitations

Research difficulties identified included time constraints which meant that interview transcripts were not provided for review by participants and methodological problems resulting in a sensitivity analysis not being applied to the quantitative results. The issues encountered may have influenced the participants' willingness to take part and the accuracy of and completeness of the data, although no feedback was received during or after the study to this effect.

The principal limitation of this study is the external validity of its findings. Firstly, as was raised by several of the study's participants, the effectiveness of many of the policies may not be able to be judged reasonably in the absence of knowledge of the context. Secondly, the 'dispersed city' as a case for the research was purposefully not precisely defined. This may have implications for the application of the findings of the research to specific urban centres, which may not be seen universally as being dispersed or car-oriented, for example.

CONCLUSION

This study contributes to addressing the discrepancy in utility cycling numbers between high and low-cycling countries. Some lessons applicable to fulfilling this aspiration have been gathered by drawing on the knowledge of Dutch and NZ cycling experts.

The results of this study indicate that the most effective measures to increase utility cycling mode share and improve real and perceived cycling safety in dispersed, low-cycling urban centres are physical infrastructure (hardware pull factors, 26.47%; push factors, 20.88%) and the socio-spatial environment (exogenous factors - policy amenable, 18.53%). This study suggests that a comprehensive suite of cycling policies with a holistic, long term perspective, integrated with other policy domains and responsive to local conditions has the ability to induce mainstream cycling to dispersed, car-oriented cities (Pucher, Dill and Handy, 2010).

Policy packages should be founded on physical infrastructure with educational, promotional and information-providing campaigns to complement it (Pucher and Buehler 2012b). An important principle evident from this study is the need to understand the needs and sensitivities of local non-cyclists and to provide infrastructure which prioritises their safety (both real and perceived) and comfort. If successful in creating a critical mass of everyday cyclists, evidence suggests that a greater cultural diversity is likely to follow.

The generation and maintenance of political and public support is crucial to the success of cycling policy in low-cycling urban centres. Incentives for cycling are an important starting point before restraints on car use are implemented, but experience from high-cycling countries suggests that the relative attractiveness of modes must be a principal consideration.

As indicated by the results of this study, the spatial characteristics which define low density, car-oriented urban environments are likely to provide limitations to the potential of cycling in dispersed urban centres (Heinen, van Wee and Maat, 2010). In this regard, the policy shift toward the compact city model and placing greater value on place making in many cities will contribute toward creating an environment which is more conducive to non-motorised modes of transport including cycling (Harms, Bertolini and Te Brömmelstroet, 2014). While the evolution of the urban form is likely to take considerable time in most cases, international examples show that substantial increases in cycling mode share can be reached in settings where concerted policy efforts are made to provide for it (Pucher and Buehler, 2012b; Mees, 2010). Although the patterns of cycling and its culture will undoubtedly be unique in different settings and expectations must be tempered due to the strong influence of change-resistant external factors, cycling in dispersed urban centres is a real prospect.

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