THE UNEXPECTED STABLE MARKET SHARE OF THE BICYCLE IN THE NETHERLANDS

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ABSTRACT

In the Netherlands, the share of the bicycle as the main mode in all person trips has been highly constant in the past three decades (about 27%). A constant share is remarkable because a number of developments in this period were unfavourable for bicycle use, like ageing of the population, growing number of immigrants, increasing car ownership, and a tendency to travel larger distances. The analysis of the paper confirms that the observed trend differs from the estimated trend, considering the autonomous developments. Possible reasons for the gap are other kinds of developments that might have encouraged cycling, and changed modal preferences in favour of the bicycle. Differences in trends in urbanised and not urbanised areas suggest that increased competiveness of the bike compared to the car in urban areas is a factor that explains part of the gap. Probably, the long-term bicycle-friendly policy of the Dutch national and local governments explains another part. The analysis of the paper gives no clear evidence of changed modal preferences. The impression is, that the policy and the increasing road and parking congestion in cities explain to a large extent why the bicycle retained its market share in an adverse world.

Keywords: bicycle, the Netherlands, modal choice, logistic regression

INTRODUCTION

In the Netherlands, the market share of the bicycle as the main mode in all person trips has been highly constant in the past three decades (about 27%). This constant share followed a large decrease in the 1950s and 1960s, and a partial recovering in the 1970s. A constant market share during a longer period is in itself not surprising. However, it becomes remarkable if one considers that a number of developments in the past decades were unfavourable for bicycle use, like ageing of the population, growing number of immigrants, increasing car ownership, and a tendency to travel larger distances. Van Boggelen and Jansen (2007) expect a decrease of bicycle trips by 3% in a 20-years period in the

Netherlands due to ageing, and an additional decrease of 2% due to a growing number of immigrants. Why do we still not observe a decreasing market share for the bicycle? Are there other, less conspicuous developments at the demand side that are beneficial for cycling? Or do the developments on the supply side, like extended bicycle infrastructure and improved vehicles, compensate for the negative impact of the autonomous developments? Or has a change in the modal preferences taken place in favour of the bicycle? The paper discusses these questions and may so contribute to understanding of the choice for the bicycle as mode for a trip. This understanding is necessary for policy makers that want to promote cycling. For reasons of sustainability and healthiness, promotion of active travelling is advisable, and the bicycle has the potential to absorb a significant higher number of trips and trip kilometres than walking, due to its relatively high speed.

One should note that the Dutch case is rather exceptional because of the high bicycle use, compared to most other countries (Pucher and Buehler, 2008). The bicycle is not, like in the US where a lot of bicycle research is done, a "fringe mode" that "represents rare behaviors" (Krizek and Johnson, 2006), but a normal mode that is used regularly by a majority of the population. In further contrast to many other countries, nearly all bicycle trips are made for transportation. Only 3-4% are not derived (just go for a ride). In the US the latter cover more than two-thirds of the bicycle trips (Handy et al, 2010). Because of its special position, Dutch research can give a useful contribution to the existing knowledge. Likewise, Dutch findings may not always be valid in other, low cycling countries.

The analyses of this paper regard the choice for the bicycle by adults. The latter are defined as persons aged 18 or older. From the age of 18, people in the Netherlands are permitted to get a driver's license. Another limitation is that only the choice for the bicycle as the main mode for trips is considered. The spectacular growth of the bicycle as an access mode to the train, resulting in large storage problems at the Dutch railway stations, is no subject of this paper. The main mode of a (multimodal) trip is defined as the mode that is used for the longest leg of the trip.

The method for looking for answers on the research questions exists of three steps that are successively discussed in the next three sections. First, a model will be estimated that describes bicycle use as a function of a large number of exogenous variables. The data are taken from recent databases of the Dutch National Travel Survey and include mainly data from the demand side of the modal choice market. Second, the question whether indeed the observed long-term development deviates from what might be expected given the developments of the influencing variables, is examined by a) mapping the developments of the most influencing variables, and b) estimating the development of the market share of the bicycle using the model and comparing this with the observed development. The third step is to try to explain a gap between estimated and observed market shares. Both missing variables in the model and possible changes in the modal preferences will be paid attention to.

FACTORS ASSOCIATED WITH CYCLING

A number of studies have been carried out on explanatory factors for cycling. They demonstrate that both demand and supply variables can have a significant impact. To start with the demand variables, Handy et al (2010) and Krizek and Johnson (2006) found a negative influence of age and a positive influence of education. Krizek and Johnson found additionally a relatively high bicycle use by men, a low bicycle use by employed persons, and a negative correlation with income. Handy et al observed a positive relation with environmental concern and a strong negative correlation with trip distance. In the Netherlands, Rietveld and Daniel (2004), and Ververs and Ziegelaar (2006) uncovered a correlation with political colour (people are less inclined to use the bicycle in right-wing municipalities and more inclined in left-wing municipalities), and negative influences of urbanisation and relief. Ververs and Ziegelaar found in addition an association with religious denomination; Moslems are less inclined to use the bicycle than Christians, and within the Christian groups Protestants have a higher bicycle use than Roman-Catholics. They also observe a relation with weather. Another Dutch study demonstrates a large difference between immigrants and natives (Harms, 2006); natives use the bicycle more frequently.

Some of the studies give evidence of significant influences of supply factors, where better supply for the bicycle increases bicycle use and better supply for alternative modes decreases bicycle use. Handy et al found that a network of separated bike paths encourages cycling, Rietveld and Daniel found a positive relation with satisfaction level with the municipal bicycle policies and negative relations with the frequencies that cyclists have to stop or experience hindrances on the route. They observe positive relations with the bicycle speed relative to the car speed, and with parking costs for the car. Pucher and Buehler (2008) state that safety for cyclists is perhaps the most important variable that explains why bicycle use is high in some countries and low in other. Safety is closely related with the existence of dedicated infrastructure for cyclists.

Data and variables

For our analysis of factors associated with cycling, we use data from the Dutch National Travel Survey. This survey is conducted continuously since 1978 and records data on household, person, trip, and leg level. The data include most of the autonomous factors that might influence the choice for cycling. These factors are mainly demand factors in the modal choice market. Supply factors, like quality of the bicycle infrastructure, are lacking. Therefore, our analysis is mainly a demand analysis and will produce a limited explanation of cycling.

The influences of next factors are investigated:

Characteristics of the household:

- Income (5 classes; the classes are indicated in Table I).
- One/more earner household (4 classes). There is the notion that the number of households with two earners, each working in different and sometimes distant cities, is increasing; this process might negatively affect cycling.
- Household size (5 classes).
- Car ownership. We tested two measures for this factor: the number of cars (4 classes), and the cover ratio of the cars. The latter is calculated as the number of cars divided by the number of persons aged >= 18 with a maximum value of 1.0. Both measures proved to be highly significant when included in the same model, and we selected both for our analyses.
- Urbanisation of the home municipality, defined on basis of the density of addresses in the living neighbourhood (6 classes).
- Predominant denomination of the province. Three classes are defined: the protestant provinces in the lowly urbanised parts of the country, the highly urbanised western provinces ("Randstad") that are mainly protestant as well but house in addition a large number of Moslems, and the Roman Catholic provinces.

Characteristics of the traveller:

- Age (5 classes).
- Gender.
- Activity status (6 classes).
- Education (5 classes).
- Bicycle ownership.
- Driver's license.
- Students pass for public transport.

Characteristics of the trip:

- Distance (22 classes).
- Season; this stands for the weather conditions and is defined cold in December to February, warm in May to September, and moderate in the remaining months.

Characteristics of the leg are not considered, because the analysis focuses on the use of the bicycle as the trip main mode.

One important demand variable is lacking: the migrants status of the traveller. We remind that in the Netherlands a large difference in bicycle use is observed between immigrants and natives. Moreover, the number of immigrants was growing significantly in the past decades. However, information about the migrant's status of the respondents is missing in the examined data.

Modelling bicycle choice

The influence of the variables on bicycle use is estimated by specifying and estimating a model that describes the choice to use the bicycle or not for a certain trip as a function of the explanatory variables. The most appropriate technique in this case is logistic regression. However, logistic regression does not take into account the impact of possible interrelationships between the exogenous variables. These interrelationships can affect the level of significance and the decision to accept or reject the null hypothesis. An alternative technique that can cope with the interrelationships is simultaneous equation modelling (SEM). This technique is based on linear regression. As we found that taking interrelationships in the model into account, does *not* affect the coefficient means but only the variances, we used a two-step method for specifying and estimating the model. In the first step we used the SEM-package AMOS 20 to identify the variables that have a statistical significant influence. In the second step we estimated a binary logistic regression model where we included only the variables that proved to be significant in the first step. We used for this SPSS 19. Variables with more than two classes were split up into dichotomous variables.

Using SEM you can take account of covariances and causal relationships between the exogenous variables. We did three kinds of estimations with AMOS:

- one without considering any relationship between the exogenous variables,
- one that takes into account covariances between the exogenous variables,
- and one that assumes that some exogenous variables are influenced by other variables, making them endogenous and giving them an intermediate position between the other predictors and the bicycle choice. The variables concerned are car ownership, urbanisation of the home municipality, and trip distance. These variables result from choices of the traveller or his/her family that might be hypothesised to be influenced by the exogenous variables and in turn are likely to affect modal choice. Covariances between the remaining exogenous variables are taken into account as well.

General results are that a) the estimated means of the coefficients are equal in the three estimations, b) the standard errors in the two estimations that take account of the interrelationships between the exogenous variables are close to each other though not fully equal, and c) the standard errors are highly dependent on the choice whether or not to take account of the interrelationships. In the latter case, taking account of the interrelationships increases the standard errors. Table I gives the results of the second SEM-estimation, including covariances between the exogenous variables, and the logistic regression of the definite model. The latter is principally the model that includes only the variables that are significant on a 95% level in the SEM estimation.

Table I – Results of the linear and logistic regressions

Variable	Category	SEM linear regression			Logistic regression		
		Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Annual income	<€7500	-0.012	0.032	0.714			
	€7500-<€15000	-0.021	0.011	0.060			
	€15000-<€22500	0.016	0.009	0.087			
	€22500-<€30000	0.008	0.008	0.272			
	>=€30000*						
Number of earners	One or no earners*						
	>=2 FT workers	0.031	0.007	0.000	0.198	0.024	0.000
	1 FT, >= 1 PT worker	0.018	0.007	0.014	0.110	0.023	0.000
	No FT, >=2 PT workers	0.035	0.024	0.150	0.142	0.056	0.011
Household size	1 member*						
	2 members	-0.014	0.011	0.179	-0.118	0.027	0.000
	3 members	-0.007	0.013	0.604	-0.045	0.034	0.190
	4 members	0.014	0.013	0.273	0.122	0.035	0.000
	>=5 members	0.024	0.014	0.099	0.178	0.038	0.000
Car ownership	No cars*						
	1 car	-0.039	0.016	0.016	-0.209	0.045	0.000
	2 cars	-0.104	0.024	0.000	-0.659	0.065	0.000
	>=3 cars	-0.12	0.026	0.000	-0.829	0.076	0.000
Car cover ratio	Ranging from 0.0 to 1.0	-0.108	0.019	0.000	-0.712	0.051	0.000
Urbanisation	Very large city	-0.032	0.013	0.016	-0.184	0.033	0.000
	Very highly urbanised	0.024	0.012	0.037	0.176	0.025	0.000
	Highly urbanised	-0.012	0.007	0.120			
	Fairly urbanised	-0.002	0.008	0.824			
	Little urbanised	-0.008	0.007	0.290			
	Not urbanised*						
Type of province	Protestant	0.034	0.005	0.000	0.258	0.017	0.000
	Urbanised Randstad	0.019	0.005	0.000	0.141	0.019	0.000
	Roman Catholic*						
Age	18-<25	0.117	0.019	0.000	0.676	0.050	0.000
	25-<50	0.076	0.014	0.000	0.382	0.037	0.000
	50-<65	0.009	0.013	0.000	0.519	0.034	0.000
	65-<75	0.081	0.012	0.000	0.457	0.031	0.000
	>=75*						
Gender	Man*						
	Women	0.006	0.005	1.088			
Activity status	Working FT*						
	Working PT	0.029	0.009	0.000	0.261	0.020	0.000
	Student	0.093	0.020	0.000	0.677	0.060	0.000
	Housekeeping	0.042	0.010	0.000	0.319	0.024	0.000
	Retired	0.025	0.011	0.030	0.207	0.029	0.000
	Other	0.016	0.013	0.207	0.168	0.031	0.000

Table I – Results of the linear and logistic regressions (continued)

Variable	Category	SEM linear regression			Logistic regression		
		Coeff.	S.E.	P	Coeff.	S.E.	P
Education	Primary school*						
	Lower secondary school	0.002	0.006	0.778			
	Higher secondary school	-0.003	0.006	0.648			
	Academic	0.022	0.007	0.000	0.161	0.015	0.000
	Other	0.006	0.046	0.894			
Bicycle ownership	No						
	Yes	0.238	0.010	0.000	3.053	0.061	0.000
Driver's license	No						
	Yes	-0.040	0.005	0.000	-0.258	0.022	0.000
Students pass PT	No						
	Yes	-0.032	0.013	0.011	-0.223	0.061	0.000
Trip distance	< 0.5 km	0.140	0.011	0.000	2.165	0.045	0.000
	0.5-<1.5 km	0.360	0.007	0.000	3,353	0.038	0.000
	1.5-<2.5 km	0.368	0.007	0.000	3.379	0.039	0.000
	2.5-<3.5 km	0.316	0.009	0.000	3.182	0.040	0.000
	3.5-<4.5 km	0.243	0.011	0.000	2.776	0.043	0.000
	…	…	…	…	…	…	…
	14.5-<15.5 km	0.045	0.019	0.015	1.049	0.079	0.000
	15.5-<16.5 km	0.023	0.030	0.456			
	…	…	…	…			
	19.5-<20.5 km	0.030	0.021	0.142			
	>=20.5 km*						
Season	Cold	-0.062	0.006	0.000	-0.430	0.016	0.000
	Moderate	-0.039	0.005	0.000	-0.274	0.014	0.000
	Warm*						
Intercept		-0.132	0.019	0.000	-6.359	0.079	0.000
R^2		0.127			Cox and Snell: 0.197 Nagelkerke: 0.296		

*: Reference class of categorical variable. If classes are combined in the logistic regression, the combined class is the reference class.
Grey highlighted coefficients are not significant (P>0.050).

The p-values in Table 1 demonstrate that, if the interrelationships between exogenous variables are not taken into account (in the logistic regression), the estimation produces more significant variables.

The number of observations is very large: 151,000 for the SEM, and 178,000 for the logistic regression. The latter number is larger because observations with missing values for the variables that are left out in the logistic regression, are now included. The number of observations with missing values is particularly high for the income variable. In the definite model specification used for the logistic regression, there is no category with less than 1,000 observations. In the specification used for the SEM analysis, there are two: income <€7500 (980 observations) and education "other" (468 observations).

Most outcomes are in line with other studies and lead to suspect that modal choice by the Dutch does not differ essentially from that by people of other countries, except for the (much) higher preference for the bicycle. However, there are two striking differences. These regard the two variables that prove to be not significant, despite the large number of observations: income and gender. In the US a negative relation between cycling and a relatively high bicycle use by men is found (Krizek and Johnson, 2006). The different impacts of just these two variables are also noticed by Pucher and Buehler (2008). They found no significant impacts on cycling by inhabitants of three northern European countries with high bicycle use (the Netherlands, Denmark and Germany), in contrast to the US. In the case of gender, a similar result has been found for Dutch pupils travelling to school (van Goeverden and de Boer, 2013). In contrast to findings in the international literature (e.g. McMillan et al, 2006) and even findings in the neighbouring Dutch speaking region of Flanders, gender has no influence on modal choice of Dutch pupils.

Another remarkable result regards the influence of urbanisation. Living in a very highly urbanised municipality can be both negatively and positively associated with cycling. The association is negative in the largest cities (Amsterdam, Rotterdam and The Hague) and positive in the other highly urbanised municipalities. The result might be the balance of a rather low quality for cycling in highly urbanised areas because of large traffic volumes and many traffic lights, low quality for car use as well for mainly the same reasons, and high quality of public transport services. The latter is highest in the largest cities while presumably using the car here is more problematic than in other highly urbanised municipalities.

The analysis produces a result regarding a maximum trip distance for cycling. The distance that people are willing to cycle varies strongly from person to person, and it is difficult to define a general maximum distance. Frequently a distance of 7.5 km is taken as the upper limit that most people are willing to cycle (e.g. by Rietveld en Daniel, 2004). The distance results of our analysis (not fully presented in the table) show a steady decrease of the coefficient when the distance increases, but there is no clear fall. However when the distance exceeds 15 km, the coefficients are not significant any more. Based on this finding, 15 km can be indicated as the maximum cycling distance, at least in the Netherlands. Certainly, there are longer trips where the bicycle is used, but these are rare.

In the definite model specification that we used for the logistic regression, we left out the two insignificant variables (income and gender) and combined classes of three other variables with insignificant categories (urbanisation, education, and distance). In a few cases we retained categories that differed not significantly from the reference. One is household size. Regarding this variable no category differs significantly from the reference category '1 member'. Still, the coefficients show a clear pattern: In single households, people are rather inclined to use the bicycle. When one person is added to the household, the inclination drops, and, when the household is growing further, the inclination is growing and surpasses that of single household members when the household has four or more members. Based on this observation and the fact that the reference class appeared to have a moderate influence, leading to lower significance of the other categories, we retained this variable and all categories. In two other cases we retained insignificant categories (households with two or more part time workers and persons with the activity status "other") because combining with the reference class would give an ambiguous reference category.

The logistic regression with SPSS produces a ranking of the variables, based on the contribution to the X^2 value when a variable is included in the model. Table II displays the variable list and their contribution to X^2 in the order of inclusion in the model by SPSS.

Table II – Contribution to the X^2

	X^2
Trip distance	26273
Bicycle ownership	5442
Car cover ratio	4672
Season	806
Activity status	593
Car ownership	263
Age	287
Type of province	235
Household size	207
Driver's license	124
Education	132
Urbanisation	95
Number of earners	70
Students pass for PT	14

By far the most important variable is trip distance. Other highly important variables are bicycle ownership of the person and cover ratio of the car in the household. The remaining variables are relatively unimportant.

DEVELOPMENT OF THE DEMAND FACTORS

Now we come to the question whether the autonomous developments are indeed unfavourable for cycling. The Figures 1 to 3 show the developments in the last three decades, 1980-2009, of the three by far most influencing variables.

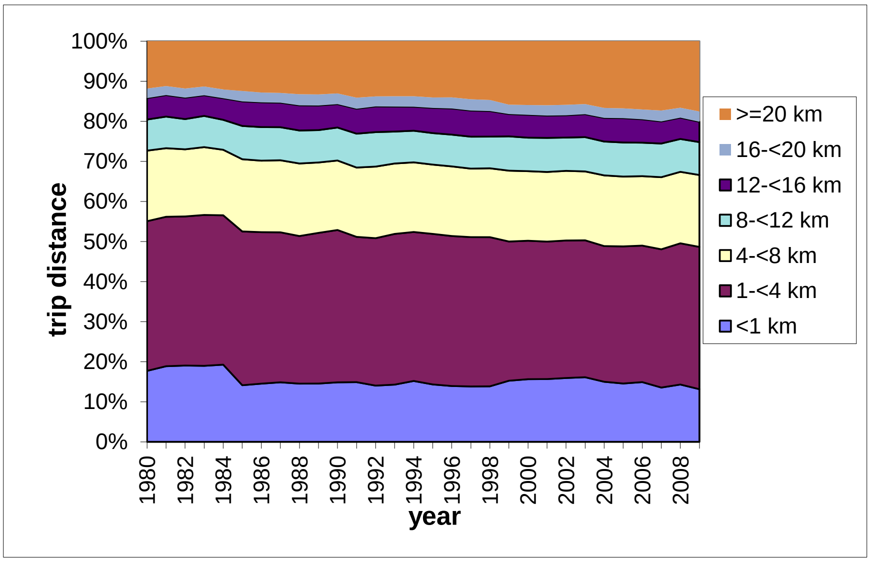

Figure 1 – Development of trip distances

There is a clear increase of long distance trips where the bicycle is not competitive. This development is unfavourable for the bicycle. However, the relative decrease of the classes where the bicycle is most appropriate, 1-8 km, is very small, from 55% to 53% of all trips. Therefore, the negative influence of the distance increase will be small as well.

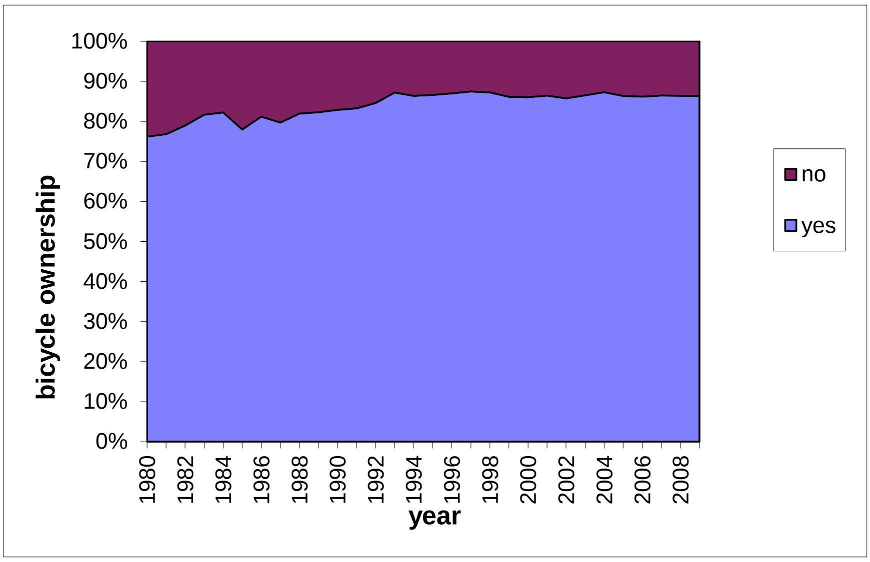

Figure 2 – Development of bicycle ownership

Figure 2 shows the proportion of Dutch residents >= 18 year that own one or more bicycles. Bicycle ownership increased, especially in the 1980's and early 1990's. This development is likely to have encouraged bicycle use. It raises the question to whether the development can be considered as 'autonomous' or as the result of changing choices. The notion that 'everyone' in the Netherlands has a bike, except for those who are not able to use it for health reasons (mainly elderly) or who never learned to bicycle and are not willing to do so (mainly immigrants), gives cause to assume the autonomous option; the development of bicycle ownership would reflect the development of elderly and immigrants. However, both the proportions of elderly and immigrants increased which might have caused a decrease in bicycle ownership. Possibly, the choice process in buying bicycles have changed, at least before 1995. This is still not a good explanation for the stability of bicycle use if the autonomous developments are unfavourable for cycling. Bicycle ownership reflects the intention to use the bicycle in normal life to a larger extent, which should not be expected in the context of unfavourable developments.

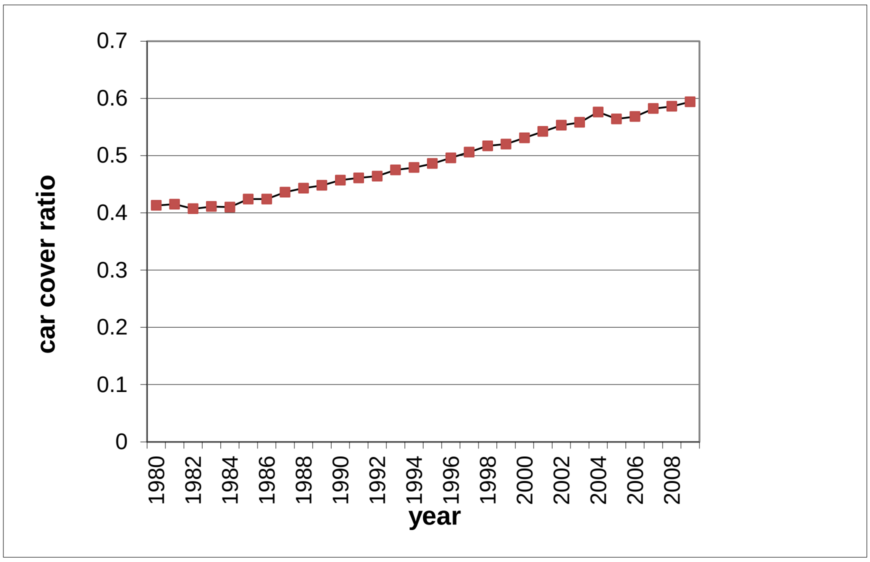

Figure 3 – Development of car cover ratio

The car cover ratio exhibits a clear grow. The development of this variable is apparently unfavourable for cycling.

Looking at the remaining 11 significant variables, 6 of them include negative developments for cycling:

- Activity status: the categories with highest bicycle use (students, housekeeping) decreased in favour of those with low bicycle use, in particular working part time and retired.
- Car ownership: this increased.
- Age: the elderly (>= 75) with low bicycle use increased at the cost of mainly the group 18-25 that has the highest bicycle use.
- Household size: the number of large households with high bicycle use decreased. The number of 2-person households with the lowest bicycle use increased, but also the number of single households with a rather high bicycle use increased.
- Driver's license: the number of persons with a license increased considerably.
- Students pass for PT: this pass was introduced in 1991. Since then the number of students having this pass was rather stable.

Certainly, a seventh variable that is not in the model should be added here: the migrant's status. Immigrants have a low bicycle use and their number was growing.

Two of the least influencing variables have positive developments:

- Education: the proportion of persons with an academic training increased considerably.
- Number of earners: the number of two-earner households including one part time worker increased.

The remaining 3 variables show no clear development that is favourable or unfavourable for cycling (season, type of province, urbanisation).

The impression is that the developments were mainly adverse for cycling. The total impact of the developments can be estimated by using the model for calculating market shares of the bicycle in the preceding decades, a kind of backcasting. Figure 4 shows the results; the figure includes the observed market shares as well.

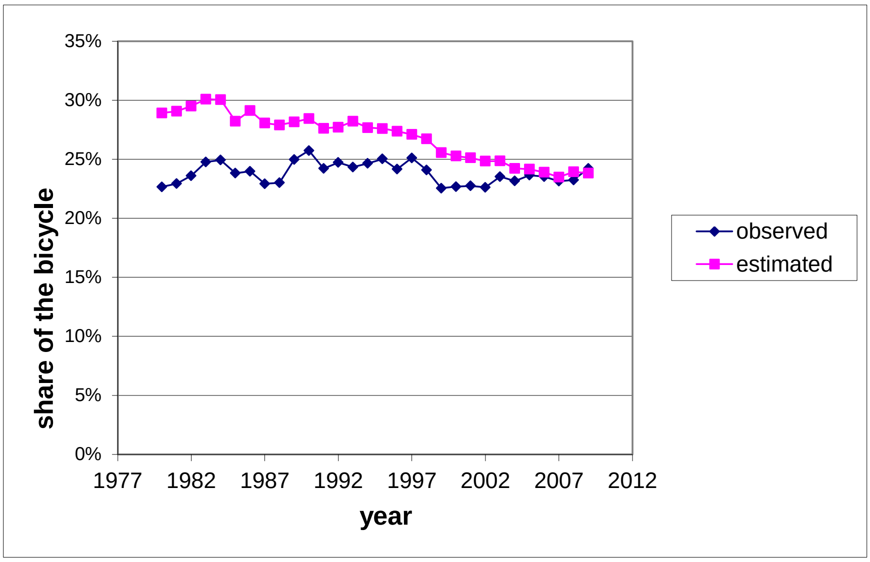

Figure 4 – Observed and estimated bicycle market shares

The estimated shares show a clear decreasing course, reflecting the bicycle-unfriendly developments. The decrease is about 0.8% per year. When going further back in time, there is an increasing gap between the estimated and observed market shares. The suspicion that the bicycle maintained its share in an adverse world is supported by these results. The question is why this happened.

UNDERSTANDING THE GAP

Possible explanations of the gap between observed and estimated trends in bicycle shares are missing significant variables in the model that affect cycling positively and changing modal preferences in favour of the bike.

Missing variables

The analysis so far focused on the demand side. Supply variables were not included. These variables might have been favourable for cycling. The demand variables are not fully included as well, though our impression is that full inclusion would rather increase than decrease the gap, because the migrant's status seems the most important missing variable.

The developments on the supply side are ambiguous. One the one hand, the Dutch national and local governments made many efforts to improve and extend the bicycle infrastructure and promote cycling in the whole period considered (Pucher and Buehler, 2008). On the other hand, a similar promoting policy was pursued for the car, the most important competitor. Regarding the latter, it can be noticed that the car suffered from its own growth by increased road congestion and parking problems. This might have strengthened the position of the bicycle; congestion and parking problems are mainly experienced in urbanised areas. If these problems play a significant role in the stability of bicycle use, the observed stability on a national scale can be hypothesised to be the balance of an increase in urban areas and a decrease in rural areas.

We tested this hypothesis by examining the developments in the most urbanised municipalities (urbanisation codes 1 and 2 according to the CBS, the Dutch Statistical Bureau) and the least urbanised municipalities (urbanisation codes 4 and 5). In addition, we estimated the model for both groups and used this for backcasting. Figures 5 and 6 present the results.

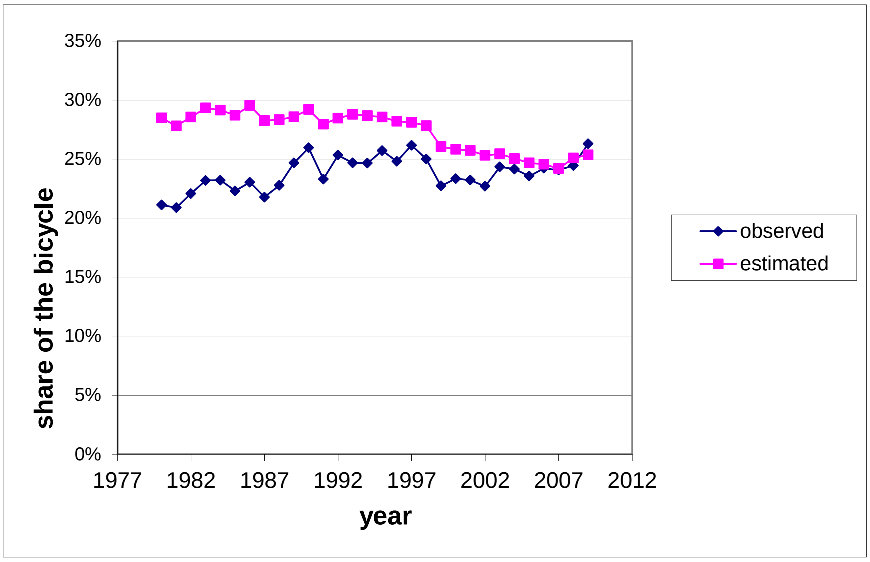

Figure 5 – Bicycle market shares in highly urbanised municipalities

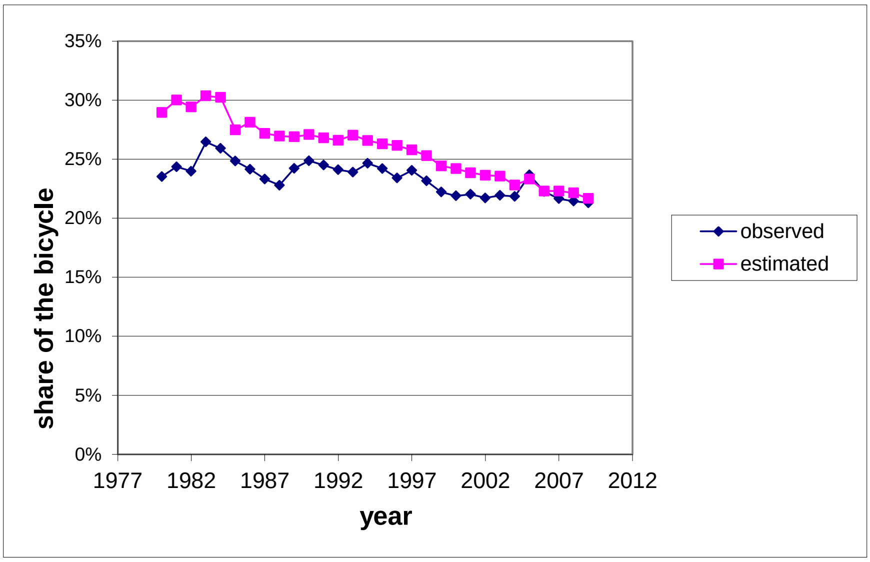

Figure 6 – Bicycle market shares in lowly urbanised municipalities

The figures show indeed a slow increase of the observed market share in urbanised municipalities and a slow decrease in more rural areas. They support the hypothesis that the car problems in urban areas are beneficial for cycle use and contribute to the explanation of the observed constant market share on a national level. However, the results cannot explain the whole national gap. If this was the case, there would be no gap between the observed and estimated market shares in the low urbanised municipalities. Still, Figure 6 shows that there a gap exists.

Modal preferences

Another possible explanation for the stability of bicycle use is a change in the modal preferences in favour of the bicycle. Preferences might have changed by improvements of the vehicle (mountain bike, e-bike, improved lighting, better tires, etc.), growing consciousness about the positive influence of cycling on health, and possibly increasing concern about sustainability. An indication that preferences might have changed is the observed increased ownership of bicycles. The increase suggests that the bicycle has become a more normal mode in everyday life. However, the increase took place before 1995 and before many improvements of the vehicle were implemented.

We investigated a possible change in modal preferences by estimating models that describe the choice for cycling in two earlier periods: 1980-1981 and 1995-1996. In advance. it can be said that some differences in modal choice are likely because a) the models for highly and lowly urbanised municipalities demonstrated some differences in modal choice and b) there has been a significant urbanisation process in the country in the past decades. The main differences between choices in highly and lowly urbanised areas are that in the former, age and education are more important variables and in the latter, car ownership and driver's license are more important. There are only differences in relative importance. The results show not any difference in the direction of the influence of a variable.

The models for the two earlier periods were estimated in the same way as we did for the recent model (2008-2009). First, the models were specified by using AMOS for determining which variables are statistically significant. Second logistic regression was employed for estimation of the models.

The results of the specification of the models were similar to those for the recent years. Gender was not significant, income was not significant in 1980-1981, while in 1995-1996 only one category differed significantly: people in the lowest income class are slightly less inclined to choose the bicycle than those in the highest (reference) class (p-value 0.019). Generally, in the 1995-1996 period the p-values are lower than in the two other periods because the sample of the survey is substantially larger. Another difference with the 2008-2009 data is that in 1980-1981 education has no significant impact. We decided to exclude gender and income in the definite models in the two earlier periods and education in the 1980-1981 model. Furthermore, we decided not to combine classes of the education (1995-1996) and urbanisation variables. The reason is that more categories differed significantly from the reference than in the 2008-2009 data.

The direction of the influences of significant variables are equal in all three periods, with just one exception: the students pass for public transport. In 2008-2009 availability of this pass influenced bicycle use negatively, while in 1995-1996 a positive influence was found. A positive significant influence would not be expected. It implies that making public transport cheaper can stimulate usage of the bicycle as the main mode for trips. It should be noted that availability of the students pass is by far the least important variable in the 1995-1996 estimation. This can be seen in Table III that displays the order of inclusion in the model (indicated as "ranking") and the X^2-values of the significant variables. The order in the table is equal to that in Table II, reflecting the ranking in 2008-2009.

Table III – Ranking and contribution to the X^2 in the two earlier estimations

	1980-1981		1995-1996	
	rank	X^2	rank	X^2
Trip distance	1	21040	1	108405
Bicycle ownership	2	11408	3	22841
Car cover ratio	3	7538	2	26538
Season	5	1028	5	3552
Activity status	6	828	4	4024
Car ownership	12	27	10	682
Age	8	514	11	623
Type of province	10	168	6	1279
Household size	9	307	8	1051
Driver's license	4	1160	7	1191
Education			12	396
Urbanisation	7	735	9	715
Number of earners	11	29	13	235
Students pass for PT*			14	17

* Not existent in 1980 and 1981

Comparing Tables II and III, one can see that trip distance is always the most important variable. Second in importance are bicycle ownership and car cover ratio. Season and activity status also are always ranked high. The number of earners and the students PT-pass always rank very low. Car ownership, that was ranked rather high in 2008-2009, is ranked low in the two earlier periods. This might have to do with a high correlation with the car cover ratio.

Give the results indications of changes in modal preferences? There is one variable that clearly fall in importance: driver's license. In 1980-1981 this was one of the most important variables, in 1995-1996 the importance was moderate, and in 2008-2009 the importance is rather low. The fall in importance may reflect the ongoing urbanisation. When comparing modal choice in urbanised and not urbanised municipalities in 2008-2009, we found that having a driver's license is more important in not urbanised areas (ranked 7) than in urbanised (ranked 12). A second possible reason is that nowadays nearly every young adult decides to get a driver's license and that the decision is less linked to the intention to drive a car.

A less pronounced decrease in importance can be observed for the urbanisation of the home municipality. Possibly the continuing merge of municipalities plays a role here. The number of Dutch municipalities decreased from 809 in 1980 to 633 in 1995 and to 441 in 2009. The merges will make the urbanisation variable less accurate and may cause a decrease in explanatory power. Other variables seem not to have changed structurally.

Looking at the coefficients of the earlier models (not published here), one can suspect that the impact of urbanisation changed. Table IV lists the coefficients and standard errors for the three periods. The figures are the results of the SEM estimation with AMOS.

Table IV – Coefficients of urbanisation in the three periods

Category	1980-1981		1995-1996		2008-2009	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Very large city	-0.062	0.010	-0.053	0.006	-0.032	0.013
Very highly urbanised	-0.019	0.010	-0.004	0.005	0.024	0.012
Highly urbanised	-0.019	0.007	-0.012	0.004	-0.012	0.007
Fairly urbanised	0.000	0.007	-0.007	0.003	-0.002	0.008
Little urbanised	0.016	0.007	0.007	0.003	-0.008	0.007
Not urbanised*						

*: Reference class
Grey highlighted coefficients are not significant (P>0.050)

The results give the impression that urbanisation becomes more encouraging for cycling. The negative impact of living in one of the largest cities decreases; the absence of an impact of the other very highly urbanised municipalities turned into a positive impact; and the negative impact of the highly urbanised municipalities disappeared. These results correspond to the finding that the bicycle market share is growing in urban areas unlike in rural areas (Figures 5 and 6). The question here is to which extent the grow in urban areas can be explained by 'autonomous' changes in modal preferences by urban citizens, and to which extent supply factors play a role, viz. increased problems for cars and improved bicycle infrastructure and facilities. The latter might give the full explanation.

The change in modal choice in urban areas together with the ongoing urbanisation contributes to the explanation of stability of the bicycle market share. The ongoing urbanisation is visualised in Figure 7. The figure shows the distribution of persons >=18 years old over the defined urbanisation categories.

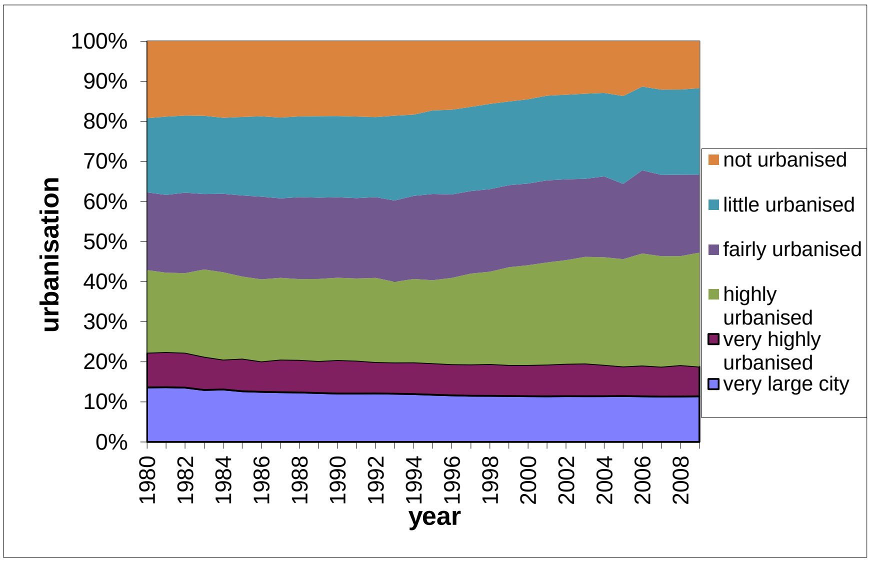

Figure 7 – Development of urbanisation

DISCUSSION

The analyses in the paper demonstrate that the initial assumption that a decrease in bicycle use should be expected, given the autonomous developments, is confirmed. The trend of the estimated development differs from the observed one. Can the gap between the trends be explained?

The estimated trend is based on calculations with a model that include only the impacts of demand variables. Supply variables describing the quality of bicycle infrastructure and that of competing modes are missing. Likewise, not all influencing demand variables are included in the model. However, absence of some demand variables is likely to reduce the gap rather than be the reason for it. Then missing supply variables and changed modal preferences should explain the gap. Other studies demonstrate that supply of both bicycle infrastructure and the infrastructure of competitive modes influences bicycle use. The continuing bicycle-friendly policy in the Netherlands resulting in extended and improved bicycle infrastructure will at least partly explain the gap between the trends. The increased bicycle use in urban areas where the car suffers from congestion and parking problems, suggests that the quality of the car infrastructure is responsible for another part of the explanation. Modal preferences might have played a role as well. However, the examination in this paper gives no clear evidence about that.

The analysis of the paper demonstrates in an indirect way that a long-term policy that promotes the bicycle can have a long-term positive impact on bicycle use. In particular in urban areas where the car is less competitive, there are good opportunities for increasing the market share of the bicycle. Assuming that many first world countries are faced with autonomous developments that are similar to those in the Netherlands, their impact on cycling might be negative. However, the Dutch results suggest that a negative trend can be neutralised or even reversed by, among others, ambitious policies that promote cycling.

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