



Working paper about

Costs and benefits of cycling (based on desktop search)

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0. Introduction

Cycling is - after walking - the easiest and most natural way to move along. This internal working paper is a compilation of the diverse advantages of cycling, from different perspectives. Additionally this paper gives information on the implementation costs of cycle measures and cost benefit analysis.

1. Benefit analysis

1.1 Benefits for the individual

For travelling less than 5km the bicycle is the fastest transport mode.

The bicycle enables flexibility, it is possible to stop spontaneously and – in most cases – the cycle route is also the shortest way. Furthermore no expensive parking space has to be found. To ride a bicycle in a city is – for some reasons - also less stressful. There are not any delays caused by congestion or waiting times for public transport services.¹

Modern bicycles are comfortable to use because of technical improvements. Riding a bicycle does not cause pollutions or noise. Bicycles are easily accessible and can be used by almost all kind of people. Especially in cities the bicycle is the ideal transport mode, because up to 5 km (and even more in case of car traffic congestion) it is the fastest transport mode (**Figure 1**). More than 30% of all trips in Europe cover a distance lower than 3km and even 50% lower than 5 km.² That means, there is a great potential for bicycle use.



Figure 1: Distance / travel time ratio for different transport modes [Dekoster & Schollaert 1999, p.11]

¹ [Reiter et al. 2010, p.6]

² [Dekoster & Schollaert 1999, p.11]

High efficiency of cycling

As the bike does not need any fossil fuels and is using its unique technique, the efficiency is very high. The required kinetic energy of a bike is the lowest of all modes of transport concerning the mass and the travelled distance. The total efficiency of a bike is 70% – 90% (depending on conditions of maintenance, driving style and technique).³

Enlarge the radius of action

The catchment area is the area around the current location which can be reached within a certain amount of time with a certain transport mode. With a walking speed of about 4 km/h a distance of ~0.7 km can be covered within 10 minutes and an area of about 1.4 km². With a bike with a speed of 15 km/h the catchment area is 14-fold bigger and with a pedelec (Pedal Electric Cycle) even bigger. Hence – compared to walking - with a bicycle or a pedelec it is possible to reach stops which are further away without having additional transport costs.

The bicycle radius of action fits to older people's needs

The share of older people in our society increases constantly. In the European Union the group of people over 65 is expected to rise about 33% until 2030 (from 16.7 billion in 2008 to 22.3 billion in 2030).⁴ But seniors prefer to stay active and mobile as long as possible. Therefore especially the mobility of elder ones should be considered for the planning of the future transportation system. As seniors more often walk, cycle or take the public transport, the amount of trips with such transport modes will probably rise significantly. Furthermore the radius of action of retired people is usually reduced to about 5 km (instead of about 18 km for the younger population). This correlates with the bicycle traffic distance. Hence a good and safe cycling infrastructure is important for seniors to stay active.⁵

Cycling supports health and may even extend life

Every year many people die prematurely because of pollution impacts. The deaths caused by traffic pollution are numerous and even more relevant than deaths caused by accidents. A study carried out by Steve Yim and Steven Barrett, pollution experts from the MIT in Massachusetts, shows that the risk to die of traffic related air pollution is at least two times higher than to die in an accident. According to the study in the UK, 5,000 people die every year prematurely because of emission impacts (e.g. lung cancer, heart diseases). In contrast 1,850 people died 2012 in road accidents.⁶ Hence the risk of a death through road emissions in the UK is 2.7 times higher than the risk to die in a road accident.

³ [West 1997]

⁴ [Statistische Ämter des Bundes und der Länder 2011]

⁵ [Reiter et al. 2010, p.7]

⁶ [Yim & Barrett 2012]

However road accidents probably cause a higher loss of live, because persons who die in an accident are on average middle aged, whereas people who die from road emissions die “only” about 10 years earlier than they would otherwise.⁷

Another survey came to a similar conclusion. Only about 10% of all impairments through traffic are caused by accidents. The more serious problem is the risk from traffic emission which is supposed to be even three times higher.⁸

Many people (600.000 persons every year) in Europe die in consequence of insufficient exercise (**Figure 2**). Therefore cycling is one of the logical consequences to combat this lack of exercise but avoid enormous traffic emissions as well. A comprehensive Danish health study which is based on a self-report of the participants about their physical activity reveals that those who cycled to work had a much lower mortality rate (20% to 28%).⁹

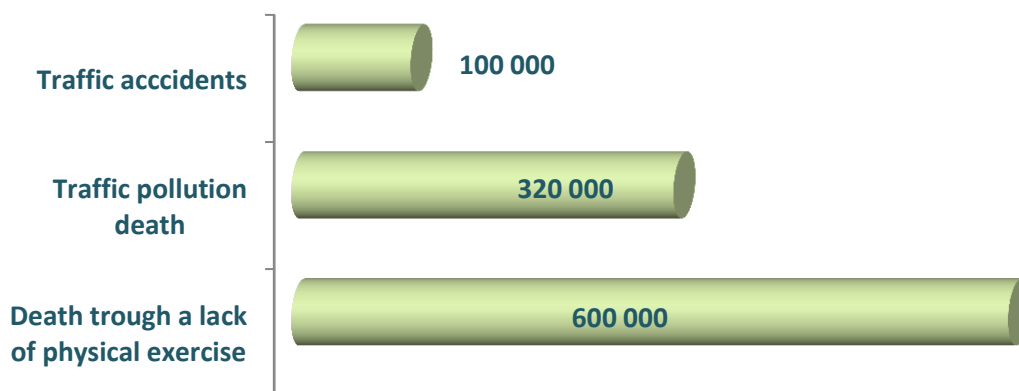


Figure 2: How traffic shortens the life of Europeans [WHO et al. 2008]

Cycling is an ideal activity for exercise, as it can perfectly be integrated into daily life.

Another survey with 100 people from Graz who took part in an exercise programme that lasted 12 weeks in 2003 is confirming the thesis above. Because 9 out of 10 people got a lack of exercise (attested in the yearly health checks), the objective of the study was to integrate more exercise into daily routine. The evaluation approved that 3 out of 4 participants improved their fitness and their body fat values (**Figure 3**). Over 50% of the test persons felt much better physically.¹⁰

⁷ [Yim & Barrett 2012]

⁸ [Reiter et al. 2010, p. 8]

⁹ [Anderson et al. 2000]

¹⁰ [Reiter et al. 2010, p. 20]

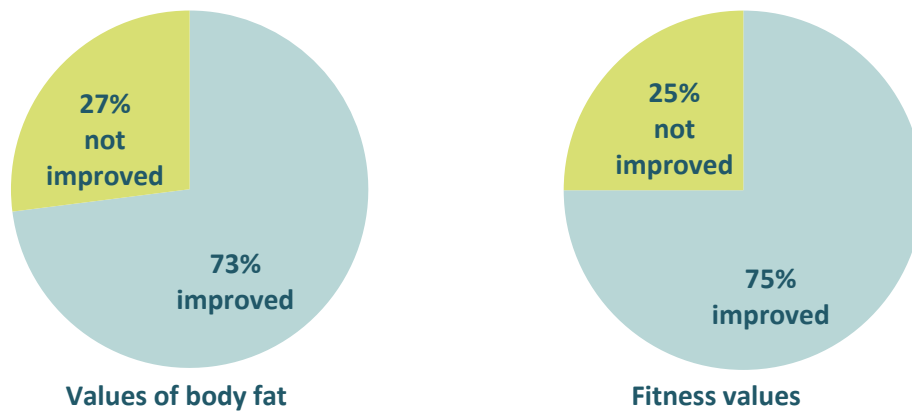


Figure 3: Evaluation of a 12 week exercise [Gronau et al. 2011]

A ride of at least 15 minutes to work, shops or other meeting is matching the recommendations for adults without spending extra time for exercise. It is also a very incidental exercise and therefore it is easier to stick on it than on the habit of going to a gym. Certainly people also save fuel costs and additional gym costs this way.¹¹

Lawrence Frank (University of British Columbia) has even quantified the correlation between the distance people drive each day and their body weight:

“Every additional 30 minutes spent in a car each day, translates into a 3 per cent greater chance of being obese,”¹² he said.

The same study states that people who live in neighbourhoods with a mix of shops and businesses within easy walking distance are 7 per cent less likely to be obese, lowering their relative risk of obesity by 35 per cent.¹³

Furthermore a lack of exercise results in higher cost for national healthcare. (see chapter 1.3 – Benefits for the economy)

The potential of danger through cars is enormous compared to the one of bikes.

The kinetic energy of a car during a collision (at an average speed of 35 km/h) is 57 times higher than the one of a bike (at an average speed of 17km/h). At the assumed maximum speed of 150 km/h of a car (for a bike 35 km/h) the kinetic energy is even about 240 times higher (**Figure 4**).¹⁴

¹¹ [Cavill & Davis 2007, p. 22]

¹² [Bigg & Reuters 2012]

¹³ [Frank et al. 2005]

¹⁴ [Reiter et al 2010, p. 12]

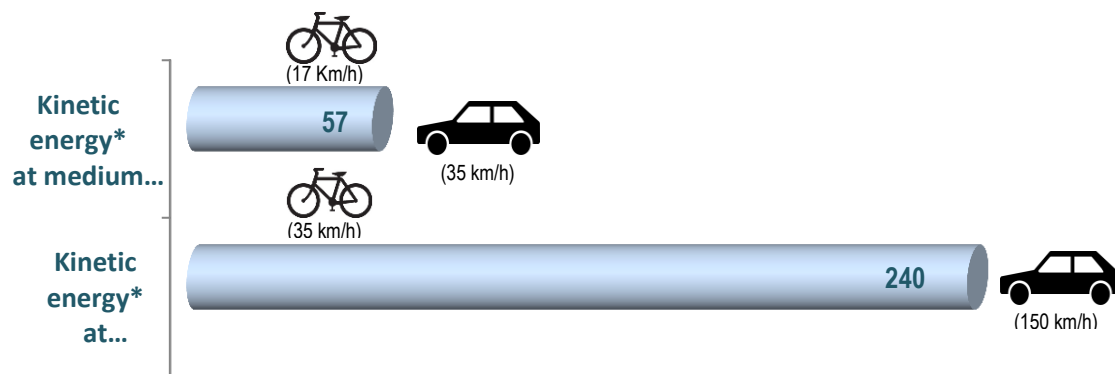


Figure 4: The potential of danger with a car or a bike at a collision [Transportlearning 2004]

From the security point of view: The more, the better

A survey from Copenhagen shows that the number of cyclists is correlated negatively to the number of injured cyclists. The study notes that less people on bicycles were injured, if the percentage of cyclists in the regarding city is higher. This Danish study between 1996 and 2008 showed that while the percentage of bicycle traffic increased by 25 % the number of injured persons per bike kilometre decreased by about 50%. The graph below features the development for the risk of bicycle accidents when bicycle traffic increases (**Figure 5**).¹⁵

The »VCD Städtecheck 2011 Fahrradsicherheit« (VCD City Check on Cycling Safety 2011) as well as previous surveys confirm this thesis. This yearly study is investigating the development of traffic safety for cyclists and their correlation with the amount of cyclists in 43 cities with more than 100,000 inhabitants. As more and more people decide to take the bike instead of other transport vehicles the number of accidents (with bicyclists involved) rose, but the percentage of injured cyclists decreased.¹⁶ In addition, cyclists on the street are becoming more “usual” and road users are more sensitised to them.

¹⁵ [Reiter et al. 2010, p. 5]

¹⁶ [Smetanin 2011], [Litman 2012b, p. 6]

the more bicycles, the safer the bicyclists

The risk of accidents and actual accidents fall drastically when more people bicycle. Car drivers keep a much better eye on bicycle traffic when there are many bicycles on the street. Right: graph showing increase in bicycling and reduction in accidents from 1996 to 2008 (Copenhagen, Denmark).²⁵

- Km/miles cycled (mio km/ miles per weekday)
- Km/miles of bicycle path, bicycle lane and green routes
- Number of bicyclists seriously injured

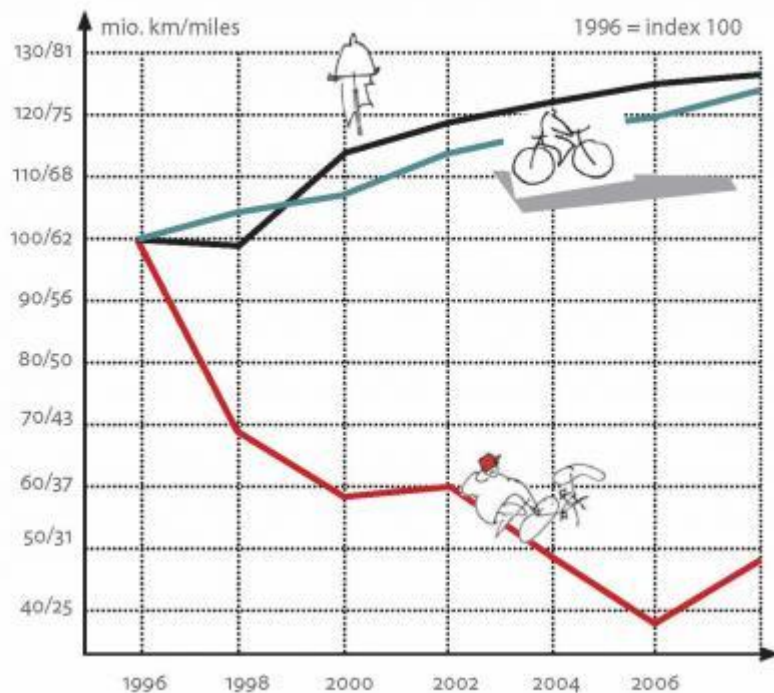


Figure 5: The more bicycles, the safer the bicyclists [Gehl 2010]

All the arguments above make clear that cycling is good for everyone's health even though cyclists are endangered by cars or other vehicles in traffic. In many German cities (43 German cities with more than 100,000 inhabitants were considered) the amount of injured cyclists is the double of the percentage in the modal split. That means, there is a higher risk to get involved in an accident on a bicycle.¹⁷

Nevertheless a Spanish study from Barcelona that compared the health risks and benefits of cycling in an urban area, found that the health benefits far outweigh the health risks. When cycling through the town the benefit-risk-balance for the risk for all-cause mortality associated with more physical exercise (positive), the exposure to fine particular matter (negative) and the higher rate of vehicle-related collision is still positive. And negative aspects are getting less dominant with a rising amount of cyclists.

In the specific case of the public bicycle rental system *Bicing in Barcelona*, the research team estimated that the *Bicing* initiative already reduces the number of deaths among *Bicing* members in Barcelona from 52.15 to 39.87 each year. They also estimated that the *Bicing* initiative is reducing carbon dioxide emissions (i.e. greenhouse gases) by 9,062 metric tonnes per year (see also the following chapter on environmental benefits).¹⁸

¹⁷ [Smetanin 2011], [Litman 2012b, p. 6]

¹⁸ [BMJ 2011]

1.2 Benefits for the environment

The bicycle is a clean way to move along

Concerning traffic emissions the bicycle is outstanding. With regard to causing pollution, in passenger transportation the car produces by far the most emissions (immediately followed by the motor cycle) (**Figure 6**). Research studies in congested urban areas show that every 90th inhabitant falls ill with lung cancer caused by diesel exhaust particulates and benzene emissions of road traffic. At main roads it is even every 39th resident.¹⁹

As the current traffic growth in Europe most probably will not stop soon, all CO₂-savings achieved through the shift from car to bicycle are already consumed by additional car traffic. However these savings by transport mode shift can be calculated: On average 747 g CO₂ are saved for each trip with a bicycle instead of the car (149.3 g*5 km).²⁰ Hence for an exemplary way to work (~5km) about 350 kg (747 g*2*[365 d -104 weekend days - 27 holidays]) could be saved in one year.

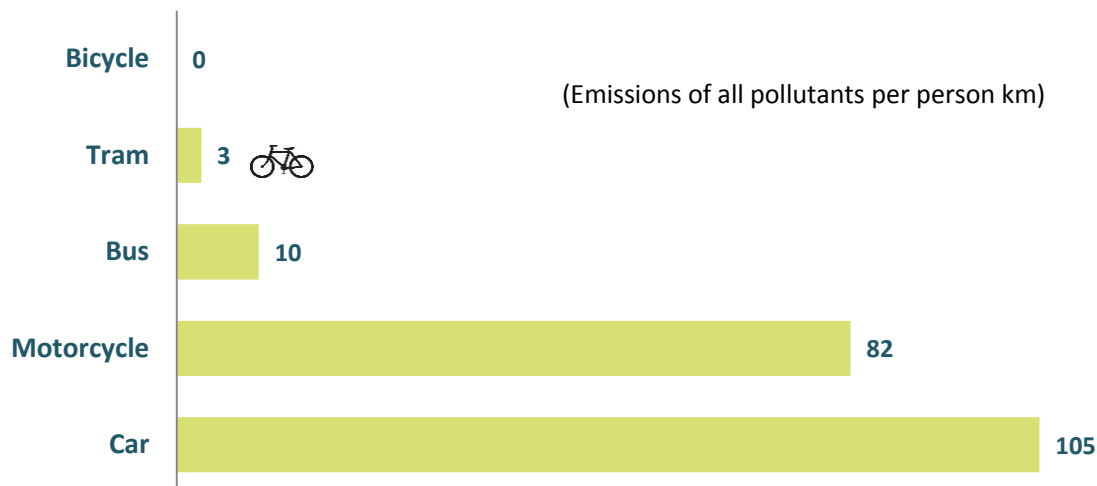


Figure 6: Environmental impact related to means of transport [Mobility-cultura, 2003]

A bicycle is by far not consuming as much space as a car

Compared to cars bicycles just need very little space for moving around and for parking. This consumption of space through stationary traffic leads to a sealing of surface which can be measured and compared. On average a parking space for cars could be substituted by 7 to 9 bicycle spaces (**Figure 7**).

¹⁹ [Reiter et al. 2010, p. 18]

²⁰ [VCD 2010, auto – reporter 2007]



Figure 7: Space requirement for stationary traffic [Australian Mobility research 2004]

A regular parking space without any roof or protection would cost about 4,000 €. 8,000 € would have to be spent for a covered one and the underground version in a parking deck would cost even about 16,000 €. In contrast, only 1,000 € would have to be spent for a proper parking area of 8 to 10 bicycles and 1,100 € to 1,300 € for a sheltered one in a bicycle station.²¹ Such biking stations can be compared to underground parking decks for cars, because they offer a high level of security with a controlled entrance zone.

Hence, car parking spaces are not only very land consuming and require an artificial sealed surface, but also do cost a multiple. In consequence space and financial resources can be saved with the investment in cycle traffic. In addition the space surface could be used for more attractive purposes than car parking.

With regard to moving traffic the road capacity for bicycles is much higher than for cars. Instead of 2,000 cars per hour on a 3.5 m wide road, 14,000 bicycles could pass on the same one in one hour. For the same amount of transport users using the bicycle instead of the car leads to fewer and narrower streets and less land consumption. These facts show that supporting cycling is also an effective measure to combat traffic congestion.²²

The space consumption of moving traffic can be measured as well with reference to the speed. And the space requirements of moving traffic are even more dominant than for stationary traffic and cause divisive effects in (public) space (**Figure 8**).

²¹ [Reiter et al. 2010, p. 19]

²² Ibid.

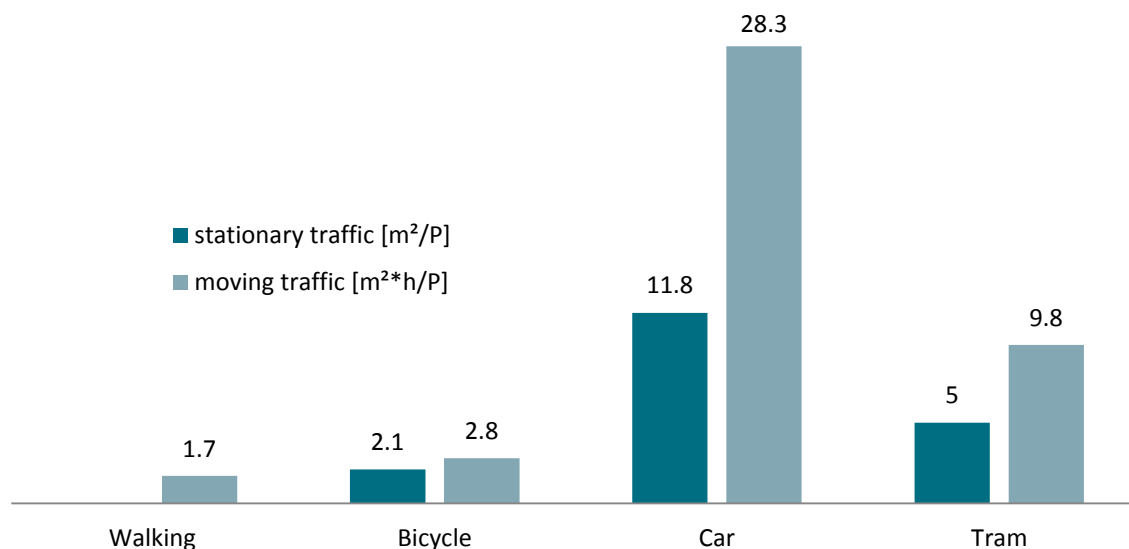


Figure 8: Required space of stationary and moving traffic [based on data from Bracher et al. 2002, p. 36]

The **Figure 9** below shows the effects for the individuals, the community and the environment as a function of the age of cyclists and the amount of cyclists who replace car drivers. In fact all those effects which are mentioned in the sections above can hardly be discussed separately because they influence each other. The effects on health are thereby higher with older people cycling. A positive effect on the environment or on congestion can just be achieved with a bigger amount of shifts.

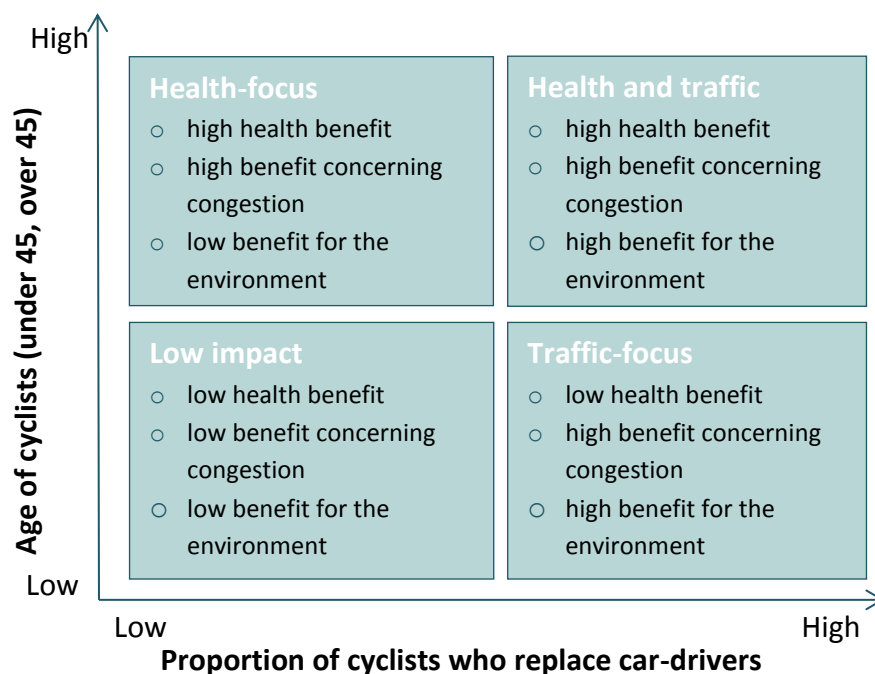


Figure 9: Conceptual link between variables and core benefits for additional cyclists [MacDonald 2007]

1.3 Benefits for the economy

For most shopping trips the bicycle is a suitable transport vehicle

In 2009 a study at hardware stores and supermarkets in Graz/Austria was executed. One result was that a car was used in 1,635 cases, but mostly (94%) a bicycle would have been sufficient. In 70% of all shopping activities the goods could have been transported on a regular bicycle with a basket and additional 14% of the shoppers could fit their purchases into a bike trailer. The remaining 10% did not even buy anything. Surprisingly nobody of the participants used a bike trailer and only in 4% the bicycle was used, but 19% took public transport or went on foot. However the car was the dominating transport vehicle (77%) (Figure 10).²³

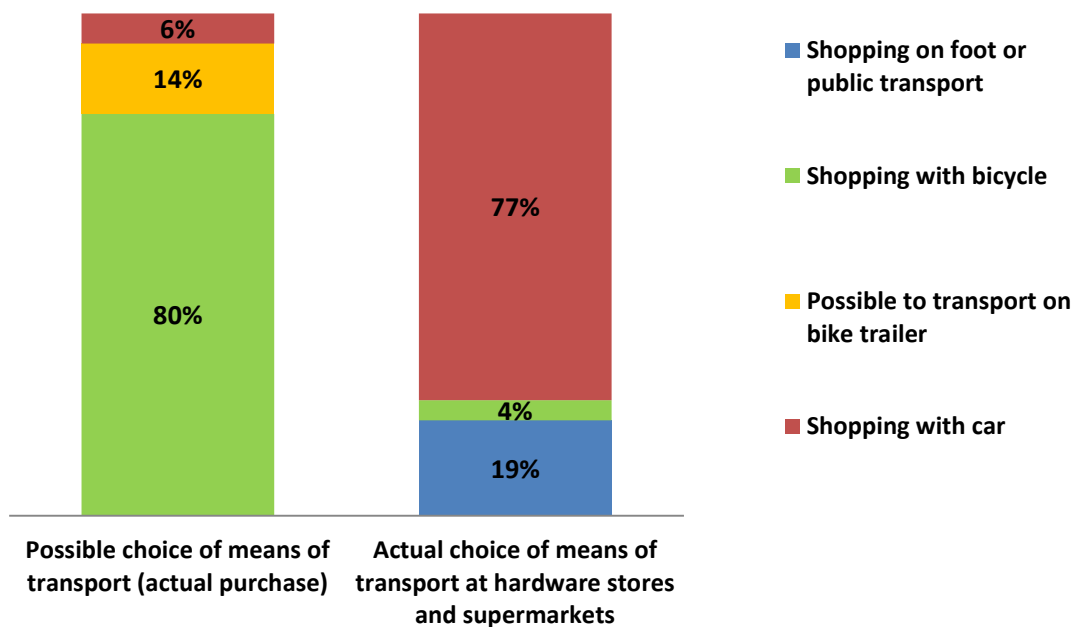


Figure 10: Possible shopping trips by bicycle compared to actual choice [data based on: ARGUS 2009]

A study in Münster (which is known as THE “German bicycle city”) came to the same conclusion. Just about 25% of the customers carry two or more bags out of the shop and therefore would need a car or at least a bike trailer for transportation. However 75% of the motorists have nothing to transport that would prevent them from using another mode of transport (e.g. cycling). Considering the distances and the quantities purchased, the study concluded that a large number of motorists could do shopping without their car.²⁴

²³ [Reiter et al. 2010, p. 17]

²⁴ [Australian bicycle council]

In addition a shopping trip with a bicycle will help to save costs which are spent by the community to compensate the environmental burden. If one person uses the bike for about 160 urban trips per year with an average distance of 4 km, savings of about 79 € for climate protection will be expected. In rural areas the British SQW institute counts with 15 €. ²⁵

Additionally every car kilometre will cost the community about 10 cents (€), but every km travelled by bicycle will bring the community a benefit of about 16 cents. ²⁶

Cyclists require less space for parking which saves considerable costs

As mentioned in the chapter about environment related benefits (chapter 1.2), the space requirement for one car parking space could be converted into 7-9 bicycle parking spaces. Companies might benefit from great cost savings if they promote cycling among their employees and customers. There are several studies about the costs of (especially car) parking. Even though specific calculations claim different costs, it is quite obvious that car spaces are multiple as expensive as bicycle facilities. In addition the promotion of cycling, internally and in public, helps to create a positive environmental friendly engagement.

Cyclists have high purchasing power

Supporting cycling customers can be quite lucrative. The British mobility-team SUS-TRANS showed that most customers live nearby the shops (in Bristol 42% in a distance of one mile and 86% in a distance below two miles). ²⁷ Furthermore the number of people arriving with the car is overestimated by the shop owners, as only 22% take the car (Bristol). ²⁸

According to the **Figures 11 & 12** below, costumers who arrive with the bicycle spend less money at every shopping trip but go shopping more frequently. The study conducted in Münster/ Germany confirms that cyclists spend 10 € more for shopping per month than motorists. ²⁹ For the seller it is even more positive as he can also save money on parking space, because cyclists need only a fraction of the space a car needs.

In Bern/ Switzerland they did a study which investigates the correlation of shopping value and current required parking space with participation of 1,200 persons. Thus cyclists are “the better customers”: Costumers on a bicycle have an average purchasing capacity of 7,500 € per m² (shop area) and car drivers spend only about 6,625 € per m² a year. It was again shown that cyclists spent less than motorists per shopping trip but they visit the shops more frequently (11 times a month as opposite to 7 times a month for motorists). ³⁰

²⁵ [Thiemann-Linden & Mettenberger 2011b]

²⁶ [Javurek 2009]

²⁷ [SusTrans 2006]

²⁸ [Thiemann-Linden & Mettenberger 2011a]

²⁹ [Reiter et al. 2010, p. 9]

³⁰ Ibid.

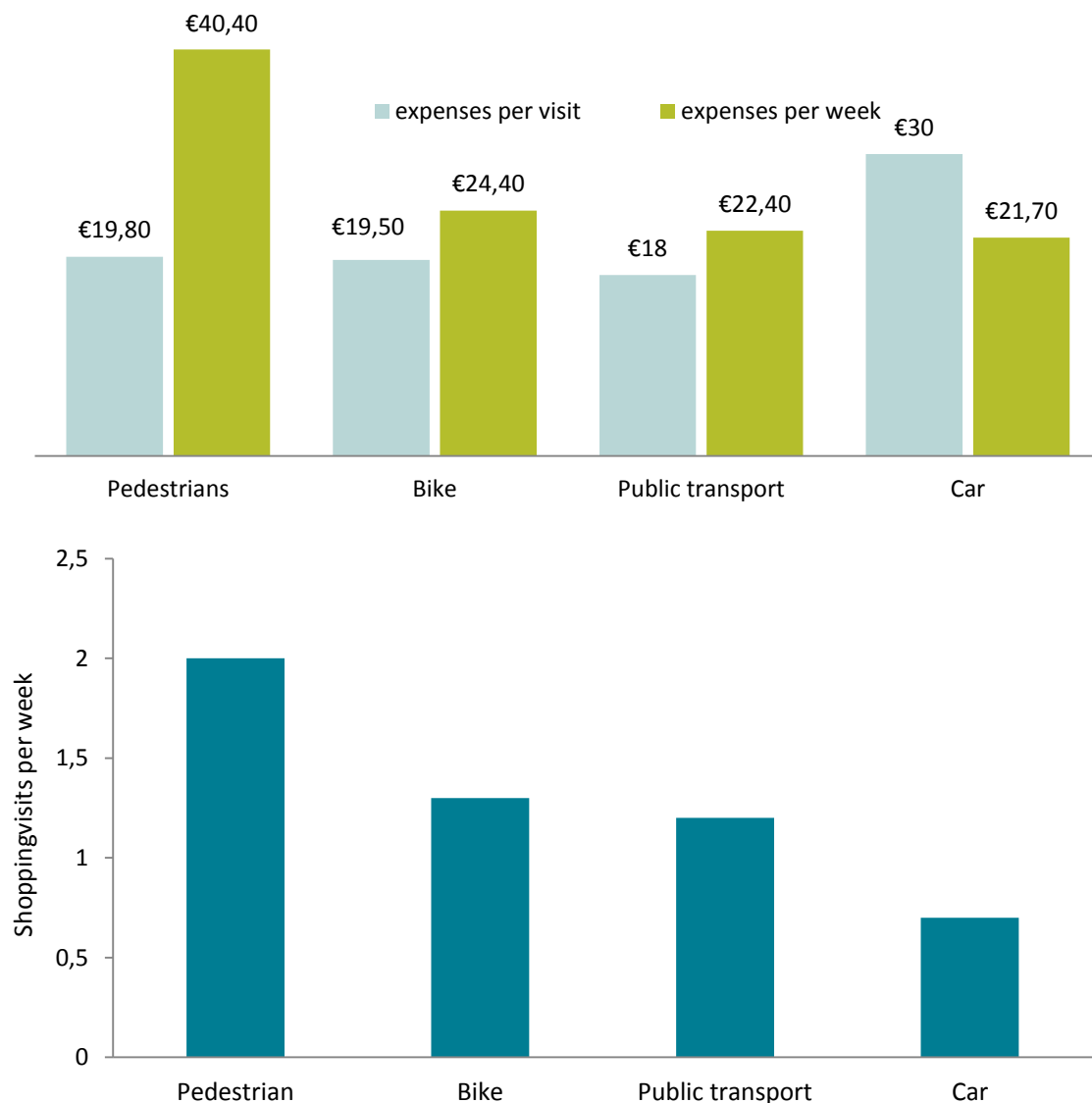


Figure 11 & 12: Shopping with different transport vehicles - Survey in 6 different French cities and regions [Thiemann-Linden & Mettenberger 2011a, p.2]

This shopping behaviour can not only be observed in Germany but in other countries as well. In Austria 80% of the cyclists (compared to 68% of the motorists) go shopping several times a week.³¹

A survey in the Netherlands (Groningen) shows that 31% of the customers are cyclists though they contribute to 34% of the turnover.³² The German wide mobility survey "Mobilität in Städten 2008" (Mobility in cities 2008) noticed that just 11% of all shopping trips are done on bike. In contrast 18% of the commuters' are cyclists (for other purposes) and 17% of the leisure traffic is on bicycle.³³ That means, obviously yet there are regular

³¹ [Gumpinger 2010]

³² [Utzmann 2004]

³³ [Thiemann Linden & Mettenberger 2011a, p. 1-2]

cyclists who just do not like to take their bicycle for shopping. Thus, there is a big potential to further attract cyclists for shopping.

Numerous independent surveys in Europe (and worldwide) came to the same conclusion. Supporting walking and cycling e.g. through traffic calming or restrictions in certain areas, has a positive effect on the retail activity. This is demonstrated by significant increases in pedestrian flow, retail turnover and profits. These benefits should always be considered when planning walking and cycling projects. Another survey in Germany investigated the influence on the turnover by measurements to support walking and cycling. In most cases the turnover increased by 5 to 20%.³⁴

To satisfy the cyclist's needs it is useful to install sheltered and lighted (guarded) parking areas in proximity to shops. Additionally shop owners can offer tyre pumps, a repair kit and maps, and provide storage facilities (with delivery service) for their customers. For example in Dresden/ Germany every fourth retailer does already offer a delivery service.³⁵

Cycling staff are the better employees

Studies from 1993 already show that companies which support cycling of their employees will profit from an increased productivity because of the improved fitness and mental well-being. Compared to other employees cycling staff is more reliable (more punctual and less sick). In one survey they found that absenteeism can even be reduced about 14% to 80% by encouraging the employees to take the bicycle. Furthermore the cyclists will be more capable and attentive during the work.³⁶

The UK Traffic Advisory Unit calculated that businesses which install facilities for bicyclists or improve their conditions, receive a benefit-cost-ratio of 1.33 to 6.50 due to an increased productivity.³⁷

*"The potential benefits of cycling to work are considerable. If the number of employees cycling regularly to work were to increase by one per cent, this would generate an annual cost saving to employers of around 27 million €. This calculation is based on a working population of about 7.4 million people and an average absenteeism cost of 280 Euros per working day."*³⁸

³⁴ [Australian bicycle council]

³⁵ [Böhmer 2006]

³⁶ [Surrey et al. 1993]

³⁷ Ibid.

³⁸ [Henriksen 2009]

Another (web based) survey on 1.236 employees found that the rate of absenteeism of the 64% cyclists (cycling more than three times a week a minimum distance of 3 km or a minimum distance of 2 km one way at least 4 times a week) was 7.4 days per year and the rate of the 37% non-cyclists was 8.7 days a year.³⁹

Supporting cycling also supports the tourism

Facilities that are provided for and encourage cycling bring tourist expenditures to regions. For example cycle tourism is an important section of tourism in Germany and reached a turnover of about 3.9 billion € in 2008/2009. Therefore this section is even more important than camping.⁴⁰

As cycle tourism often takes place in rural areas, these structurally weak locations will be strengthened. Go cycling in holiday is also a travel mode which is attractive for many target groups and very popular with older people and families.⁴¹

An investigation at the Technische Universität Dresden showed that cycling tourists spend 20% more money compared to those tourists using motorised vehicles.⁴²

Overseas, studies have shown similar benefits. In the United States:

- The Maine State Department of Transportation estimated that tourists who were cycling in the region spent \$ 36.3 million directly in 1999 and 98% of them were not even staying overnight. Taking into account the “spin over” or “multiplier” effects which appear when money flows through the regional economy this would sum up to even \$ 66.8 million per year.⁴³
- Also in Australia, there are very detailed estimates on how specific services and regions profit from cycle tourism (estimates based on national cyclists calculate with 213 million AUD/ annum which is equivalent to ~ 173 million €)⁴⁴

³⁹ [Grous & MComm 2012]

⁴⁰ [Dunkelberg & Hegemann 2009]

⁴¹ [Krauder et al. 2006]

⁴² [Böhmer 2006]

⁴³ [Maine Department of Transportation 2001]

⁴⁴ [Faulks et al. 2007]

1.4 Benefits for the community

Reduced traffic congestion and higher return on investment

During peak hours when everybody has to get to work, to school or to the kindergarten streets are overloaded. People spend their valuable time waiting in traffic jam. In many cases public transport is not an alternative (also crowded and uncomfortable during that period, no matching services etc.). However, public transport providers will not purchase additional busses and trams for only one or two hours a day, as this is economically not feasible. Hence, to attract bicycle traffic is a suitable solution to deal with the increased traffic volume in peak hours. Consequently the promotion of cycling has positive effects for all transport users. Within this context it is important not to attract motorised travel in parallel (e.g. by building new roads) as this will prevent people from switching to non-motorised transport modes.⁴⁵

Figure 13 describes the expected benefits of the reduction of motorised traffic in US Dollar-Cents per reduced motor vehicle mile. This includes every car trip shifted to non-motorised transport modes. All reductions in additional vehicle travel can enhance walking and cycling conditions and help to develop a more compact and diverse land use. The table also distinguishes different traffic loads.

Impact Category	Urban Peak	Urban Off-Peak	Rural	Overall average	Comments
Vehicle cost savings	\$0.250	\$0.225	\$0.20	\$0.225	This reflects vehicle operating cost savings. Larger savings result if some households can reduce vehicle ownership costs.
Avoided chauffeuring driver's time	\$0.700	\$0.600	\$0.500	\$0.580	Based on \$9.00 per hour driver's time value.
Congestion reduction	\$0.200	\$0.050	\$0.010	\$0.060	
Reduced barrier effect	\$0.010	\$0.010	\$0.010	\$0.010	
Roadway cost savings	\$0.050	\$0.050	\$0.030	\$0.042	
Parking cost savings	\$0.600	\$0.400	\$0.200	\$0.360	Parking costs are particularly high for commuting and lower for errands which require less parking per trip.
Energy conservation	\$0.030	\$0.030	\$0.030	\$0.030	

⁴⁵ [National Complete Streets Coalition 2010]

Pollution reductions	\$0.100	\$0.050	\$0.010	\$0.044	
Reduced pavement *	\$0.010	\$0.005	\$0.001	\$0.002	
Increased accessibility *	\$0.080	\$0.060	\$0.030	\$0.051	

* Financial relevance, if one person changes from car driving to cycling

Figure 13: Typical Values – Reduced Motor Vehicle Travel [Litman 2012a, table 21, 22]

Investments done in the field of cycling have a more positive effect on the employment in comparison to the fast road construction. This is because labour costs are relatively high compared to material costs.

A study in Austria noticed that the effect on employment is – compared to investments in motorised traffic – 4.4 times higher for measures concerning non-motorised traffic.⁴⁶

⁴⁶ [Haller 2005]

Benefits for the health care system

“Physical activity is recognised as an important element of a healthy lifestyle, reducing the risks of ill-health and premature death. For this reason physical activity has been identified as a ‘best buy’ for public health.”⁴⁷ The consequences of inactivity are high costs for the economy caused by a higher risk of diseases. A study from Great Britain found that “Illness as an outcome of physical inactivity has been conservatively calculated to be £1.08 Billion per annum in direct costs to the NHS [National Health Service] alone (2007 prices). Indirect costs have been estimated as £8.2 Billion per annum (2002 prices). [...] Indirect costs include expenditure not directly attributable to the NHS, such as informal care, inferior physical and mental function, deficient physical and mental well-being, and loss of productivity through sick leave.”⁴⁸

In a cost-benefit-analysis (CBA) of walking and cycling it is necessary to consider these health care system costs. A “Research by SQW Consulting for Cycling for England sets out a summary of the monetary values that have been estimated for one new cyclist, cycling regularly for a year. [...] The average benefit per additional cyclist is £590 per year.”⁴⁹ For a positive return on investment (1:1 or higher) in a cycling project there is a rule of thumb: “every £10,000 invested, would need to generate at least one extra cyclist, each year, over a 30 year period in order to break even. Where the effect of the intervention is likely to be shorter, the number of extra cyclists will need to be higher.”⁵⁰

According to Morris (1994) there are some studies considering the CBA of walking and cycling. “Almost all of the studies report economic benefits which are highly significant, with benefit to cost ratios averaging 13:1 (UK and non-UK).”⁵¹ Therefore the support of walking and cycling even in daily life is a good opportunity to increase the physical activity of the population and to reduce costs for health services.

A Norwegian study demonstrated that cycling creates an economically measurable benefit of 15 Cent per km covered by bike (net health benefit of cycling).⁵² As mentioned before, another study reports that every km driven by car will cost the community about 10 cents (€), but every km travelled by bicycle will bring the community a benefit of about 16 cents.⁵³ Studies conducted throughout Europe have estimated that a physically inactive person who starts to ride a bike to work instead of using a car gives an economic benefit of approximately 3,000-4,000 € per year to the community.⁵⁴

⁴⁷ [Morris 1994, p. 3]

⁴⁸ Ibid.: p. 2.

⁴⁹ Ibid.: p. 5.

⁵⁰ Ibid.: p. 6.

⁵¹ Ibid.: p. 9.

⁵² [Reiter et al. 2010, p. 20]

⁵³ [Javurek 2009]

⁵⁴ [Sælensminde 2004]

Excursus: HEAT-Health-Economic Assessment-Tool

One method for the evaluation and calculation of health benefits is the application of the Health Economic Assessment Tool (HEAT) for cycling. The tool refers to the health benefits of cycling (and walking) and was elaborated by 30 international scientists with the support of the WHO. An evaluation with this tool is very convenient and therefore applicable by non-academics as well. The corresponding questionnaire is available for free on the web page and includes 16 questions regarding the number of trips and their length, the duration and the number of participating cyclists. Furthermore the tool can calculate a benefit-cost-ratio, if the costs of the evaluated measure are known.⁵⁵

Based on several studies which discuss the effect of cycling on all-cause mortality, the tool will answer the following question:

“If x people cycle y distance on most days, what is the value of the health benefits that occur as a result of the reduction in mortality due to their increased physical activity?”⁵⁶

This way the tool can also be used beforehand in the process of planning cycle infrastructure to model the impact and value for investment of different measurement. And, the measure can also be applied to calculate the current benefits from cycling in certain cities or to workplaces. Hence with the tool you could set an exemplary calculation and the expected profit with different numbers of employees who cycle.

Certainly HEAT can also be used for the purpose of promotion to show decision makers and politics the importance of cycling. As the tool is based on data from the *Copenhagen Center for Prospective Population Studies*, the calculations refer to economic saving by reducing all-cause mortality among cyclists from the related study area. **Figure 15** shows the basic calculation of the tool. The **distance cycled in study area** is composed of the number of trips/day x the distance cycled per day x days cycled in the area.

$$1 - \left(\frac{\text{Distance cycled in study area}}{\text{Distance cycled in Copenhagen}^*} \times (1 - RR^{**}) \right)$$

* Distance cycled in Copenhagen calculated based on 3 hours per week for estimated 36 weeks/year at estimated 14km/h
 **RR = relative risk of death in underlying study (0.72) (Andersen et al., 2000)

Figure 15: Estimation of economic savings based on reduced mortality among cyclists in the study area [Rutter et al. 2007/2008]

⁵⁵ [WHO 2011]

⁵⁶ [Eder 2011]

A practical application of HEAT for cycling is the Austrian national cycling target of 10% bicycle traffic by 2015. Using this tool an annual health benefit of 811 million € and 824 “saved lives” were calculated for this objective.⁵⁷

Another practical example is from the Czech Republic:

“The level of cycling in the city of Pilsen is low, but a study by the Charles University Environment Centre (Czech Republic) showed that 2% of participants would be ready to take up regular cycling if the infrastructure were improved. Assuming an average of 2 cycling trips per day, the mortality savings from such an increase in cycling would result in discounted annual savings of €882 000. The calculation was based on a representative study on travel behaviour in 764 subjects. The study included questions on willingness to change travel means, provided certain improvements in the transport infrastructure would be made.”⁵⁸

1.5 Summary of benefit analysis

The benefits of cycling (campaigns) are numerous. One of the most dominant aspects is the increase of physical fitness. One value is a healthier society with fewer diseases and in consequence the cost of the health care system and for the health insurance will decrease. This is a strong public benefit which has an impact on everyone. Regular physical activity would also increase the life expectancy of the people.

The following **Figure 16** illustrates how all benefits for individuals, the community and the environment are connected. As seen transport funding can affect travel activity (mode choice) and many correlated consequences. An effect which seems to serve the environment is also a benefit for all individuals, because people suffer less health troubles with less noise or a lower exposure to pollution. The increase of social capital could be realised with investment in public transport which is correlated to the individual mental well-being.

All of these factors lead to financial savings on different levels as well, because healthier people do spend less medical fees and absenteeism will be less frequent.

⁵⁷ [Eder 2011]

⁵⁸ [WHO 2012]

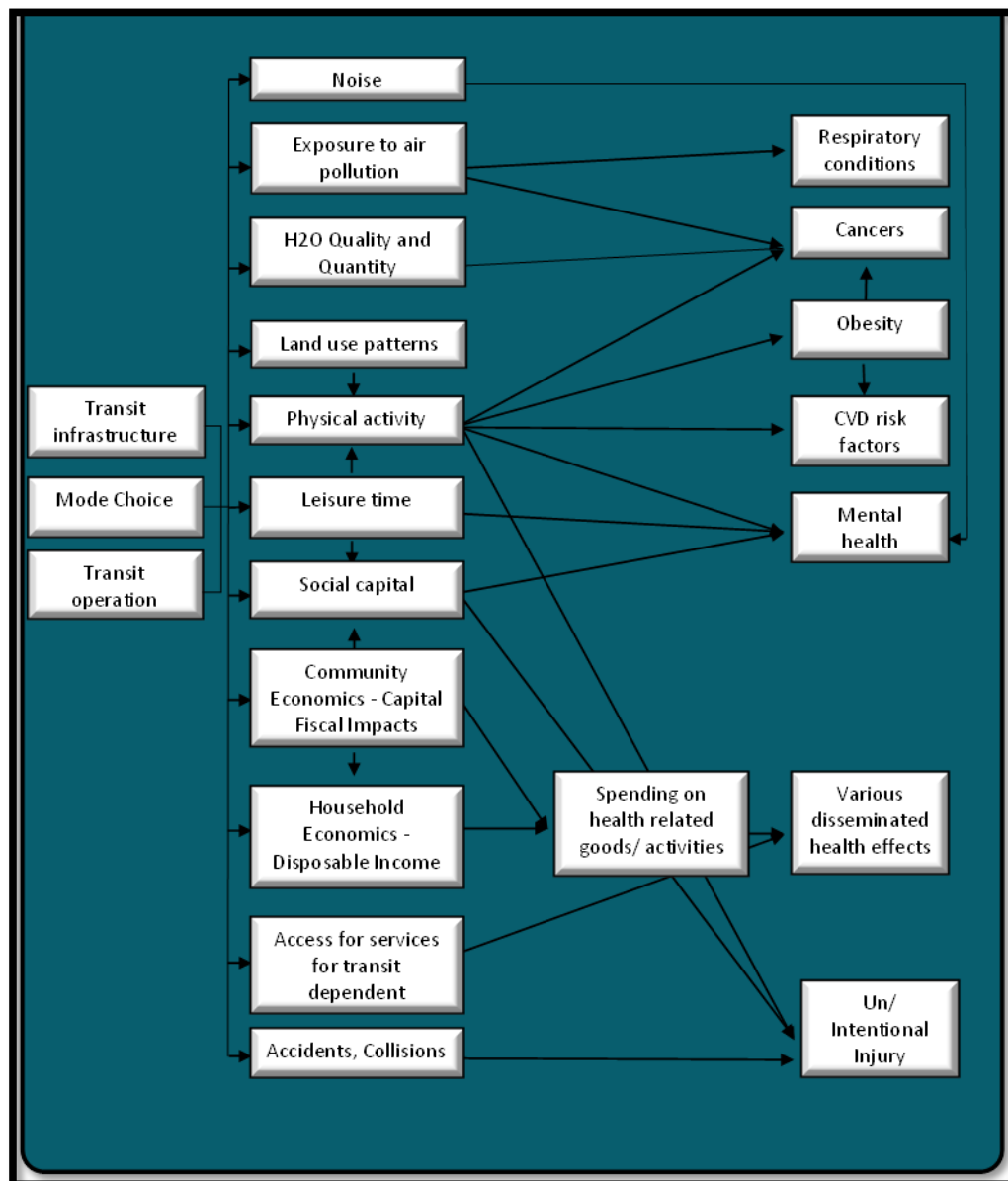


Figure 16 Transit Funding Health Impact Assessment Framework [Cole et al. 2008]

A calculation of yearly savings with cycling can be done with the assumption of a one-per cent shift from car driving to cycling. During urban rush hours savings of about \$5.60 are counted per shift from car to bike for one trip. Trip at off peak times are counted with \$2.86.⁵⁹

With the background of climate change, peak oil and congested cities, it is the time to rethink the current travel behaviour and habits. Not the environment only will be grateful about that, but also people in other countries and further generations.

⁵⁹ [Litman 2012a]

2. Cost analysis

2.1 Investments compared to modal share

As some of the arguments from the benefit analysis already show, non-motorised transport modes are not only the most environmental-friendly ones, but also the most inexpensive ones, not only for the individual. Hence with just a small financial input, a comparable huge impact can be achieved. However the following figures from Freiburg/ Germany show the significant gap between the expenses and the modal share of transport modes (**Figure 17**).

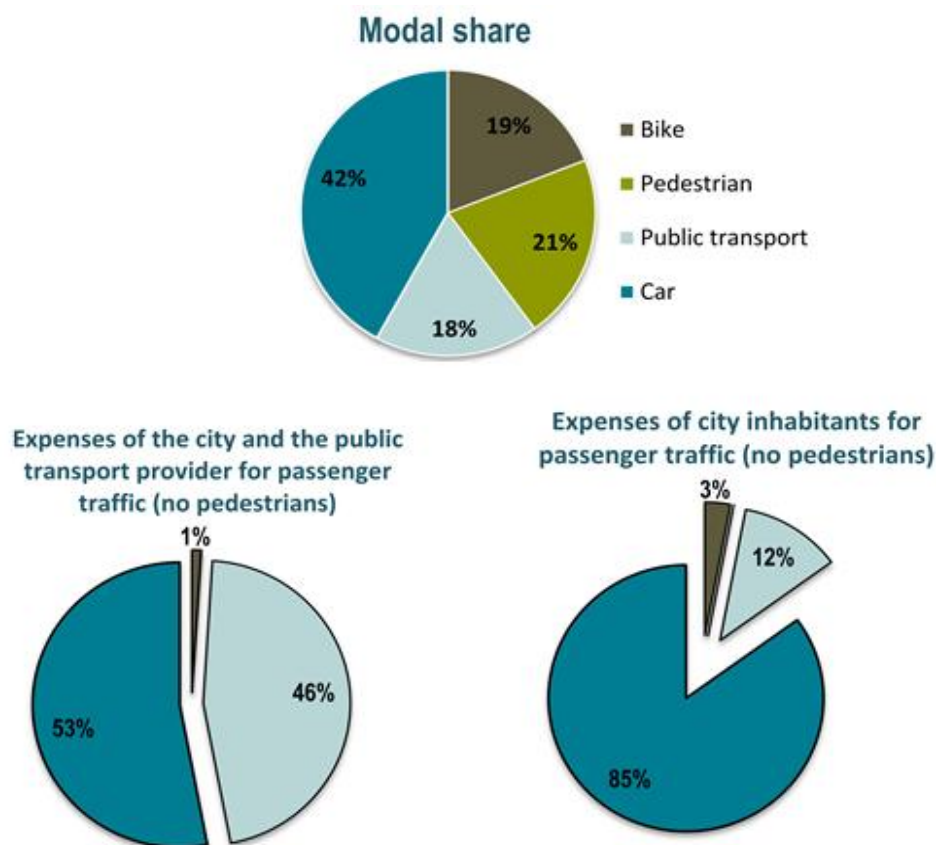


Figure 17: Modal share and expenses for passenger traffic in Freiburg/ Germany [Bracher et al. 2002, pp. 107]

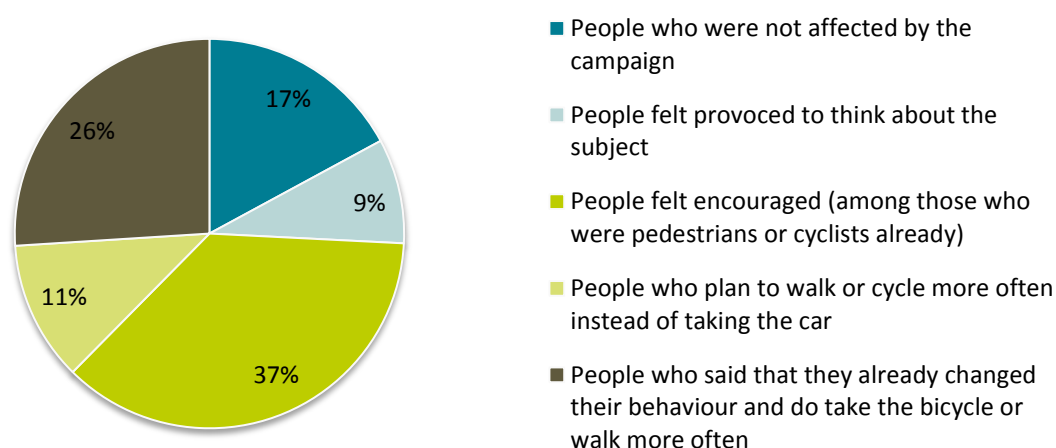
Compared to the city, even the users spend a share of expenses for cycling (3%) which indicates that probably more people would use a bicycle, if the infrastructure and the conditions would be improved.

2.2 Cost-effective promotional campaigning

Within mobility management a popular measure to foster non-motorised transport is promotional campaigning. This is a smooth way of interaction, but it can be very effective.

A very popular promotional campaign in Germany was initiated on behalf of the national ministry of ecology (Bundesumweltministerium - BMU). It was called “Kopf an – Motor aus” (“Head on – engine off”) and took place in nine cities. In 2009 four cities participated (other five cities were elected in 2010) and the feedback based on an extensive survey was mostly positive. The promotional campaign consisted of huge placards all over the cities, a lottery for cyclists and pedestrians and other actions like spontaneous hugging of cyclists and pedestrians on the street to thank them for saving CO₂.

The evaluation of the campaign (through a questionnaire beforehand and afterwards) came to the result that 95% judge the objective of the campaign to shift from car driving to non-motorised transport as positive. And more than 4 out of 5 are affected positively by the campaign (**Figure 18**).



* About 76% of the participants could remember the campaign during the survey by telephone (n = 795)

Figure 18: Effect on the people who remembered the campaign [Baedeker et al. 2010]

The evaluation also calculated that in all four cities 58,212,842 motor vehicle km could be saved every year through a shift from car driving to cycling and walking (based on a questionnaire from the telephone survey). Furthermore this leads to a CO₂ saving of about 13,649.75 t per year. Assuming that 1.2 million € were spend for the implementation, it can be calculated that 88 € have to be spend to save one ton of CO₂. This is fairly little compared to 4,000 - 4,500 € which have to be spend to save one ton of CO₂ with hybridisation of car engines. Hence even promotional activities can have a significant impact and can be very cost-effective.⁶⁰

⁶⁰ [Baedeker et al. 2010]

Another aspect of such a promotional campaign is a possible **multiplier effect** (people who noticed the measure carry on the information). Though this effect is hard to measure, a questionnaire could try to go into this aspect.

Besides promotion with a campaign in public space there exists a bunch of further options to promote cycling. An interview / a consultation of stakeholders or leaders of related communities (such as bicycle clubs) will help to carry the information and to evoke a considerable multiplier effect.

2.3 Evaluation of cycling infrastructure investments

The following **Figure 19** shows a possible process for the evaluation of (cycling) infrastructure measurement. It was developed and tested for the evaluation of the Wannsee-Route in Berlin/ Germany. In that case a new route for cyclists was constructed and the additional passenger km (respectively saved car km) were counted to contrast the expenses for the new route with the savings from operating costs, CO₂ – Emissions and material damage from accidents. With respect to all indicators which can be monetised, a benefit-cost-ratio can be calculated for such a contrast. As this quotient shows the relation between the advantages that turned out afterwards and the costs that had to be invested, it is a meaningful and descriptive method. Furthermore a benefit-cost-ratio can be used for a prognosis: Which amount of shifts would be necessary for a certain benefit-cost-quotient?

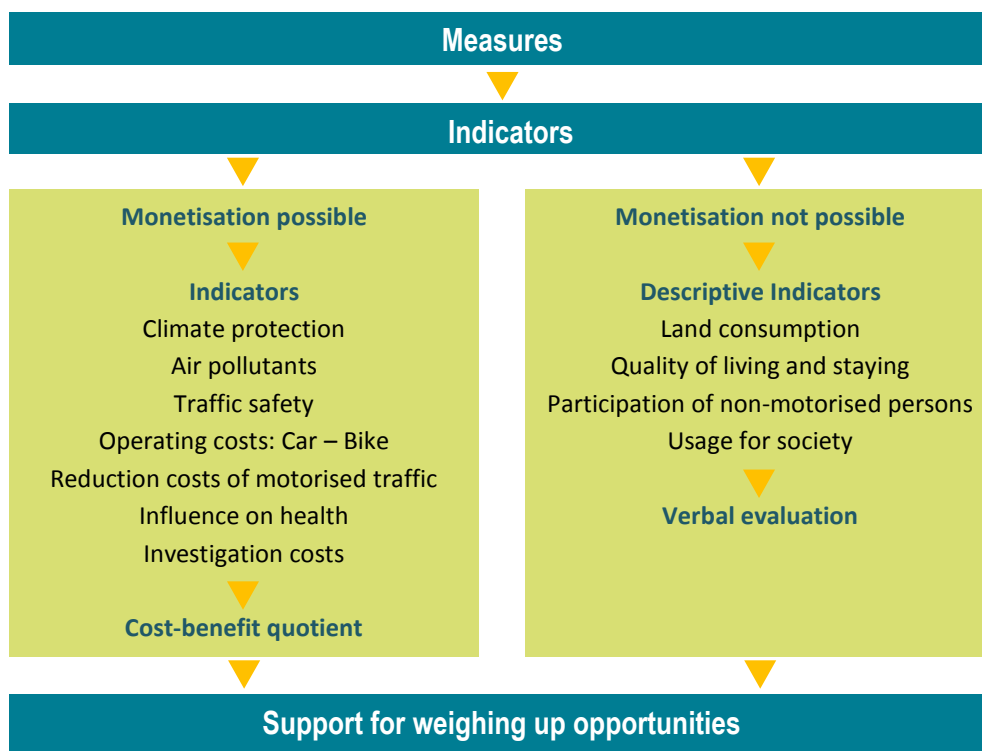
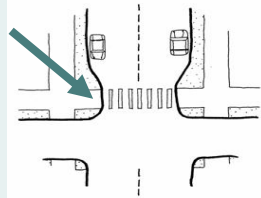


Figure 19: Process for benefit-cost-analysis using the example of Wannsee-Route in Berlin/Germany [Schäfer et al. 2008]

The following **Figure 20** offers information on the expenses of certain cities in Germany for motorised traffic and cycle traffic. It can be used for an orientation on the infrastructure costs. Furthermore cost for additional facilities like parking spaces or speed humps are mentioned.

As a result of the low space requirements and the significantly smaller axial loads, bicycle traffic is by far less costly. However the costs depend on the local conditions and for a reliable prognosis on the cost they have to be calculated for each case study separately.

	Bike traffic	Motorised traffic	Comment
Costs for a one-km drive way in one direction	100,000 – 200,000 € (with or without included walk-way)	450,000 ... 700,000 € (inner-city streets, no highway)	
Costs of operation and maintenance		~ 4,500 € for 1km urban road (cleaning, winter service, landscaping for 1,000 m ² /km and maintenance)	Driving 1km costs 10 Cents for the public, cycling saves 16 Cents (see above)
One urban parking space *	200 € (without roof) 750 € (sheltered)	5,000 ... 10,000 €	
Parking in underground car park or garage *	700 ... 1,500 €	> 60,000 €	
Operating costs for bike parking spaces (110 h / week opening)	60,000 €/year		
Total costs to become a cycle friendly city	max. 205€/ inhabitant (e.g.: 133 €/ inhab. in Münster/ Germany)		For every € spend for bicycle traffic, 3-5 € are saved in the sector of health care.
Municipal subvention for motorised traffic (total expenses – revenues in 2000)		Per inhabitant and year Bremen (DE): 11 € Dresden (DE): 123 € Stuttgart (DE): 145 €	
Expenses for bike traffic (1998 - 2000) per inhabitant an year	Hamburg (DE): 1.60 € Dresden (DE): 3.00 € Münster (DE): 3.70 € Dessau (DE): 22.10 € Delft (NL): 12.80 €		

	Basel (CH):	14.30 €	
Average economic speed: ⁶¹ Yearly driven km ----- expenditure of time additional to driving time	12km/ h	Total car traffic: 17km/h Car traffic in cities: 6km/ h Traffic of cars authorised in the city: 11km/h	
Dynamic land consumption: ⁶² = (length of vehicle + stopping distance) x width	6.2 m² (15km/ h)	Divided through average number of passengers 82 m² (100km/ h) 30 m² (50km/ h)	Pedestrian: 1.6 m² (5km/ h)
Dividing strip		\$150-200 per linear foot	
Curb bulbs		\$10,000-20,000 per bulb	
Speed humps		\$2,000 per hump	
Traffic signals		\$15,000-60,000 for a new signal	
Traffic signs		\$75-100 per sign	
Traffic circles		\$4,000 for landscaped circle on asphalt street and \$6,000 on concrete street.	

* See also Figure 21

Figure 20: Expenses for bike and motorised traffic, a compilation of [ICLEI 2001], [Staatsministerium für Wirtschaft und Arbeit Sachsen 2005, p. 5], [Schmidt 2002, p. 34, 192], [Litman 2012a, table 15], [seattle.gov], [Hessischer Rechnungshof 2007]

The following [Figure 21](#) is dedicated to parking costs and summarises different sources and circumstances considered. The price for car parking depends very much on the location (urban or rural), the type (roof protection, underground or garage) and equipment (security etc.).

⁶¹ To calculate the average economic speed the yearly driven km are divided by the total time related effort. Thereby this effort consists of the travel time + financing (conversion of cost into time with average net wages per hour) + time investment for maintenance + lost lifetime because of accidents. [Schmidt 2002, p. 34, 192]

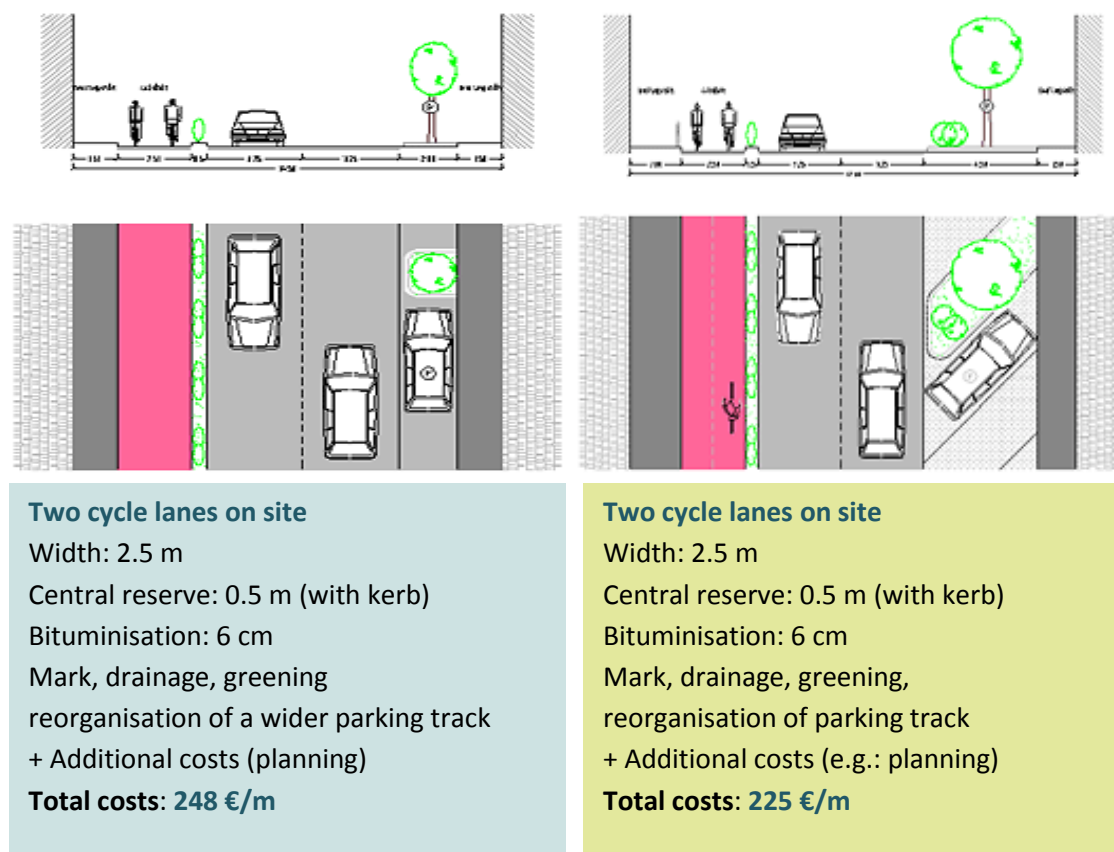
⁶² The dynamic land consumption (land consumption of the moving traffic) can be calculated by adding the length of the vehicle (or the step length) and stopping distance. Afterwards this value has to be multiplied with the width. For calculation with cars the value has to be divided through the average car occupancy rate [Schmidt 2002, p. 34, 192]

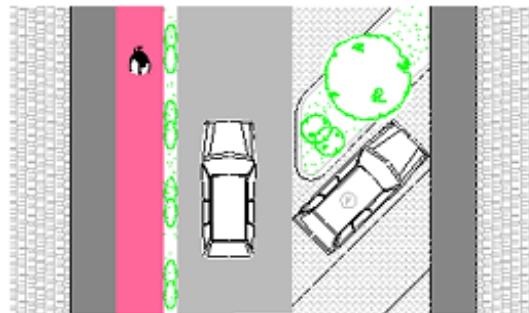
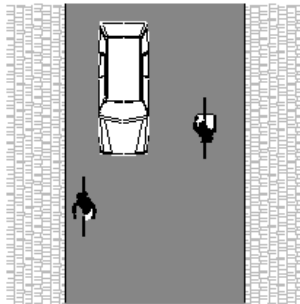
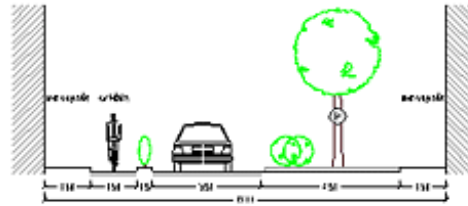
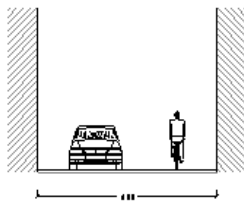
Common parking space	Parking space with roof	Underground parking	
3,000 €	8,000 €	16,000 €	VCÖ 2005
2,000 – 3,000 € (37.50 € running costs per space and year)	4,000 – 8,000 € (parking module)	Parking deck (automatic): 8,000 – 14,000 €* Parking deck: 10,000 – 15,000 € Underground garage: 15,00 – 25,000 € (running costs per space and year)	Sagolla 2006
<i>“The average costs of a space in a parking garage with several decks are about 5,000€. With a very efficient construction method these costs may be reduced to about 3,000€ per parking space. However they may also rise to about 10,000€ depending on the local conditions, additional facilities and on the aesthetic requirements”</i>			AcelorMittal 2011
3,000 € for 25m ² (180 € for yearly maintenance) and 1,000 € for a bicycle parking space (8 € for yearly maintenance)			Ritscher 2009

* plus the costs for the land (significant difference between urban and rural parking) and operating costs of about 50 – 150 € per parking space and month

Figure 21: Comparison of parking costs (Costs related to car parking, if not indicated differently)

There are several ways to combine bicycle and car traffic in street design that also influence the investment costs. The following **Figure 22** shows the investment costs of streets with integrated cycle lanes for different profiles. Depending on the intensity of traffic sometimes the car lanes and the cycle lanes should be separated for example with the help of a green strip.





Mixed traffic

Width: 4.5 m

Mark

+ Additional costs
(e.g.: planning)

Total costs: 25 €/m

Single cycle lane against the one way

Width: 1.5 m

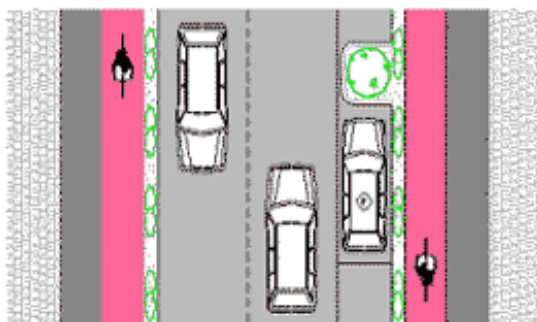
Central reserve: 0.5 m (with kerb)

Bituminisation: 6 cm

Mark, drainage, greening, reorganisation
of a wider parking track

+ Additional costs (e.g.: planning)

Total costs: 240 €/m



Two cycle lanes on both sites

Width: 1.5 m

Central reserve: 0.5 m (with kerb)

Bituminisation: 6 cm

Mark, drainage, greening, reorganisation
of parking track

+ Additional costs (e.g.: planning)

Total costs: 324 €/m

Figure 22: Profiles and investment costs of cycle lanes [Theil 2002]

2.4 Individual costs

Cyclists need equipment and should be physically fit themselves, too. But the expenses are relatively small, especially compared to the expenses for car use. A new bike might cost about 500 € and requires further 100 € for maintenance every year for 5,000 km ridden in one year. Such a bike should last at least 10 years which means that an average km would only cost about 0.03 € $([500 \text{ €} + 10 \text{ years} \cdot 100 \text{ €}] / [5000 \text{ km} \cdot 10 \text{ years}])$.⁶³ In fact many people already have a bicycle which they could use more. Thus, marginal costs of increased cycling are smaller.

However all kinds of transportation base on energy consumption, but instead of petrol, cycling requires food. Although food is more expensive than petrol, smaller amounts are sufficient (for one km 50 calories would be burned by someone who weighs about 70kg – this corresponds to the calories of a half slice of bread). Furthermore people usually enjoy this extra level of fitness as they enjoy eating. Hence it is rather a pleasure to consume energy in form of food.⁶⁴

⁶³ In comparison, the costs of a VW Golf can be calculated with 0,35 €/km. [Die Einsparberater 2012]

⁶⁴ [Litman 2012a, p. 44]

3. Summary of non-motorised transport's benefits and costs

Figure 23 summarises various benefits and costs of non-motorised transport that should be taken into account for the evaluation of (investments in) transport systems. It is an overview of the arguments given in the benefit analysis above with some added costs statements.

Impact Category	Description	Benefits *
Improve NMT Conditions	Benefits from improved walking and cycling conditions	
User benefits	Increased user convenience, comfort, safety, accessibility and enjoyment	\$0.25/ mile
Option value	Benefits of having mobility options available in case they are ever needed	\$0.35/ mile
Equity objectives	Benefits to economically, socially or physically disadvantaged people	\$0.35/ mile
Increase NMT Activity	Benefits from increased walking and cycling activity	
Fitness and health	Increased physical fitness and health	\$0.2/ mile (\$0.5/ mile for walking)
Reduced Vehicle Travel	Benefits from reduced motor vehicle ownership and use	
Vehicle cost savings	Consumer savings from reduced vehicle ownership and use	\$0.20/ mile
Avoided chauffeuring	Reduced chauffeuring responsibilities due to improved travel options	
Congestion reduction	Reduced traffic congestion from automobile travel on congested roadways	\$0.02/ mile
Reduced barrier effect	Improved non-motorised travel conditions due to reduced traffic speeds and volumes	
Roadway cost savings	Reduced roadway construction, maintenance and operating costs	\$0.05/ mile
Parking cost savings	Reduced parking problems and facility cost savings (assuming 1-mile average trip length)	\$1.00/ mile
Energy conservation	Economic and environmental benefits from reduced energy consumption	\$0.04/ mile
Pollution reductions	Economic and environmental benefits from reduced air, noise and water pollution	\$0.05/ mile (air) \$0.03/ mile (noise)
Land Use Impacts	Benefits from support for strategic land use objectives	
Pavement area	Can reduce road and parking facility land requirements	
Development patterns	Helps to create more accessible, compact, mixed, infill development (smart growth)	
Economic	Benefits from increased productivity and employment	

Development		
Increased productivity	Increased economic productivity by improving accessibility and reducing costs	
Labour productivity	Improved access to education and employment, particularly by disadvantaged workers.	
Shifts spending	Shifts spending from vehicles and fuel to goods with more regional economic value	
Support specific industries	Support specific industries such as retail and tourism	
Costs	Costs of improving non-motorised conditions	
Facilities and programs	Costs of building non-motorised facilities and operating special programs	
Vehicle traffic impacts	Incremental delays to motor vehicle traffic or parking	
Equipment	Incremental costs to users of shoes and bicycles	
Travel time	Incremental increases in travel time costs due to slower modes	
Accident risk	Incremental increases in accident risk	\$0.04/mile

* monetised benefits of 1,000 miles shifted from motorised to non-motorised travel under urban off-peak conditions. Since many benefits are not monetised, total benefits are probably larger. The benefit can also be calculated per commuter (average distance: 5 miles).

Figure 23: Summary of non-motorised transport benefits and costs [Litman 2012a, table ES-1, 19, 20, 25]

To foster non-motorised traffic (particularly an advanced infrastructure for bicycles) needs consideration of the factors which affect cycle traffic. Furthermore there are certain areas and certain target groups with a higher demand. Demographics, economics, the condition of walking and cycling paths, the quality and the price of alternatives, and land use patterns are such factors.⁶⁵ These aspects should be considered for a successful implementation of non-motorised traffic measures and a shift of transport modes in favour of cycling (Figure 24).

⁶⁵ [Dill & Giebe 2008, p.11]

Factors Bicycle	Travel Impacts
Age	Bicycle use increases until middle age and then decreases. Cyclists tend to have lower average age than non-cyclists.
Gender	Men tend to cycle more than women.
Education	Bicycle use increases slightly with education.
Students	Students tend to bicycle. Schools, colleges and universities are major bicycle trip generators.
Vehicles	People without a car available are more likely to cycle.
Drivers licenses	People who cannot drive are more likely to cycle.
City size	A population of less than 100,000 appears to offer a better environment for cycling, and so may have higher rates of cycling than larger cities.
Employment status	Higher unemployment is associated with more cycling.
Professional status	Among employed people, professionals and managers appear more likely to cycle than blue collar and sales workers
Household income	Utilitarian cyclists tend to have lower average incomes compared with non-cyclists. Recreational cyclists tend to have higher than average incomes.
Trip length	Cycling is most common for short trips (<5 mile).
Parking fees	Commuters who must pay for parking may be more likely to bicycle.
Facility conditions	Bicycle facilities (paths and lanes) and roadway conditions considered favourable for cycling tend to increase bicycle travel.
Travel costs	Market trends or policies that increase vehicle travel costs may increase bicycling.
Bicycle parking	Secure bicycle parking may encourage cycling.
Community values	Some communities support utilitarian cycling more than others.

Figure 24: Factors Affecting Bicycle Travel Demand [based on Levitte 1999]

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