ERASMUS UNIVERSITY ROTTERDAM – Erasmus School of Economics

Bachelor Thesis Urban, Port and Transport Economics

A comparison between the quantified effect of a bicycle allowance on presenteeism and absenteeism and the costs for employers

Name student: F. Olde Damink

Student ID: 543851

Supervisor: M. J. A. Gerritse

Second assessor:

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Abstract

This paper compares the quantified effect of a bicycle allowance on presenteeism and absenteeism to the costs of the allowance for employers. The aim of this study is to offer an understanding of the expenses and revenues related to a bicycle allowance, considering the recent *Kies de Fiets!* campaign by the Dutch government. Through their campaign, the Dutch government aims to increase the number of commuter cyclists by 10%. This should mainly be accomplished by incentivizing commuter cycling amongst employees. One of the most significant incentivizes is the bicycle allowance.

Firstly, it was concluded that employees who would shift transport modes because of the bicycle allowance live at an average distance of 11,11 kilometers from their work. This implies that the average yearly costs for employers of the allowance are €764,94 per mode shifting employee.

Thereafter, it could be determined that the average increase in weekly MET-minutes from the modal shift is 960. The decrease in work impairment for regularly active people (3.526,6 MET-minutes weekly) could not be measured. For inactive people (weekly MET-minutes <600), the modal shift leads to a decrease of 1,1% in presenteeism and absenteeism. This is equal to a yearly revenue of €2.015,88 per mode shifting employee. Therefore, the conclusion could be drawn that for an averagely active employee the costs of the modal shift are €764,94 each year, while for an inactive employee the revenues are €1.250,93 each year.

The views stated in this thesis are those of the author and not necessarily those of the supervisor, second assessor, Erasmus School of Economics or Erasmus University Rotterdam.

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1. Introduction

Governments all around the world are constantly trying to decrease the emission of greenhouse gasses and increase the health of their citizens. Incentivizing cycling is a suitable method to achieve both aims simultaneously. A person living ten kilometers from their work will prevent the emission of 440 kilograms of CO_2 yearly by commuter cycling. This amount of CO_2 is equal to the quantity twenty-two trees take up in one year (Gemeente Heerlen, 2023). Additionally, cycling improves physical as well as mental wellbeing. 80% of commuters who cycle to work meet the recommended exercise guideline for good physical health published by the Dutch government just by commuting (De Haas & Van den Berg, 2019). However, 42,3% of all Dutch citizens aged 18-65 do not meet this guideline (CBS, 2020). Meeting the guideline is a matter of great importance, as it decreases the risk of catching diseases such as diabetes, heart disease and multiple types of cancer (World Health Organization, 2020). Furthermore, research has proven that increased levels of physical activity enhance the mental wellbeing of the population and reduces the risk of developing a mental illness (Ekholm et al., 2022).

The Netherlands is the unrivalled number one when it comes to the proportion of total trips travelled by bicycle. In 2018, 27% of all trips were bicycle trips, leaving runner-up Denmark (18%) and Germany (10%) far behind (Harms & Kansen, 2018). Despite this, approximately 1500 deaths in The Netherlands are caused by insufficient levels of physical exercise each year. The impact of air pollution on our health is even greater, causing over 4500 deaths yearly (OESO & European Observatory on Health Systems and Policies, 2021) (StatLine, 2022). Polluted air caused by vehicle emissions is estimated to be the cause of one in five cases of asthma in Dutch children (Van Dongen, 2019). It is therefore not surprising that the Dutch government often promotes and incentivizes cycling among its citizens.

On the 18th of July 2022, the Ministry of Infrastructure and Water Management presented the *Nationaal Toekomstbeeld Fiets* to the House of Representatives. The aim of this policy is to increase the number of commuters cycling to work with 100.000 at the start of 2025, with January 2022 as the reference month. Cycling should become the most attractive transport mode for all trips shorter than 15 kilometers. This will be accomplished by the expansion of cycling infrastructure, improvement of bicycle parking and the overall stimulation of cycling. Aside from the government, encouragement to choose the bicycle should mainly derive from employers. The *Kies de Fiets!* campaign, a part of the *Nationaal Toekomstbeeld Fiets,* was created to encourage employers to stimulate cycling among its employees (Heijnen, 2022) (APPM & Tour de Force, 2023). The desired result of *Kies de Fiets!* is to increase the number of commuter cyclists by an additional 10% before 2025. Employers can (financially) stimulate employees by for example implementing a bicycle allowance per kilometer, providing sufficient bicycle parking space with charging stations and ensuring the availability of showers (Rijksoverheid, 2022).

The *Kies de Fiets!* campaign was created with the intention to spread awareness among employers about the benefits of employees cycling to work. An employee choosing the bicycle as a transport mode takes up less parking space than employees traveling by car, is less prone to absence through illness, has a higher productivity while working and can cause a decrease in other car-related expenses (Werken in Beweging, 2021). Cycling thus increases the overall productivity of employees by decreasing absenteeism and presenteeism.

Research by MuConsult (2019) has shown that if all employers would provide a bicycle allowance of 19 Euro cents per kilometer, the total number of employees cycling to work would increase by 14%. This would mean that the aim of the *Kies de Fiets!* campaign would be achieved. To convince employers to provide this allowance, an estimation of the average costs and benefits per employee receiving the allowance should be provided. There are several studies that have quantified the benefits of physical activity. Hafner et al. (2020) concluded that an increase in physical activity would lead to productivity gains, especially through lower presenteeism. This would lead to a yearly increase in global gross domestic product (GDP) of 0,15% - 0,24%. Additionally, Hendriksen et al. (2010) concluded that commuter cycling leads to an average decrease in absenteeism of 1,3 days yearly. Previous research therefore implies that cycling increases productivity, which could lead to financial benefits for employers. It may therefore be advantageous for employers to introduce commuter cycling initiatives.

It has been proven that cycling has a positive effect on the productivity of employees. The difference between the average costs of a bicycle allowance of 19 Euro cents per kilometer for employers and the quantified increase in productivity, has however not yet been measured. Hence, a void in the literature on this topic exists. Filling this research gap can contribute to evidence-based decision making and policy making by the Dutch government. Therefore, this paper's research question will be:

To what extent do the financial benefits caused by the decrease in absenteeism and presenteeism as a result of a modal shift to cycling compensate for the costs of a bicycle allowance of 19 Euro cents per kilometer?

To answer this research question, this paper will first discuss the most important theory on bicycle allowances, MET-minutes, presenteeism and absenteeism. Thereafter, previous research done on the effect of physical activity on productivity will be reviewed. This will follow in an overview of the data and methods that will be used to formulate an answer to the research question. This section will first discuss in what way the average distance to work for employees who would shift modes as a result of the implementation of a bicycle allowance (modal shifter) will be calculated. This information will be used to compute the average yearly costs of a bicycle allowance per mode shifting employee. Hereafter, the average time spent cycling will be determined. With this information, the average increase in weekly MET-minutes for modal shifters can be measured. Lastly, the average increase in MET-minutes will be used to calculate the decrease in absenteeism and presenteeism, which will be used to determine the monetary benefits for employers. After all these values are computed, an answer to this paper's research question can be formulated.

2. Theoretical Framework

2.1 Bicycle allowance impact assessment

Through the *Kies de Fiets!* campaign, the Dutch government promotes the provision of a bicycle allowance by employers, as it increases the productivity of employees and decreases the emission of greenhouse gasses and health costs. The aim of this research is to calculate the difference between the benefits from increased productivity and costs of a bicycle allowance for employees that would shift to modal cycling when their employer would implement a bicycle allowance. The Netherlands, employers are allowed to provide a travel allowance for their employees. This allowance can be given for kilometers traveled by public transport, car, or bicycle.

2.1.1. Bicycle Allowance and Costs

The magnitude of the bicycle allowance depends on the number of kilometers the employee cycles to and from work. In this paper, the allowance each employee will receive will be 19 cents per kilometer, as this was the maximum allowance employers were allowed to give until 2023 (Belastingdienst, 2023). Additionally, the survey data by MuConsult (2019) that will be used is based on an allowance of 19 cents per kilometer. The aim of this paper is to measure the financial consequences of the implementation of a bicycle allowance for employers who do not currently provide this allowance. Therefore, the number of cycled kilometers used in this research is the average number of kilometers employees who would shift transport modes would cycle when their employer would provide an allowance. It is thus only made up of the average cycling distance for mode shifting employees. This papers first sub question is:

1. What is the effect of the provision of a bicycle allowance of 19 Euro cents per kilometer on the average number of kilometers cycled?

A report set up on behalf of the Dutch tax authorities concludes that currently, only 13% of all employers offer a bicycle allowance per kilometer. Research based on results from the survey *Beter Benutten Vervolg 2018,* carried out by the Ministry of Infrastructure and Water Management, predicts that the number of employees who would cycle to work would increase by 14% when all employees would receive a bicycle allowance. Additionally, results from this survey show that the distance to and from work for modal shifters is relatively large compared to the current average for cyclists, which is 7,3 kilometers (MuConsult, 2019) (CBS, 2022). This is understandable, since the financial incentive is higher for employees who live further from their work. Since research has hinted that the distance from work for modal shifters is greater than the current average modal cycling distance, this paper will firstly hypothesize the following:

Employees who shift transport modes resulting from the provision of a bicycle allowance of 19 Euro cents per kilometer live further from work than the current average distance for commuter cyclists.

2.1.2. The metabolic equivalent of task (MET)

Measuring the increase in physical activity as a result of the modal shift to commuter cycling is necessary to determine the decrease in presenteeism and absenteeism. An effective approach to do this is by measuring the weekly MET-minutes of employees before and after the modal shift. The metabolic equivalent of task (MET) can be used to rate the intensity of physical activities. The increase in productivity will thus be determined based on the increase in MET-minutes. This method has also been used by Hafner et al. (2020) in their research on the influence of physical activity on global economics. It is additionally used by the World Health Organization (2022) to indicate the minimum level of physical activity a person should engage in. The MET measures the intensity of physical activity in multiples of the energy that a body requires when resting. The MET for a minute is thus 1 when a person is sitting quietly or lying down while relaxing and 0,9 while sleeping (Harvard, 2022).

The absolute intensity of METs can be divided into three main categories, namely lightly intense physical activities, moderately intense physical activities, and vigorously intense physical activities. Light intensity physical activity covers activities that demand a person to stand up or make light movements. This includes all physical activities with a MET smaller than 3, for example sitting while typing (1,8) and strolling (2,3). Moderate intensity includes activities that take some effort but still allow a person to have a conversation. This category covers all physical activity with a MET between 3 and 6, examples being pilates (3,8) and commuter cycling (4). Lastly, vigorous intensity is defined as activities leading to heavy breathing or even panting, depending on a person's level of fitness. Under this category, all physical activities with a MET higher than 6 are included. Examples of exercises that are vigorous intense are running (8) and rope jumping (10) (CBS, 2018) (OMICS, 2019).

Thus, to measure the decrease in work impairment after the modal shift, information on the increase in MET-minutes is needed. This brings us to this papers' second sub-question:

2. How much will an employee's weekly MET-minutes increase as a result of the modal shift to commuter cycling?

As previously stated, the employees who would shift modes after being offered a bicycle allowance live further from work than the current average for modal cyclists. Therefore, most of the modal shifters will trade public transport or cars for bicycles. Some employees may have gotten some physical activity before the shift by walking (parts) of the commute. Nevertheless, it is expected that most employees will experience increased physical activity levels following the modal shift. Hence, this paper will hypothesize the following:

The provision of a bicycle allowance will lead to an increase in the number of weekly MET-minutes for modal shifting employees.

2.1.3. Cycling and Presenteeism

Frequent exercise increases mental health, energy levels and the functioning of the brain. This is because the majority of your braincells house mitochondria, which are often described as the cell's "power plants". These mitochondria generate ATP, a chemical that serves as the body's energy source. Engaging in physical exercise stimulates the creation of fresh mitochondria within your cells, enabling your body to produce more APT gradually. This not only enhances your physical stamina, but also increases your mental abilities. This effect can also be seen after a low-intensity workout (Pozen, 2012). Frequently engaging in physical exercise can thus lead to a decrease in presenteeism. Presenteeism refers to a situation where employees experience reduced productivity while at work due to injuries, illnesses or other conditions. Despite being physically present in the workplace, these employees may struggle to fulfill their duties effectively and are prone to making mistakes. Although not as closely monitored as absenteeism, the economic impact of presenteeism is believed to be more significant, especially since the productivity of employees dealing with long-term conditions often consistently declines (Kenton, 2023). Cycling to work increases the physical activity of employees and can thus lead to a decrease in absenteeism. This increased employee productivity is often beneficial for employers. This leads us to the third sub-question:

3. What is the quantified effect of the decrease in presenteeism as a result of the increased number of cycled kilometers due to the provision of a bicycle allowance?

When looking at previous research about the effect of physical exercise on presenteeism, it can be seen that even though most research confirms that physical activity increases presenteeism, the magnitude of the effect still varies largely between the studies. In one of the most recent studies on this matter, Hafner et al. (2020) used survey data on over 120 thousand individuals to determine the effect of physical activity on productivity at work. They concluded that if every adult individual on the planet would engage in moderate exercise for at least 150 minutes each week, the GDP would increase by 314 to 446 billion American dollars annually. This would partly be caused by a decrease in health costs and a decrease in absenteeism. However, the majority of the increase in GDP (227 billion American dollars) would be caused by the decrease in presenteeism. Additionally, results from research done by Hampson et al. (2017) shows that presenteeism costs the United Kingdom 17-26 billion British Pounds yearly. Due to the information gained by looking at this past research, this paper hypothesizes the following:

The increase in physical activity due to the provision of a bicycle allowance per kilometer for employees will lead to a decrease in presenteeism.

A decrease in presenteeism can be quantified by determining the decrease in productivity. To what extent an increase in physical activity leads to a decrease in productivity due to presenteeism depends on the increase in minutes of moderate-intensity physical activity.

2.1.4. Cycling and Absenteeism

Research has proven that increased physical activity decreases absenteeism (Hendriksen et al., 2010). One of the main reasons for this is that physical activity reduces the risk of many chronic illnesses such as type 2 diabetes, heart disease and cancer (CDC, 2023). Absenteeism is often defined as the consistent absence of an employee from their workplace. Absenteeism goes beyond the acceptable number of days away from the office for legitimate reasons like pre-planned vacations, occasional illness and family emergencies. Consistent absence refers to a continuous pattern of absenteeism that exceeds the acceptable limits (Kenton, 2022). For this research, absenteeism will be defined the way Hafner et al. (2020) have defined it in their research. It includes all-cause absenteeism and all lengths of absence. Additionally, the number of absent days include weekends and the reductions in hours worked as a result of illness. The assumption that the provision of a bicycle allowance of 19 cents per kilometer for all employees would lead to more cycling and the proof that cycling to work decreases absenteeism leads to the third sub-question:

3. What is the quantified effect of the decrease in absenteeism as a result of the increased number of cycled kilometers due to the provision of a bicycle allowance for all employees?

When examining the outcomes of previous research done on the effect of cycling on absenteeism, the following can be found. Hendriksen et al. (2010) concluded that cycling to work decreases the average number of absent days with over one day each year compared to non-cyclists. They also concluded that employees who cycle longer distances and cycle more often are even less prone to absence. Additionally, Amlani and Munir (2014) provided a review of all research done on the effect of physical activity on absence among employees. The outcome of this research suggests that absenteeism can be reduced by increased physical activity. Lastly, Losina et al. (2017) concluded that the rate of illness-related absenteeism rises as physical activity decreases. Consequently, as a result of the outcomes generated by past research, this paper will hypothesize the following:

The increase in physical activity due to the provision of a bicycle allowance per kilometer for employees will lead to less absenteeism.

2.1.4. Conceptual Framework

As mentioned before, there are several benefits for employers resulting from employees commuting by bicycle. Employers might save on parking costs, fuel/maintenance/allowance costs for cars, allowance costs for public transport and experience benefits from a decrease in absenteeism and presenteeism (Werken in Beweging, 2021). This research will only consider the benefits of the decrease in absenteeism and presenteeism, as the other benefits vary heavily between employers (BBOF & Belastingdienst, 2022). The other benefits for employers will also be present when more employees commute by bicycle. However, they will not be considered in this research.

This research will only discuss the costs from the bicycle allowance and gains from the decrease in absenteeism and presenteeism for employees persuaded by the allowance. Therefore, only the effects of a bicycle allowance on employees who do not cycle currently and whose employers do currently not provide a bicycle allowance will be considered. The map of the conceptual framework that will be used is shown in
figure 1.

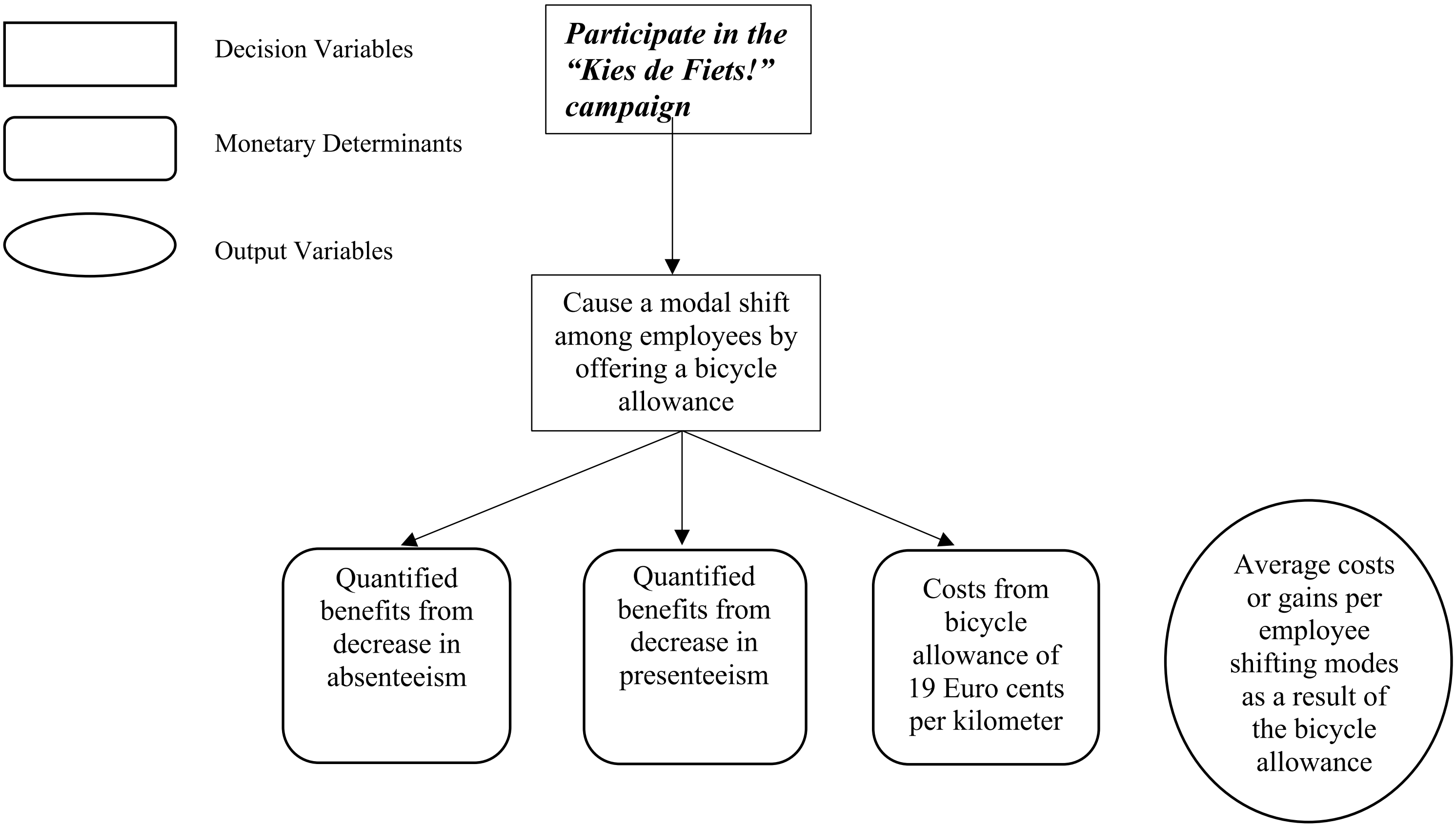

Figure 1. Conceptual framework for the impact assessment of the bicycle allowance on the costs for employers.

2.2. Previous Research

The financial benefits of a physically active population have been captured and quantified multiple times in previous research. The aim of this section is to elaborate further on these past studies, highlighting their similarities, differences, and key findings. Furthermore, a comparative assessment will be conducted between these previous studies and this research.

For a long time, it has been known that physical activity positively influences a person's health. Previous longitudinal studies using data on 288.724 individuals have proven that physical activity reduces the long-term risk of many diseases like obesity, Alzheimer's disease, coronary heart disease, dementia, and type 2 diabetes (Reiner et al., 2013). Additionally, past research has provided evidence that physical activity increases concentration, attention levels and working memory (Marmeleira, 2013). Andersen and Durstine (2019) have estimated that the costs of chronic illnesses and premature morality caused by physical inactivity are approximately $145 billion globally each year. This knowledge has incentivized further research on the monetary benefits of physical activity as a result of better overall physical health, mental health and cognitive performances.

The effect of physical activity on presenteeism and absenteeism has been researched multiple times in the past. However, estimates on the magnitude of the effect vary greatly between studies. There is a lot of uncertainty, particularly regarding the impact of physical activity on presenteeism. There are studies confirming the existence of an association between physical activity and presenteeism, such as the study by Hunter et al. (2021). In their study, survey data on 433 employees from New-Zealand and Australia aged 18-65 was used. An odds ratio of 2,1 for the association between physical activity and physical work abilities was found, together with an odds ratio of 1,8 for the association between physical activity and mental work abilities. A second study by Walker et al. (2017) also confirmed the existence of an association between work limitations and physical activity. In this research, self-reported data on 6.515 employees over a two-year period was used. A third stud by Von Thiele Schwarz and Hasson (2011) verified the presence of a negative association between physical activity and presenteeism. In light of their study, 177 employees mandatorily engaged in an additional 2,5 hours of physical activity each week. A significant increase in self-reported productivity was found.

When assessing the previous research on the effect of physical activity on presenteeism, the conclusion can be drawn that exact estimates of the magnitude of the effect are missing. However, Hafner et al. (2020) computed detailed estimates on the effect of physical activity on work impairment. Work impairment includes presenteeism and absenteeism. In their study, the effect on the GDP if all adults globally would engage in at least 150 minutes of moderate-intensive exercise weekly has been quantified. This is the minimum amount of physical activity an adult should engage in according to the guidelines of the World Health Organization (WHO). They measured the effects of increased physical activity on presenteeism, absenteeism and healthcare costs. By using data on over 120 thousand individuals, they were able to conclude that a sufficiently active population would lead to a yearly increase in GDP of 0,15%-0,24%, which equals to an increase of 314- 446 billion American Dollars added each year. It is estimated that over 70% of this increase in GDP is caused by a decrease in presenteeism. In their research, Hafner et al. (2020) used data on employees from the United States, Australia, multiple Asian countries, and several European countries including The Netherlands. Therefore, the estimates from this study are quite general and applicable for many countries. The estimates from the study by Hafner et al. are widely seen as the most trustworthy, considering the large number of participants and control variables such as sociodemographic variables, occupational variables, and health & lifestyle variables.

The total macroeconomic effect of increased physical activity has not yet been measured for The Netherlands. However, Hendriksen et al. (2010) studied the effect of cycling to work on absenteeism for Dutch employees. They used self-reported data and on cycling and company data on absenteeism of 1.262 employees to determine the existence and extent of the association. This resulted in the conclusion that non-cycling employees were absent 8,7 days each year on average, whilst employees who cycle to work were only absent for 7,4 days. Furthermore, they concluded that commuters who cycle more frequently and cycle longer distances are less often absent.

A study by Losina et al. (2017) measured the effect of physical activity on absenteeism by assessing the behavior of 292 employees over a period of 24 weeks. They concluded that sufficiently active people (≥150 minutes of physical exercise each week) on average were absent for 14 hours in the studied time period. Employees with 75-149 minutes of physical activity each week had a 2,4-fold larger absenteeism rate, while employees with 0-74 minutes of physical activity each week had a 3,5-fold larger absenteeism rate.

From the previously stated information the conclusion can be drawn that the estimates on absenteeism are more precise than the estimated on the effect of physical activity on presenteeism. This is explainable since absenteeism can be measured more easily than presenteeism.

Another research on the financial effect of increased physical activity by PMJ Economics (2019) measured the benefits of physically fit employees for businesses in the United Kingdom (UK). This study also used the WHO guidelines on physical activity as the minimum amount of exercise a person should engage in. In this research, the effects of physical activity on absenteeism and presenteeism were measured. It thus did not include the effect of increased physical activity on health costs, as its only intent was to measure the monetary benefits for businesses. Thereafter, these effects were quantified to revenues per employee and financial benefits for the entire UK. The study estimated that if every employee in the UK would be sufficiently active, it would lead to a yearly gain of 6,6 billion British Pounds for all UK businesses combined. They concluded that the transformation of an inactive/ fairly active employee into an active employee would cause a yearly revenue for businesses of 616,51 British Pounds per employee. These findings are mostly in line with the findings from the research by Hafner et al. (2020).

Lastly, Spence and Dinh (2015) studied the effect it would have on the Canadian economy if 10% of Canadians with suboptimal levels of physical activity would become sufficiently active. In their research, they considered the effect of decrease in premature deaths and decrease in absenteeism on the GDP. They concluded that this would lead to a cumulative increase in the GDP of 7,5 billion Canadian Dollars between 2015-2040. Hafner et al. (2020) did include the benefits resulting from decreased presenteeism rates in their calculations. The decrease in presenteeism accounts for a much larger part of the increase in the GDP than the decrease in absenteeism and health costs. Consequently, their estimates for Canada are significantly higher.

Aside from the benefits from decreased presenteeism and absenteeism due to increased physical activity, this research will also focus on the costs for employers of the provision of a bicycle allowance.

On the instructions of the Dutch Ministry of Infrastructure and Water Management, MuConsult (2019) studied the magnitude of the modal shift that would take place if all employees would receive a bicycle allowance of 19 Euro cents per kilometer. To do so, they made use of data from the survey *Beter Benutten Vervolg 2018*, which was carried out by the ministry. They concluded that 14% of employees would shift to modal cycling when their employers would provide bicycle allowances. This implies that the aim of the *Kies de Fiets!* campaign would be met if all Dutch employers would provide a bicycle allowance of 19 Euro cents per kilometer.

This research differs from previous research as this research will measure the difference between the costs of a bicycle allowance and the revenues resulting from a decrease in presenteeism and absenteeism. The financial benefits for employers from decreased presenteeism and absenteeism have not yet been measured for Dutch employees. The difference between these revenues and the costs of a bicycle allowance has not yet been measured anywhere. Hence, there is a gap in the existing literature that this study aims to fill.

Through the *Kies de Fiets!* campaign, the Dutch government aims to persuade employers to promote cycling among its employees, for example by providing a bicycle allowance. Employees that currently already cycle to work will only cost the employer money when the employer would provide a bicycle allowance. However, results from research by MuConsult (2019) have shown that many employees would shift to modal cycling when a bicycle allowance would be provided. This increased physical activity will be beneficial for the productivity of employees. It would therefore be helpful and maybe even persuading if an indication of the difference between the costs and benefits of the allowance would be provided. Information regarding these costs and revenues is therefore helpful to promote cycling amongst employees.

3. Data & Methodology

3.1. Data

3.1.1. Costs of the bicycle allowance

Multiple types of data are needed to estimate the average costs of a bicycle allowance per employee that would shift transport modes. Firstly, data on which employees would shift to modal cycling when their employers would provide a bicycle allowance is needed. Hence, data on the effects a bicycle allowance of 19 Euro cents per kilometer has on an employee's behavior is required. This data will be retrieved from the results of an employee survey carried out by the Ministry of Infrastructure and Water Management in the context of the *Beter Benutten Vervolg 2018* program. On behalf of the ministry, this data has been analyzed by MuConsult (2019). From this data, the effects of a bicycle allowance on the modal choice of employees have been measured. The effects have been split up for employees living at a maximum distance of 7,5 kilometers, employees living at a 7,5-to-15-kilometer distance and employees living at a 15-to-25-kilometer distance from work. An overview of the results is provided in Table 1.

To determine the costs for employers, the exact distance from work for modal shifting employees is needed. Hence, information concerning the distribution within the distance intervals is needed. To find the average distance for each distance interval, the dataset *Onderweg in Nederland 2018* (ODIN) will be used. This dataset provided by CBS (2019) contains data on the daily travel behavior of Dutch people.
Lastly, the average number of working days for Dutch employees is needed. This number will be retrieved from the report *De Arbeidsmarkt in Cijfers 2018* drawn up by CBS (2019).

3.1.2. Presenteeism and absenteeism

To determine the increase in physical activity, multiple data sources are necessary. First of all, the average weekly physical activity excluding walking and cycling to work of Dutch population aged 18-65 is needed. This information will be retrieved from the dataset *Tijd per week besteed aan beweegactiviteiten 2001-2022*. This dataset by CBS and RIVM (2023) as part of the database *Sport en Bewegen in Cijfers* contains information on the average number of minutes Dutch people engage in physical activity (MET > 3) each week.

Additionally, the average distance to work for mode shifters and the average speed for cyclists are needed to measure the decrease in work impairment. The average distance to work for mode switchers will be retrieved in the first sub question. The average cycling speed for regular bicycles, e-bikes and speed pedelecs will be subtracted from the report *Achtergrond rapport: Aanschaf en gebruik van de elektrische fiets* (De Haas & Huang, 2022).

To estimate and quantify the effect of an increase in physical activity on presenteeism and absenteeism, results from previous research will be used. Hafner et al. (2020) studied the effect of an increase in minutes of moderate- and vigorous intense physical activity on the worktime that is lost due to presenteeism and absenteeism. The results are based on survey data of 120.142 individuals worldwide. This research will use the estimates computed by Hafner et al. (2020) to determine the average decrease in work impairment due to decreased presenteeism and absenteeism. The results of this research that will be used in this paper can be found in Table 5.

To be able to quantify the productivity gain due to a decrease in presenteeism and absenteeism, estimates from De Sociaal-Economische Raad (2014) will be used. In their report it was estimated how much revenue a 1% decrease in presenteeism and absenteeism would yield.

3.2. Methodology

3.2.1. Conceptual framework

This research will calculate costs and benefits for employers of employees that would shift to modal cycling cycling (modal shifter) as a result of a bicycle allowance of 19 Euro cents per kilometer, using the conceptual framework as shown in Figure 1. The costs that will be evaluated are the average costs of the bicycle allowance for modal shifters. The revenues that will be evaluated are the quantified decrease in presenteeism and absenteeism as a result of the modal shift. The reasoning behind only evaluating the costs and benefits for modal shifters is that the costs and benefits of a bicycle allowance for employees that are already commuter cyclists will merely exist of the costs of the allowance. The costs and revenues for these employees are therefore already known and are thus not of added value to include in this study.

The calculations in this research are based on a bicycle allowance of 19 Euro cents per kilometer, since this was the maximum amount allowed by the Dutch government until the first of January 2023 (Rijsoverheid, 2023). The results of the employee survey *Beter Benutten Vervolg 2018* provided by the Ministry of Infrastructure and Water Management that will be used in this paper are also based on an allowance of 19 Euro cents per kilometer.
Employers may benefit from a higher number of cycling employees in more ways than this paper covers. Employers might save money on for instance parking spaces and other car-related costs. Additionally, many employers already offer allowances for cars and public transport. In that case, an employee receiving a bicycle allowance of 19 Euro cents per kilometer instead of a car allowance of 19 Euro cents per kilometer would not change the costs for an employer. Under Dutch law, employers are not obliged to provide any sort of travel allowance (Het Juridisch Loket, 2023). Consequently, the current situation in terms of travel allowances provided differs a lot between companies.

To test the hypotheses and formulate an answer to the research question '*To what extent do the financial benefits caused by the decrease in absenteeism and presenteeism as a result of a modal shift to cycling compensate for the costs of a bicycle allowance of 19 Euro cents per kilometer?*', secondary quantitative data as well as results from previous research will be used. Quantitative data is fitting for this research since data on travel patterns of Dutch citizens and company data on sickness absence and travel allowances is needed. In the following paragraphs, an overview of the complete methodology per sub question will be shown.

3.2.2. Yearly costs of the bicycle allowance

As stated before, this paper will use a bicycle allowance of 19 Euro cents per kilometer. To determine which employees would switch from car or public transport to bicycle when offered a bicycle allowance, results from the employee survey *Beter Benutten Vervolg 2018* provided by the Ministry of Infrastructure and Water Management (2019) will be used. The results have been tested and summarized by MuConsult (2019). 7.032 Dutch employees participated in the survey. The results on which employees would shift to commuter cycling when their employers would provide a bicycle allowance can be seen in Table 1. When looking at Table 1, it can be concluded that when the distance from work increases, relatively more employees would shift to modal cycling after being offered a bicycle allowance. This can be understood since the monetary incentive increases as distance increases. Thus, since the average distance to work for modal shifters differs from the overall average for modal cyclists, a new average must be computed.

Table 1. **Behavior as a result of the implementation of a bicycle allowance of 19 Euro cents per kilometer for different distance categories**

Distance interval	Distance to work	Current share[1]	Modal shifters[2]	Weight of interval
1.	Max. 7,5 km	49%	11%	28,75
2.	7,5- 15 km	32%	18%	30,72
3.	15- 25 km	19%	40%	40,53
Total		100%	18,8%	100

Note. Data from *Beter Benutten Vervolg 2018* summarized by MuConsult (2019).

The distance intervals used in Table 1 are 0 - 7,5 kilometer, 7,5 - 15 kilometer and 15 - 25 kilometer. Since these intervals are quite broad, additional data is needed for specification. To calculate the average cycling distance for a mode shifter, data concerning the distribution within these distance intervals is needed. This data will be retrieved from the dataset *Onderweg in Nederland 2018* provided by CBS (2019). By analyzing this data in Excel, the average distance for each distance interval will be computed. Thereafter, the average distance per interval will be multiplied by the appropriate weight, which can be found in Table 1. The formula used to determine the average cycling distance for mode switchers will therefore be:

[1] Share of total number of kilometers in the sample

[2] Percentage increase of current share as a result of the implementation of a bicycle allowance of 19 cents per kilometer

$$\textbf{1.}\quad Average\ distance\ to\ work\ for\ modal\ shifters = average\ distance\ interval\ 1 \cdot weight\ interval\ 1 + average\ distance\ interval\ 2 \cdot weight\ interval\ 2 + average\ distance\ interval\ 3 \cdot weight\ interval\ 3$$

Thus, by combining the results from the *Beter Benutten Vervolg 2018* survey and the dataset *Onderweg in Nederland 2018*, a more precise estimation of the cycling distance for modal shifters can be made. The yearly amount of travel allowances an employee receives is calculated by the multiplying the distance traveled with the yearly number of working days and the allowance per kilometer. Therefore, the yearly costs for employers of the bicycle allowance can be computed using the following formula:

$$\textbf{2.}\quad Yearly\ costs\ of\ bicycle\ allowance = 2 \cdot average\ distance\ to\ work \cdot allowance\ per\ km \cdot average\ yearly\ working\ days$$

3.2.3. Yearly revenue from decreased presenteeism and absenteeism

To determine the yearly revenue for employers resulting from a decrease in presenteeism and absenteeism, multiple formulas will be used. Firstly, the average weekly minutes of physical activity for non-cyclists needs to be measured. Thereafter, the average number of weekly MET-minutes for Dutch people aged 18-65 will be computed.

First of all, the number of MET-minutes for the average Dutch person aged 18-65 will be calculated. In Table 2, an overview of the number of MET's used per minute per activity can be found. In Table 3, the total weekly physical activity of Dutch adults aged 18 up to 65 can be found.
By combining the two tables, the total current MET-minutes per week for commuters by public transport/walking and by car can be determined.

Table 2. **Metabolic Equivalents (MET) values for different exercises.**

Metabolic Equivalents of Tasks	**MET**[3]
Light intensity physical activities	*< 3*
sleeping	0,9
Sitting while relaxing	1
Sitting while doing desk work, writing or typing	1,8
Strolling (walking very slowly, at 2,7 kilometers per hour)	2,3
Walking (slowly, at 4 kilometers per hour)	2,9
Moderately intense physical activities[4]	*3 to 5,9*
Resistance training with light weights, 8-15 repetitions	3,5
Calisthenics (for example push- and sit ups), with moderate effort	3,8
Pilates, moderate effort	3,8
Yoga, moderate effort	3
Calisthenics/exercises in water	3,5
Walking (normally, at 5 kilometers per hour)	3,3
Cycling (normally, at 16 kilometers per hour) for example to work or for pleasure	4
Vigorous intense physical activities	*> 5,9*
Jogging (normally, at 8 kilometers per hour)	7
Calisthenics (for example push- and sit ups), with vigorous effort	8
Running (Normally, at 11 kilometers per hour)	8
Rope jumping	10

Note. Data from OMICS (2019).

[3] 1 MET = 1 kcal kg^{-1} hr^{-1} or 1 MET = 3.5 ml kg^{1} min^{1} of O_2

[4] Only moderately and vigorous intense activities count for the physical activity guideline

Table 3. **Average time (hours per week) spent on physical activity for adults aged 18 up to and including 64.**

Weekly physical activity in hours for Dutch adults aged 18-65[5]	
Commuting and activities at work	
Walking to and from work	1,0
Cycling to and from work	1,0
Activities at work	6,1
Spere time	
walking	3,1
Cycling	1,2
Gardening	1,0
Odd jobs	1,3
Household tasks	1,6
Sports	2,7

Note. Data based on the Health Survey/Lifestyle Monitor from CBS and RIVM (2019).

In addition to the average Dutch person aged 18-65, this research will also consider the effect of a modal shift towards cycling for inactive people. An inactive person is a person that does not meet the physical activity guidelines. In The Netherlands, 42,3% of people aged 18-65 do not meet these guidelines (CBS, 2020). The government's guideline on the minimum amount of exercise is 150 minutes of moderate- or vigorous intense exercise each week. This is uniform to the guideline set up by the WHO (2022). One minute of moderate- or vigorous intense physical activity on average equals four minutes of metabolic equivalents of task (Hafner et al., 2020). Therefore, 150 minutes of moderately intensive exercise is equal to 600 MET-minutes.

Hence, the average weekly MET-minutes for two groups will be computed: the averagely active Dutch person and the inactive Dutch person.

Thereafter, by using the previously calculated information on cycling distance for mode shifters, the additional MET-minutes per week can be found. To do so, the average time spent cycling for mode switchers must be computed.

According to the report *Landelijk Reizigersonderzoek 2022*, the maximum time most employees are willing to commute is 30 minutes one way. The average commuter cycling speed for Dutch people is

[5] Only activities with a MET value > 3 are included.

approximately 15 km/h. Additionally, an electric bicycle has a maximum speed of 25 km/h and an average speed of 21,8 km/h (MuConsult, 2023). Lastly, a speed pedelec has a maximum speed of 45 km/h and an average speed of 30,7 km/h (Hulshof & Van Gurp, 2018). Therefore, this research will make use of the assumptions displayed in Table 4.

Table 4. **Modal choice for each distance interval and average speed per distance interval.**

Distance interval	Transportation mode[6]	Average speed
1. (< 7,5 km)	Regular bicycle	15 km/h
2. (7,5 – 15 km)	Electric bicycle	21,8 km/h
3. (15 – 25 km)	Speed pedelec	30,7 km/h

Note. Data for average speed from MuConsult (2023) and Hulshof & Van Gurp (2018).

By combining the information in Table 1, Table 4 and Table A4, the average commuting time per distance interval can be measured. Thereafter, by inserting this information into the fourth formula, the average time spent commuter cycling per week can be computed.

$$\textbf{4.}\quad \textit{Average time spent commuting by bicycle per week (in minutes)} = \\ (\textit{average time spent cycling each day for distance interval } 1 \cdot \textit{weight distance interval } 1) + \\ (\textit{average time spent cycling each day for distance interval } 2 \cdot \textit{weight distance interval } 2) + \\ (\textit{average time spent cycling each day for distance interval } 3 \cdot \textit{weight distance interval } 3) \cdot \textit{average number of weekly working days}$$

By adding the average time spent commuting by bicycle each week to the MET-minutes of a person that does not cycle to work, the MET-minutes per week for a mode shifter can be determined. When the MET-minutes after the modal shift for regularly active and inactive people have been determined, Table 5 can be used to determine the potential decrease in absenteeism and presenteeism for the two groups. Thereafter, the percentages of worktime lost can be quantified in financial terms by using the corrected data on financial benefits from decreased presenteeism and absenteeism computed by Sociaal-Economische Raad (2014).

[6] Based on the assumption that employees are willing to commute for 30 minutes one-way.

$$5.\ quantified\ decrease\ in\ absenteeism\ and\ presenteeism\ per\ year = (yearly\ revenues\ caused\ by\ 1\%\ decrease\ in\ presenteeism + yearly\ revenues\ caused\ by\ 1\%\ decrease\ in\ absenteeism) \cdot percentage\ of\ worktime\ lost\ due\ to\ absenteeism\ and\ presenteeism$$

Table 5. **The association between physical activity and work impairment due to absence and presenteeism (% of work time lost) **p<0,01**

Interval	MET minutes per week	Decrease in work impairment due to absenteeism and presenteeism[7,8]
1.	0-600	0
2.	600-750	-0,008** (-0,004 to -0,012)
3.	750-900	-0,011** (-0,007 to -0,015)
4.	900-1.500	-0,011** (-0,007 to -0,015)
5.	1.500-2.100	-0,016** (-0,012 to -0,02)
6.	>2.100	-0,018** (-0,014 to -0,022)

Note. Reprinted from "Estimating the global economic benefits of physically active populations over 30 years (2020–2050)", by Hafner et al. (2020).

4. Results

In this section, further details regarding the outcomes produced by following the previously described methodology will be discussed. First of all, the calculations made to find the average cycling distance and commute time for mode switchers will be presented. Thereafter, the change in MET-minutes per week resulting from the modal shift will be discussed. Hereafter, the decrease in presenteeism and absenteeism resulting from the increase in MET-minutes will be presented. Lastly, an overview of the costs and revenues of the bicycle allowance for employers will be given.

4.1 Costs of the bicycle allowance

As previously described, the average cycling distance for mode switchers will be determined by combining information from the dataset *Onderweg in Nederland* (ODiN) 2018 and the employee survey *Beter Benutten Vervolg 2018* from the Ministry of Infrastructure and Water Management (CBS, 2022) (MuConsult, 2019). The average distance to work per distance interval can be retrieved from the dataset

[7] **p<0.01, *p<0.05. n=117 240. 95% CIs in parentheses

[8] Controlled for sociodemographic variables, occupational variables and health & lifestyle variables.

ODiN 2018. A full overview on how these averages are computed is provided in section A1, A2 and A3 of the Appendix. Table 6 was formed by merging information from Table 1 and Table A4.

Table 6. **Interval distribution and average weight based on elasticity for each distance interval.**

Distance interval	Average distance to work	Weight of interval
1. 0 – 7,5 km	3,364 km	28,75
2. 7,5 – 15 km	9,185 km	30,72
3. 15 – 25 km	18,0595 km	40,53

To determine the average yearly costs for employers of a bicycle allowance, the average distance to work for modal shifters is needed. By using the first formula, the averages for each distance interval can be combined into an overall average.

Now that it has been concluded that the average distance to work for modal shifters is 11,11 kilometers one way, the yearly costs for employers can be determined. By inserting the average distance for mode shifters in the second formula, the average yearly costs of this allowance for employers can be determined. Since the Dutch working population on average works for 31 hours a week, the number of weekly working days used in the second formula is four (CBS, 2019). Dutch employees on average have 25 holidays each year (Dillen & Van Zwienen, 2018). This number will be subtracted from the total number of yearly working days. According to Dutch law, the number of kilometers must be rounded when determining the magnitude of the travel allowance (Rijksoverheid, 2019). Therefore, the number of kilometers that will be used is 11. This results in an average yearly bicycle allowance of €764,94 per modal shifting employee.

4.2 Revenues

4.2.1 Commuter cycling time

As stated earlier, a calculation of the average time spent cycling is necessary to determine the increase in MET-minutes for modal shifters. The average time spent commuter cycling will be computed by combining the average distance for each distance interval with the average cycling speed for each distance interval. The findings are displayed in Table 7.

Table 7. **Commute time for each distance interval based on the modal choices regular bicycle, e-bike and speed pedelec.**

Distance interval	Average time spent cycling to and from work
1. 0 - 7,5 km	27 minutes
2. 7,5 – 15 km	50 minutes
3. 15 – 25 km	71 minutes

By inserting the information from Table 7 and Table 1 into the fourth formula, the average time spent commuting by bicycle per week can be calculated. By using this formula, it can be concluded that the average time spent commuter cycling each week for the three intervals is 208 minutes. This information will be used to calculate the increase in MET-minutes for mode shifters, which will thereafter be used to determine the possible decrease in presenteeism and absenteeism.

4.2.2 MET-minutes

To be able to measure the increase in productivity resulting from increased physical activity, the weekly cycling time needs to be transformed into MET-minutes. Table 2 provides examples of MET values for different types of physical activity. In this table it can be seen that one minute of cycling with regular effort, for example to work or for pleasure, is equivalent to four MET-minutes. According to a small-scale Dutch study conducted by Peterman et al. (2016), using an e-bike or speed pedelec for commuting also qualifies as a form of moderately intense physical activity. This implies that the 208 minutes cycled by modal shifters on a weekly basis are equal to 960 MET-minutes. To be able to determine whether this has a significant effect on productivity, the average weekly MET-minutes before and after the modal shift must be calculated.

The average weekly MET-minutes for Dutch adults can be conducted by combining the information in Table 2 and Table 3. Table 3 gives an overview of the average amount of physical activity Dutch adults aged 18-65 engage in weekly. Physical activity in this case implies that the activity has a MET greater than three (Sport en Bewegen in Cijfers, 2023). The results generated by combining these two tables are provided in Table 8.

Table 8. **Average weekly physical activity in MET-minutes for Dutch adults aged 18-65.**

Weekly activities	MET-minutes
Commuting & Activities at work	
Walking to and from work	198
Cycling to and from work	244
Activities at work	1098
Spere time	
Walking	576,6
Cycling	408
Gardening and odd jobs	90
Household tasks	288
Sports	624

It can thus be concluded that the average amount of physical activity of Dutch persons aged 18-65 equals 3.526,6 MET-minutes weekly. However, inactive commuters with an inactive job ceteris paribus are only engaged in 1.986,6 MET-minutes of physical activity. An inactive job in this case means that the activities performed by an employee have a MET below 3, for example desk work which has a MET of 1,8 (OMICS, 2019).

Previously it has been concluded that a modal shift resulting from a bicycle allowance would, on average, imply a weekly increase in MET-minutes of 960. When keeping all other activities unchanged, this would imply that an employee who shifts from inactive commuting to commuter cycling as a result of the implementation of the allowance and performs average on all other activities would go from 3.084,6 MET-minutes to 4.044,6 MET-minutes. The MET-minutes of inactive commuter with an inactive job would increase from 1.986,6 to 2.946,6 as a result of the modal shift.

However, even though according to CBS and RIVM (2022) the average time per week spent on physical activity for Dutch adults is 1.136 minutes a week, 42,3% of Dutch adults do not meet the recommended 150 minutes of moderately- or vigorously intense physical activity (CBS, 2020). This implies that the level of physical activity for Dutch people aged 18-65 greatly varies between people. According to CBS (2022), this is often caused by disabilities, obesity, and inactive jobs.
Following the guideline set up by the World Health Organization (2022), the assumption is that the average MET for the moderately- and vigorously intense physical activities is four. This would mean

that 42,3% of Dutch adults engage in less than 600 MET-minutes of physical activity each week. This implies that when an employee who does not meet the guideline would shift to modal cycling, their activity level would increase from interval 1 to interval 4 in Table 5.

From Table 9 it can be concluded that people who do not meet the WHO's guideline on physical activity make very little use of active transportation compared to people who do meet the guideline (De Haas & Van den Berg, 2019). This implies that the 4.519.448 people aged 18-65 who do not meet the guideline mostly travel by private vehicle or public transport. Therefore, it is very plausible that the modal shifting employees had a low level of physical activity/were inactive before the modal shift. This increases the credibility of the estimates mentioned in the previous paragraphs.

Table 9 **Difference in active travel minutes between people who meet and do not meet the WHO guideline on physical activity.**

Year	Average travel duration using active modes of transport in three days (people meeting the WHO guideline).	Average travel duration using active modes of transport in three days (people not conforming to the WHO guideline).
2016	135 minutes	16 minutes
2017	139 minutes	16 minutes
2018	149 minutes	15 minutes

Note. Table reprinted from '*De relatie tussen gezondheid en het gebruik van actieve vervoerwijzen'* by De Haas and Van den Berg (2019).

4.2.3 Presenteeism and absenteeism

To determine the decrease in presenteeism and absenteeism for a modal shifter, their weekly MET-minutes before and after the modal shift must be compared to the intervals in Table 5. Table 5 displays the decrease in work impairment due to absenteeism and presenteeism for multiple levels of physical activity compared to a non-active person (MET-minutes < 600). Table 5 shows that the highest interval of which the effects have been researched is a weekly amount of >2.100 MET-minutes. It is only possible to measure the increase in productivity for employees who shift categories resulting their increased physical activity. Since interval 4 is applicable to employees with an average of 1.500-2.100-MET minutes, it is only possible to measure the decrease in absenteeism and presenteeism for employees who fitted in that interval before the modal shift. When looking at the previous section it can thus be concluded that only employees who have an inactive job and drove to work prior to the modal shift switch categories. Employees who have an inactive job and additionally made use of an inactive transportation method before the modal shift go from a weekly average of 1.986 MET-minutes to a weekly average of 2.946,6 MET-minutes after the shift. This implies that these employees go from a 1,6% decrease in work impairment to a 1,8% decrease after the modal shift. This suggests a decrease of 0,2% in absenteeism and presenteeism resulting from the modal shift for these employees.

To quantify this decrease, formula 5 must be used. Research done by De Sociaal-Economische Raad (2014) has shown that in 2012, a 1% decrease in absenteeism led to a revenue of €412 and a 1% decrease in presenteeism led to a revenue of €953 per employee. By correcting the data from 2012 for the inflation, it can be concluded that in 2023 a 1% decrease in work impairment leads to an increase in revenues for the employer of €1.832,62 per employee per year. This implies that a 0,2% decrease in work impairment leads to a revenue of €366,52 per employee each year.

As stated previously, 42,3% of Dutch people aged 18-65 currently have a weekly number of MET-minutes lower than 600. This implies that if one of those people would shift modes because of the bicycle allowance, their weekly MET-minutes would increase to somewhere between 900 and 1.500. Considering the data presented in Table 4, this means that the modal shift would lead to a 1,1% decrease in presenteeism and absenteeism for people who do not meet the physical activity guideline. A 1,1% decrease in work impairment equals a revenue of €2.015,88 per employee each year.

5.1. Discussion

5.1.1. Findings

This research quantified the average yearly revenues and costs of employees who shift modes after being offered a bicycle allowance of 19 cents per kilometer. The aim of this research was to determine to what extent the costs of the allowance for employers would be covered by the revenues gained from decreased absenteeism and presenteeism.

Firstly, this research calculated the average costs of the allowance per mode shifting employee. The average distance from work for mode switchers was computed by combining data on the effect of a bicycle allowance from the *Beter Benutten Vervolg* survey with the dataset *Onderweg in Nederland 2018*. After processing the data, the conclusion was drawn that the commute distance for employees who would shift modes after being offered a bicycle allowance is 11,11 kilometers one way. Since the current average distance to and from work for modal cyclists is 7,3 kilometers, it is safe to say that the hypothesis formulated in section 2.2.1. can be confirmed. Hereafter, multiplying the average cycling distance with the average yearly working days led to a cost of €764,94 per mode shifting employee.

Secondly, this research calculated that the weekly increase in MET-minutes resulting from the modal shift is 960. For employees shifting from inactive commuting to commuter cycling, an increase in MET-minutes is guaranteed since inactive commute does not generate MET-minutes. Therefore, the hypothesis formulated in section 2.2.2. can be confirmed for this group.

For the employees shifting from walking or partly walking (public transport) to modal cycling, an increase in MET-minutes is not guaranteed. Since the MET value for walking is 3,3, an employee should have walked for > 290,9 minutes before the shift to experience a decrease in MET-minutes. This is equal to a distance of 2,73 kilometers one-way based on a four-day work week. Therefore, the hypothesis formulated in section 2.2.2. only holds for employees who walked less than 5,45 kilometers to and from work before the modal shift.

The conclusion was drawn that the average Dutch person aged 18-65 already has a weekly number of MET-minutes greater than 2.100, even after subtracting the MET-minutes from commuting. Since the average employee already engages in the highest level of physical activity researched by Hafner et al. (2020), the decrease in absenteeism and presenteeism resulting from the modal shift could not be measured for this group. Therefore, the hypotheses formulated in section 2.2.3 and 2.2.4. cannot be confirmed for employees engaged in an average amount of physical activity.

However, 42,3% of Dutch people aged 18-65 have a weekly number of MET-minutes below 600. It was concluded that when an employee in this category would shift modes because of the bicycle allowance, this would lead to decrease in work impairment of 1,1%. This equals a revenue per employee of €2.015,88 per year.

The decrease in work impairment researched by Hafner et al. (2020) includes the decrease in absenteeism as well as presenteeism. It is estimated that approximately 70% of the decrease in work impairment is caused by a decrease in presenteeism, while the remaining 30% is caused by a decrease in absenteeism. This implies that the decrease in presenteeism generates a revenue of €1.411,12, while the remaining revenue of €604,76 is caused by the decrease in absenteeism. Since these results confirm that a modal shift would lead to a decrease in presenteeism and absenteeism, the hypotheses formulated in section 2.2.3 and 2.2.4. can be confirmed for previously inactive employees.

5.1.2. Strengths and weaknesses

When taking into account the methodology of this study, several limitations can be found. Firstly, this research only considers the decrease in presenteeism and absenteeism as a source of revenue for employers. However, a shift towards cycling among employees causes more financial benefits for employers. Other financial benefits may include reduced costs for parking spaces and other car-related expenses. Therefore, the actual revenues from the modal shift for employers are often higher than the revenues from increased productivity.

Secondly, a lot of the data on which the results of this study are based are self-reported or results from interviews. Even though the results on the link between physical activity and productivity at work from Hafner et al. (2020) are based on results from data on 120.143 individuals, the data still consists of self-reported survey data from employees and employers. Therefore, numerous biases like social desirability bias might still have an impact on the results of the study. Additionally, the results from the research done by MuConsult (2019) on the behavioral effects the provision of a bicycle allowance has on employees are based on results from surveys carried out by the Ministry of Infrastructure and Water Management. Therefore, this data might be less accurate than for example record-based data on the effect of a bicycle allowance on behavior. Lastly, the indiciduals included in the sample carried out in the light of the *Onderweg in Nederland* studies also had to fill in questionnaires (CBS, 2019). Since the respondents had to report their own travel behavior, differences between the reported distances and actual distances may occur.

Additionally, the assumption that all the employees in the different distance categories use the same transport mode is unrealistic. To compute the weekly increase in MET-minutes for mode switchers, it was necessary to calculate the average time spent cycling for mode shifters. To do this, the average cycling pace for each distance interval had to be computed. Since previous research from De Haas and Huang (2022) has shown that people want to commute for an hour a day maximum, the best fitting solution was to assume that the employees in distance interval 1 would commute by regular bicycle, the employees in distance interval 2 by electrical bicycle and the employees in distance interval 3 by speed pedelec. However, this generalization differs from reality. Therefore, this assumption weakens the outcome of this research.

Furthermore, the research done by Hafner et al. (2020) only measures the decrease in work impairment for a few physical activity intervals. The study assumes that the highest level of productivity is met when the number of weekly MET-minutes is larger than 2100. However, not making distinctions after the highest level in Table 5 is reached does not automatically mean that there is no distinction in real life. It merely implies that it has not been studied. Thus, even though the average Dutch person aged 18-65 already engages in a level of physical activity worth > 2100 MET-minutes weekly, this does not necessarily imply that their productivity cannot improve as a result of increased physical activity. Therefore, it cannot be ruled out that shifting modes to cycling effects the productivity for employees with weekly MET-minutes >2100 prior to the shift.

Moreover, the assumptions on the weekly MET-minutes of employees prior to the modal shift contain some limitations. To be able to draw conclusions concerning the number of MET-minutes of employees, it was for example assumed that employees who drive to work have zero MET-minutes from commuting and an unchanged number of MET-minutes in the remaining posts. This assumption contains some weaknesses since those employees could compensate for the lack of physical activity while commuting and as a result perform above average in other posts. In this case, assumptions could only be made under the condition of ceteris paribus. This implies that it is assumed that other conditions remain equal. However, this assumption contains limitations and is therefore not particularly realistic.

5.1.3. Recommendations

5.1.3.1. Future research

Considering the discussion points mentioned previously, there a several recommendations for future research. Firstly, there is a lack of evidence-based research on which employees shift modes after being offered a bicycle allowance. This papers' information concerning modal shifters is based on results from the survey *Beter Benutten Vervolg 2018*, carried out by the Ministry of Infrastructure and Water Management. In this survey, employees who did not receive a bicycle allowance had to report if receiving a bicycle allowance would impact their modal choice (MuConsult, 2019). Therefore, the behavioural effect of a bicycle allowance is now only based on self-reported information. A significantly more accurate calculation of the costs and increase in productivity of a modal shifter could be made when there is more research and data available on which employees actually shift modes after the implementation of a bicycle allowance.

Additionally, there is a void in the literature concerning the effect of an increase in physical activity for a person who already has over 2100 MET-minutes of moderate- and vigorous intense physical activity before the increase. As previously stated, the average Dutch person already engages in a weekly average of 3526,6 MET-minutes of moderate- and vigorous intense physical activity. Therefore, the effect of an increase in physical activity cannot be measured for the average Dutch person. This does however not necessarily imply that an increase in physical activity has no effect on people with a weekly average of over 2100 MET-minutes. The possible effects just have not been not studied yet. Hence, it is recommended that these effects will be studied in future research.

Furthermore, there is no previous research as specific as the research done by Hafner et al. (2020) that separates the effect of increased physical activity on only presenteeism. There are multiple studies that confirm the existence of an inverse relationship between physical activity and presenteeism. An example being the research by Walker et al. (2017) on the long-term relationship between self-reported

physical activity and self-reported presenteeism. However, no research has been published that specifies the percentual decrease in worktime lost due to presenteeism when a persons' physical activity increases with a certain amount. Hence, while the existence of a relationship is known, specific figures and numbers on the decrease in presenteeism are lacking.
Additionally, the studies that researched the effect of physical activity on absenteeism also contain some limitations. There are studies that have measured the difference in numbers of days absent for employees practicing sports and not practicing sports. An example of this is the research on the effect of sports on employee absenteeism by Van den Heuvel (2005). As previously mentioned, there is even a study concerning the difference in absenteeism for commuter cyclists and non-commuter cyclists by Hendriksen et al. (2010). However, these studies only measure the absent days for two categories of employees. In these studies, an employee is either classified as a physically active person/modal cyclist or as an inactive person/not a modal cyclist. To be able to measure the effect of increased physical activity on absenteeism, it is necessary for future research to make more distinctions between different levels of physical activity, and not just between two categories.

Lastly, it is recommended that through future studies and surveys, more information will become available concerning the employees who would shift modes because of a bicycle allowance. Currently, it is only known at what distance from work those mode shifters live. However, when more information about their level of physical activity, modal choice and lifestyle before and after the shift becomes known, the MET-minutes and therefore the productivity increase estimates will be more accurate. This information is useful for employers as well as policy makers.

5.1.3.2. Policies

Considering the results of this research, it can be recommended to the Dutch government to increase resources to support the *Kies de Fiets!* campaign. It is recommended that the campaign should especially be directed to inactive employees, meaning employees with a weekly number of MET-minutes below 600. This is recommended since it has been proven that the largest decrease in work impairment can be seen when this group would shift to modal cycling. Therefore, a modal shift within this group would cause the biggest increase in economic output.

Additionally, one of the aims of the prevention agreement for 2040 by the Dutch Government (2018) is to decrease the proportion of the population that does not meet the physical activity guideline from 47% to 25%. Increasing modal cycling within this group will cause an increase in weekly MET-minutes from <600 to 900-1500. Since the provision of a bicycle allowance incentivises a modal shift, making the allowance obligatory for employers may serve as a way to decrease physical inactivity. However, as previously mentioned, more research must be done to identify the characteristics of the employees that would shift modes as a result of receiving the bicycle allowance.

5.2. Conclusion

In conclusion, this study answered the research question "*To what extent do the financial benefits caused by the decrease in absenteeism and presenteeism as a result of a modal shift to cycling compensate for the costs of a bicycle allowance of 19 Euro cents per kilometer?".* This question has been answered by first determining that the average distance from work for employees who would shift to modal cycling because of the allowance is 11,11 kilometers. Using this distance, it could be ascertained that the average yearly costs for employers are €764,94 per mode shifting employee. Thereafter, by calculating the increase in weekly MET-minutes caused by the modal shift, the decrease in presenteeism and absenteeism could be calculated. It was determined that the modal shift would lead to an increase in physical activity of 960 MET-minutes. The average Dutch person aged 18-65 already has the highest level of physical activity studied by Hafner et al. (2020), even after subtracting the physical activity from commuting. However, 42,3% of Dutch people aged 18-65 engage in less than 600 MET-minutes of physical activity. If an inactive person would shift to modal cycling as a result of the implementation of a bicycle allowance, it would lead to a 1,1% decrease in work impairment. This equals a yearly revenue of €2.015,88 per employee. Hence, the answer to this paper's research question is that for averagely active employees the costs of the allowance are €764,94 each year, while for inactive employees the yearly revenues are €1.250,94 per employee.

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Appendix

A1: Description of the relevant variables in the dataset *Onderweg in Nederland 2018* (CBS, 2019).

Table A1 **Relevant content of the variable 'KAfstV'.**
This variable is represented by 'EN' in the Excel formulas.

KAfstV	Travel distance per trip
1.	0,1 – 0,5 km
2.	0,5 – 1,0 km
3.	1,0 – 2,5 km
4.	2,5 – 3,7 km
5.	3,7 – 5,0 km
6.	5,0 – 7,5 km
7.	7,5 – 10 km
8.	10 – 15 km
9.	15 – 20 km
10.	20 – 25 km

Note. Adapted source from *Onderweg in Nederland 2018 codebook* (CBS, 2019).

Table A2 **Relevant content of the variable 'MotiefV'.**
This variable is represented by 'DQ' in the Excel formulas.

MotiefV	Motive for travelling
1.	To and from work

Note. Adapted source from *Onderweg in Nederland 2018 codebook* (CBS, 2019).

Table A3 **Relevant content of the variable 'Hvm'**
This variable is represented by 'ER' in the Excel formulas.

Hvm	Main transport mode during trip
1.	Car
2.	Train
3.	Bus
4.	Tram
5.	Metro
9.	By foot
17.	Motor
18.	Scooter

Note. Adapted source from *Onderweg in Nederland 2018 codebook* (CBS, 2019).

A2: Full version of the Excel formulas used to compute the average distance to work for modal shifting employees.

Formula A1: Average distance from house to work for the distance category 0 - 7,5 km.
AVERAGEIFS(EN:EN;EN:EN;">=1";EN:EN;
"<=6";ER:ER;1;ER:ER;2;ER:ER;3;ER:ER;4;ER:ER;5;ER:ER;9;ER:ER;17;ER:ER;18;DQ:DQ;1)
4,7200

Formula A2: Average distance from house to work for the distance category 7,5 - 15 km.
AVERAGEIFS(EN:EN;EN:EN;">=7";EN:EN;
"<=8";ER:ER;1;ER:ER;2;ER:ER;3;ER:ER;4;ER:ER;5;ER:ER;9;ER:ER;17;ER:ER;18;DQ:DQ;1)
7,6740

Formula A3: Average distance from house to work for the distance category 15 - 25 km.
AVERAGEIFS(EN:EN;EN:EN;">=9";EN:EN;
"<=10";ER:ER;1;ER:ER;2;ER:ER;3;ER:ER;4;ER:ER;5;ER:ER;9;ER:ER;17;ER:ER;18;DQ:DQ;1)
9,6119

A3: Conversion from dataset codes to kilometers

Table A4 **Average 'KAfstV' value and average number of kilometers for each distance category.**

Distance category	Average value of the variable 'KAfstV'	Average in kilometers
1. 0 – 7,5 km	4,7200	3,364 km
2. 7,5 – 15 km	7,6740	9,185 km
3. 15 – 25 km	9,6119	18,0595 km