The impact of COVID-19 and policy measures on commuting in the Netherlands

Taale, Henk; Olde Kalter, Marie-José; Haaijer, Rinus; Damen, Carlijn

DOI
10.1016/j.cstp.2022.10.018

Publication date
2022

Document Version
Final published version

Published in
Case Studies on Transport Policy

Case Studies on Transport Policy 10 (2022) 2369–2376

Contents lists available at ScienceDirect

Case Studies on Transport Policy

journal homepage: www.elsevier.com/locate/cstp

The impact of COVID-19 and policy measures on commuting in the Netherlands

Henk Taale [a,*], Marie-José Olde Kalter [b], Rinus Haaijer [c], Carlijn Damen [c]

[a] Rijkswaterstaat & Delft University of Technology, P.O. Box 2232, 3500 GE Utrecht, Netherlands
[b] Ministry of Infrastructure and Water Management, Netherlands
[c] MuConsult

ARTICLE INFO

Keywords:
Commuting
COVID-19
Policy measures

ABSTRACT

In the Netherlands, one of the main goals of the Ministry of Infrastructure and Water Management is to increase accessibility and, at the same time, to reduce the negative externalities created by transport, such as congestion and greenhouse gas emissions. Within the Ministry, there was a clear need for a national and integrated monitoring instrument to measure the impact of policy measures on travel behaviour. To satisfy this need, we carried out a national traveller survey in 2019, 2020 and 2021. This paper describes some of the results of these surveys. Annual analyses include the trends in car ownership and mode choice for different purposes, with particular attention to commuting behaviour. It appears that travel time, convenience and flexibility play an important role in mode choice. Travel costs are less important and COVID-19 did not play a decisive role. It appears that free parking or availability of parking space has the most considerable impact on car use for commuting. In October 2019, employees travelled on average 3.8 days per week to work. In October 2020, mainly because of COVID-19, this number decreased to 2.9 travelling days and in October 2021, the number of travelled increased to 3.1. We examined the relationship between changes in car use for commuting between 2019, 2020 and 2021, and external developments in living and working, changes in the level of service of different transport modes and policy measures, both by the government and by employers. In addition, we investigated the influence of the COVID-19 pandemic on car use for commuting and this appeared to be an important factor, although external factors also play an important role. Finally, we estimated the effect of these changes in car use for commuting on congestion and CO_2 emissions.

1. Introduction

In the Netherlands, one of the main goals of the Ministry of Infrastructure and Water Management is to increase accessibility and, at the same time, to reduce the negative externalities created by transport, such as congestion and greenhouse gas emissions. Therefore, the government focuses on improving the utilisation of the available road capacity and stimulating sustainable modes of transportation. The National Climate Agreement (Climate Consultation, 2019), A National Vision on the Future of Cycling (Tour de Force, 2019), and the Mobility-as-a-Service pilots (MinIenW, 2019) are examples of policy measures to achieve these goals. Monitoring and evaluation are essential parts of these projects. On the one hand, to analyse the achieved results and impact, and on the other hand to evaluate and adjust the adopted policies.

For decades, a system with loop detectors is available on the national highways that measures flows and speeds and is very useful, for example, for an analysis of traffic operations in normal or abnormal situations, or for the evaluation of traffic management measures (Taale, 2006). However, traffic management is only a part of the complete package of policy measures to deal with the problems related to transport and mobility. Also important is mobility management, for which the focus is on travel behaviour and the impact on the use of transport systems in general. Available and traditional travel surveys, such as 'En Route in the Netherlands' (CBS, 2020) or the Netherlands Mobility Panel (KiM, 2021), are limited in days, the number of travellers or the scope of the questions. Therefore, within the Ministry, there was a clear need for a new national and integrated monitoring instrument to measure the

* Corresponding author.
E-mail addresses: henk.taale@rws.nl (H. Taale), mariejose.oldekalter@minienw.nl (M.-J. Olde Kalter), r.haaijer@muconsult.nl (R. Haaijer), c.damen@muconsult.nl (C. Damen).

https://doi.org/10.1016/j.cstp.2022.10.018
Received 25 April 2022; Received in revised form 21 October 2022; Accepted 31 October 2022
Available online 4 November 2022

impact of policy measures on travel behaviour. Amongst others, the usefulness and necessity arose from the following three topics:

1. **Regional employers' approach:** the focus of the regional employer's approach is on stimulating the use of sustainable transport modes by employees, such as public transport and the bicycle (e.g. providing e-bikes). It could also be on other sustainable travel behaviour, for instance travelling outside peak hours or teleworking. Employers are stimulated to implement this approach, but it is not mandatory. Agreements about monitoring and evaluating this policy are made between the national government, regional authorities, and employers. The national government is responsible for providing insight into the effects of this approach at the national level.
2. **In addition to existing monitoring.** For existing programs and projects, such as Mobility-as-a-Service and the themes Personal Mobility and Electric Transport from the National Climate Agreement, an adequate system for monitoring will or shall be set up. However, not all effects of policy measures can be traced back to hard figures. For some topics, there is a need for more qualitative information that supports the quantitative statistics, for instance, the motivations and barriers to use electric vehicles. An extensive national survey provides insight into objective changes in travel behaviour and subjective perception towards mode choice and other travel-related aspects.
3. **Strengthening of the policy cycle:** Monitoring and evaluation are essential parts of the policy cycle. A national and integrated monitoring instrument offers the possibility to identify (new) trends and developments, but also to learn from existing measures and pilots: what works and what not. In this way, policymakers can adapt to the needs and requirements to achieve the desired behavioural changes.

To satisfy the needs, the National Traveller Survey (NTS, in Dutch it is Landelijk Reizigersonderzoek or LRO) was set up and carried out in 2019 (MuConsult, 2020), 2020 (MuConsult, 2021) and 2021 (MuConsult, 2022). The aim of the survey was twofold:

1. To provide insight into short-term changes in commuting behaviour of Dutch employees and other travellers, their attitude towards different policy measures, and their motivations and barriers to use different transport modes for commuting.
2. To provide insight into the impact of changes in commuting behaviour on traffic delays and CO_2-emissions, and the contribution of different policy measures to these changes in behaviour.

This paper describes some of the results of the three surveys, carried out in 2019, 2020 and 2021. Annual analyses include the trends in car ownership and mode choice for different purposes. For commuting behaviour, we show the most important factors that influence mode choice for commuting and the perception of the commuting trip. The relationship between changes in car use for commuting between 2019 and 2021, and external developments in living and working, changes in the level of service of different transport modes and policy measures, both by the government and employer, are examined. Although it was not one of the objectives defined at the start, the data collected enabled us to investigate the influence of the COVID-19 pandemic on car use for commuting. Other studies found that car use for commuting drastically decreased during the COVID-pandemic (for example, Van der Drift et al., 2021). In particular, because working from home increased substantially (OECD, 2021) Finally, the impact of these changes in car use for commuting on congestion and CO_2 emission is estimated.

2. Theory and practice of change

The theory of planned behaviour is currently the main framework to explain changes in travel behaviour. This theory states that our choices are affected by attitudes, subjective norms and perceived behaviour control (Ajzen, 1991). There are different definitions of attitudes, but normally it is defined as the degree in which someone favours certain behaviour. Van Wee et al. (2019) formulated a model on how attitudes could change due to triggers. The model describes three types of processes that influence each other and could change attitudes: cognitive processes, behavioural processes and affective processes. These processes can be triggered on three levels: the personal level, the social level and environmental level. Triggers on the personal level could be information or experiences, while triggers on the social level come from people in one's network (family, friends, etc.). The COVID-19 pandemic is typically a trigger on the environmental level, which clusters triggers such as changes in the transport system or societal changes. However, note that a change in attitude does not necessarily leads to a change in travel behaviour (e.g., Kroesen et al., 2017; Olde Kalter et al., 2020).

Another way to connect the impact of certain events with mobility patterns, is the theory of substantial changes (Van Cranenburgh et al., 2012). Travel behaviour does not just follow trends, but is influenced by unconventional changes, referred to as 'substantial changes'. These substantial changes can differ in the speed with which the change takes place and can take place in different so-called 'spheres'. A distinction is made between changes in the 'techno-sphere' (changes that are related to technologies), the 'antropo-sphere' (changes as a result of human actions) and the 'bio-sphere' (changes that take place as the result of natural processes). The COVID-19 pandemic is clearly a substantial change in the biosphere, which had and still has a large impact on travel behaviour and for example changed the attitude towards teleworking (Begheijn, 2021) and the attitude towards public transport (Ton et al., 2022).

The COVID-19 pandemic forced the government to implement all kinds of measures to keep the number of hospitalisations below the capacity of hospital beds. Fig. 1 shows the daily number of hospitalisations and the COVID-19 stringency index for the Netherlands. This index is composed of nine metrics that represent measures of the government on, amongst others, closures of schools and workplaces, restrictions of all kinds and stay-at-home requirements (Hale et al., 2021).

These measures, especially during periods of lockdown, had a large impact on mobility patterns and people changed their travel behaviour accordingly. For example, to avoid physical contact, most governments requested people to work from home as much as possible and to use public transport only when strictly necessary. Social distancing was one of the most impacting measures on mobility patterns and travel behaviour (e.g.,Tirachini and Cats (2020); Shamshiripour et al., 2020; Molloy et al., 2021). However, less is known about the structural impact of the COVID-19 pandemic on travel behaviour, and the long-term consequences for policy making. Gkiotsalitis and Cats (2020) found that there is a severe lack of knowledge regarding the potential impact of the pandemic on public transport operations, while Copolla and De Fabiis (2020) show that public transport companies appear very much uncertain about the future. The aim of the research presented in this

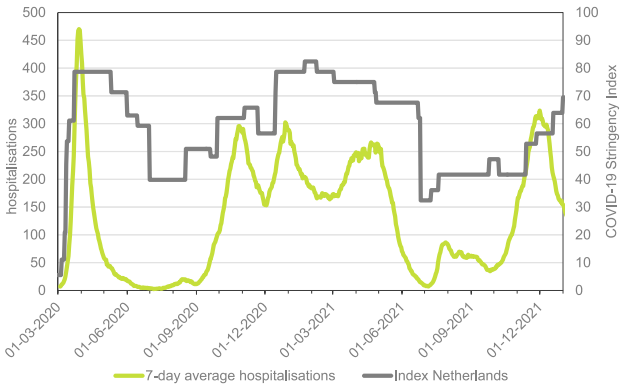

Fig. 1. Hospitalisations and COVID-19 measures.

paper is to show the relation between changes in travel behaviour and the COVID-19 pandemic and other factors, such as changes in car ownership, personal characteristics and attitudes. Moreover, because we did the research for a number of years in a row, we could investigate how these changes evolve over time.

3. Research design

To conduct the research, the approach of the clustered impact method was chosen. This method takes into account both the policy measures and the external circumstances. In this way, a possible overlap in the separate effects is avoided and possible synergy between measures can be found. To model the changes in commuting behaviour and the impact of these changes on accessibility, sustainability and safety, a conceptual design was used which is shown in Fig. 2.

The model shows on the left side different (external) factors that influence our travel behaviour. First, our travel behaviour is affected by policy measures, both from the government and employer. Second, external factors, such as changes in the residential location, household composition or income, might also affect our travel behaviour. Indirect, various factors, for example, social demographic characteristics, habits, attitudes and our social environment, influence the choices we make regarding our travel behaviour.

The conceptual model was used to design a questionnaire that considers all these aspects. Between 10,000 (2019) and 13,000 (2020 and 2021) respondents filled in this online questionnaire. The sample was drawn from an existing and large panel in the Netherlands, controlling for age, gender, education, residential location, car ownership and household composition. All three surveys were conducted in October (2019, 2020 and 2021) and were treated as independent measurements, although part of the respondents participated in two or all three of the surveys. In a follow-up study, we plan to do a panel-analysis on these responses.

In the COVID-19 year 2020, the government imposed stricter measures in late September. Next to several other measures, employees were again advised to work at home as much as possible. Therefore, in 2020 additional questions were asked about teleworking and the data for 2019 was acquired for this topic through retrospective questions. Although, the measures were less strict in October 2021 (as shown in Fig. 1), the advice was still to work at home, so the questions about teleworking were repeated.

After the raw data was collected, three steps were needed for the analyses. First, the data was cleaned by checking it for completeness and if the respondent had taken the questionnaire seriously. After that, the data was weighted for age, gender and education for each province and furthermore for job sector and part of the country for the total sample (source distributions come from the CBS, Statistics Netherlands). The unweighted sample differed most from the job sector distribution, followed by education and part of the country, as shown in Table 1. After an iterative sequential weighting procedure the selected, weighted, sample was representative for the Dutch working population aged over 17 on the in Table 1 listed characteristics (chi2-tests, 5 % significance level).

Finally, the data was scaled up from the sample to the total Dutch population. For example, in 2020 there were 12,887 respondents. On a population of 13,541,079 adults that meant an incremental factor of about 1,092. For 2021, this factor was about 1,061. The results shown in the next paragraph are all weighted and scaled with these respective factors. In April 2020, at the beginning of the COVID-19 pandemic, MuConsult also conducted a research on the travelling behaviour of the Dutch commuters. Since the survey questions are mostly similar, it is possible to compare the results with the 2020 and 2021 results. Therefore, for some results a comparison with April 2020 is also possible.

Table 1
Unweighted percentages for the sample populations and for the Netherlands.

		Sample population			Dutch population
		2019	2020	2021	2021
Gender	Man	51,1	46,7	47,1	49,3
	Woman	48,4	53,0	52,4	50,7
	Different/ Unknown	0,5	0,3	0,5	
Age	18–30 years	18,2	17,9	16,5	18,9
	31–45 years	25,0	24,0	23,9	22,7
	46–65 years	39,7	40,6	40,5	34,0
	> 65 years	17,1	17,5	19,1	24,4
Education	High school	34,3	32,8	32,7	42,0
	College	33,1	31,2	30,8	22,9
	University	30,2	33,5	34,1	35,2
	Other/none	2,5	2,5	2,4	
Job type	Construction	10,9	9,4	9,3	11,6
	Commercial service	30,0	24,6	23,8	36,1
	Non-commercial service	26,2	32,1	31,9	22,0
	Unemployed	4,9	5,1	4,3	2,6
	Non-labour force	28,0	28,8	30,8	27,7
Part of the country	North	8,8	8,9	8,8	10,0
	East	13,7	26,6	13,7	18,7
	South	24,6	16,6	24,6	21,1
	South-West	28,2	19,8	28,2	23,7
	North-West	24,8	28,1	24,8	26,5
Urbanisation	Highly urban	22,8	23,2	24,9	23,3
	Largely urban	34,5	35,0	30,1	27,5
	Moderate urban	15,0	14,8	18,7	17,9
	Low urban	20,3	20,1	15,2	16,8
	Non-urban	7,4	6,9	11,0	14,6

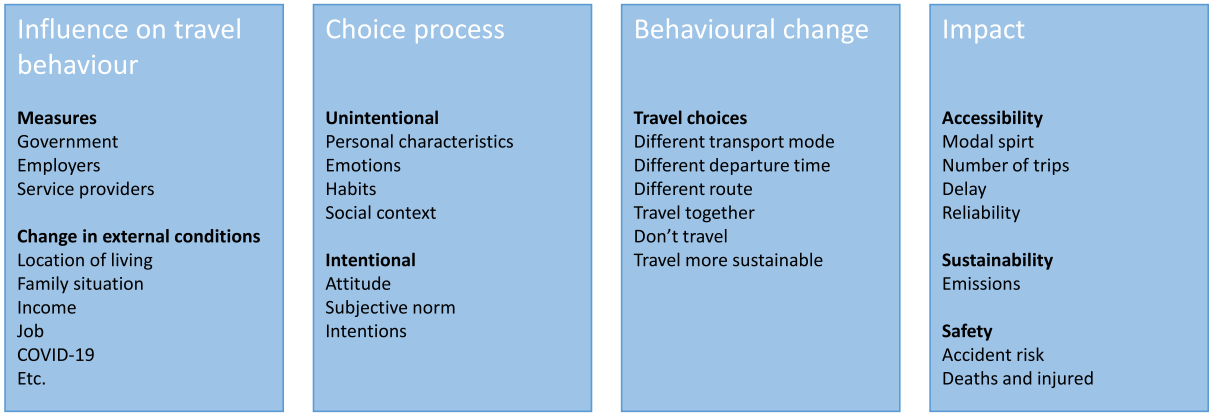

Fig. 2. Conceptual model for changes in travel behaviour.

4. Results

The results of the NTS can be divided into two parts. First, we aim to describe the travelling behaviour of the Dutch citizens. How often do they travel? By which means of transport? And what motivations lie underneath these choices? The second part is meant to describe and analyse the differences found in commuting travel by car.

4.1. Descriptive analysis

Before addressing the actual travel behaviour, this paper explores the trend in car ownership as well as the different travel motives. These, and the following results, will help us to understand the explanatory analyses of car travelling choices.

The years 2020 and 2021 have been peculiar years: the COVID-19 pandemic has demanded people to travel less, to work from home as much as possible and even to avoid public transport. These circumstances have influenced both the amount of travel as well as the preferred means of transportation. In January 2021, de Dutch news flashes stated the following: “Corona boosts used car sales: 2 million in a year”. However, because the sales of new cars was in 2020 less than in 2019 (-20 %), the total number of cars sold decreased with 1.4 %. This is consistent with the results of the NTS 2020, because from this questionnaire it became clear that the number of cars in the Dutch households have decreased by 1.3 %. In 2021 the sales of new and used cars increased a little bit compared with 2020 (+1%), but it was still 3% lower than in 2019 (see Fig. 3).

The COVID-19 pandemic and the corresponding regulations have led to a massive reduction in the amount of travel days for working activities. In the NTS 2020 it was also asked if trips were made for other purposes and which means of transport were used most for these separate purpose. It was found that fewer people tend to travel for shopping and to do groceries (-3%) and visiting family or friends (-13 %). The largest decrease, however, was the number of people travelling for leisure activities, such as sports and going out (-19 %). In 2021 travel for these activities increased again, but still the levels are lower than in 2019, except for business trips (Fig. 4). It is not clear why business trips increased both in 2020 and 2021. It could be due to the increase of people working in the non-commercial service sector.

This paper mainly focuses on the trends in commuting behaviour. What has become apparent is that employees are more capable of working from home than we could have ever imagined beforehand. In 2019 44 % of the respondents claimed that their work is not suitable for working from home. In 2020, this percentage has decreased to 40 % and in 2021 to 38 %. In accordance with the regulations, we saw a massive increase in the number of employees working from home. In October 2019, 25 % worked from home for at least one day a week and in October 2020, this share equalled 42 %, which was still the case in October 2021. Naturally, this has led to fewer travelling days amongst the Dutch employees (Fig. 5). In October 2019, employees travelled on average 3.8 days per week to work, in April 2020, this decreased to a low of no less than 1.7. In October 2020, employees started to travel more to work again, with an average of 2.9 days per week and this increased to 3.1 days in October 2021. However, this average is still much lower than in 2019.

Besides the change in travelling days, we also see that the individual transport modes have increased in popularity. In Fig. 5, also a distinction is made between the different modes used for travelling. Even though the average amount of travelling days by car has decreased, the share of the car in the total modal split had increased. The same trend is visible for travellers by bike. After doing some further research it can be concluded that commuters did not travel more often by car or by bicycle, but those who previously used these kinds of travelling modes were simply more likely to keep on travelling to work.

Which aspects determine which transport mode is chosen by our commuters? The respondents were asked to scale a list of aspects from 1 (plays no role at all) to 7 (it is a decisive factor). The results of 2021 were that the most important factors influencing mode choice are convenience, travel time and flexibility, as is shown in Fig. 6. These figures differ not much different from the results of 2020.

Travel costs are less important and also COVID-19, as an additional aspect in 2020, did not play a decisive role and even less in 2021. This conclusion is somewhat speculative because it is possible that respondents were not always able to isolate COVID-19 as a separate independent factor and that the aspects convenience, impact on health and COVID-19 could correlate with each other.

The main motives as mentioned in Fig. 6 can also be detailed by transport mode. After making this distinction and apart from the main motives, it can be concluded that especially commuters by car and by public transport are basing their decision also on the facilities at their working place. Car commuters are mentioning privacy and the availability of (free) parking places as decisive factors in their choice to travel by car, as shown in Fig. 7. Commuters who have a lease car available mention that as the decisive factor (41 %) and owners of electric vehicles mention the possibility of charging.

Employees that travel by public transport state that a good and solid connection is key as well as a station or bus stop near their working location. Commuters by bike, on the other hand, base their mode choice on more intrinsic motivations such as the fact that travelling by bike is relaxing. The results mentioned here are found in all three inquiries.

4.2. Explanatory analysis

Model specification

In addition to the descriptive analyses, an explanatory analysis was performed. A multivariate regression was conducted with as dependent variable the difference between the two years in the number of days per week the car was used for commuting. People who did not use the car in both years were excluded from the analysis, people who used the car in one of these years but not in the other were included. The explanatory

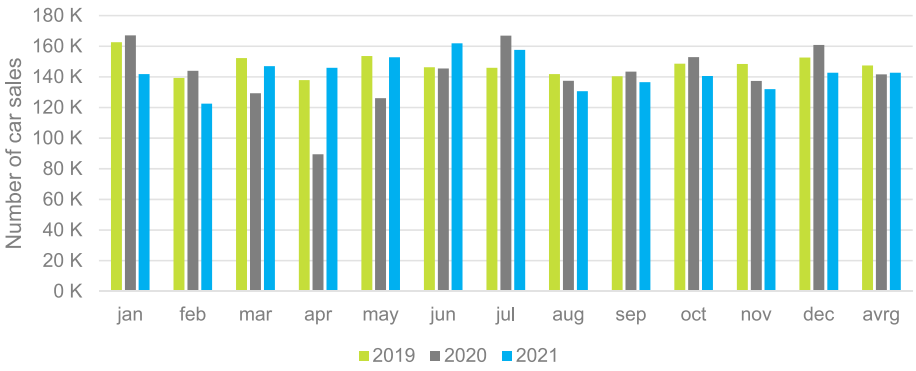

Fig. 3. Total car sales in the Netherlands (new and used).

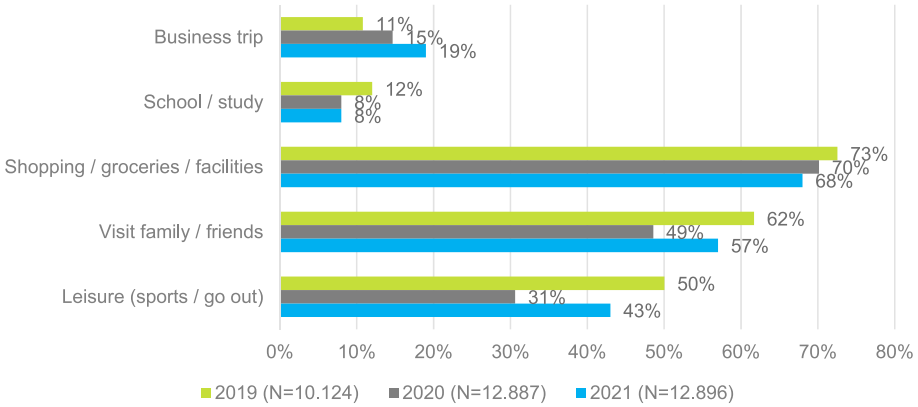

Fig. 4. Share of the people that travel for other reasons than commuting.

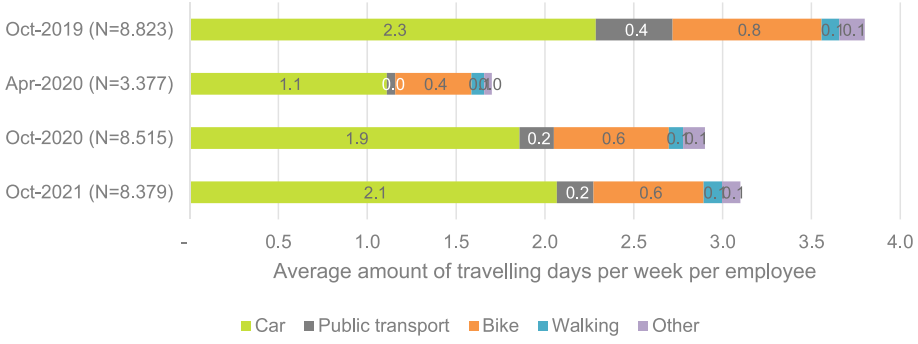

Fig. 5. Average amount of travelling days a week.

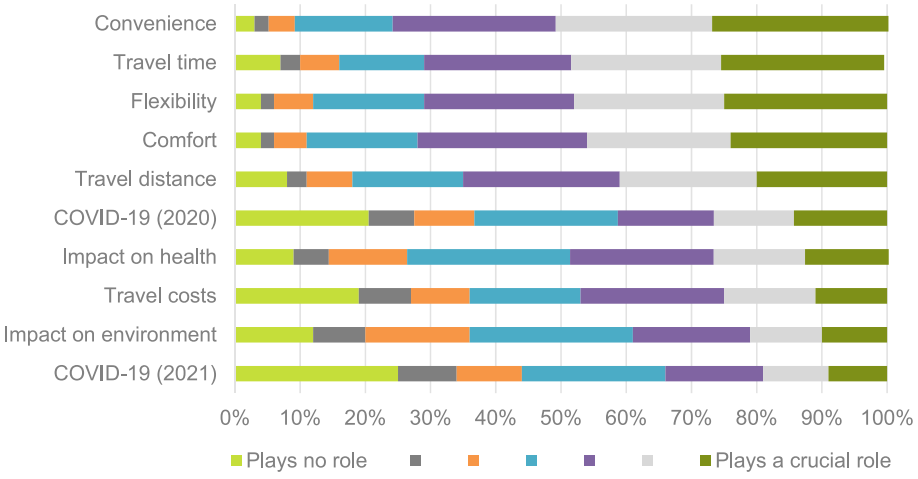

Fig. 6. Aspects in deciding transport mode choice for commuting.

analysis was conducted for the 2019 as well as for the 2020 and 2021 studies. Explanatory variables consist of several types:

- Changes in commuting characteristics between the years. For instance, a change in the number of working days a week, or the work or residential location.
- Changes in the characteristics of the means of transport that can be used for commuting. For instance, a change in the parking situation on the work location, in the frequency of public transport or the cycling route.
- Changes in arrangements offered by the employer for (the costs of) commuting. For instance, arrangements for working at home, compensation for travel expenses for the means of transport that is used for commuting, or compensation for buying an (e-)bike to be used for commuting.
- Participation in national, regional of employer related programs to stimulate the use of other means of transport than the car for commuting (sustainable travel behaviour).

In most cases these variables are defined as 0–1 dummy variables (e.g. has moved or participated in a program is "1″), or as "-1, 0, 1" variables, were a "-1" means that something became worse, "1" that it improved and "0" that it did not change since last year, or it was not applicable. In the questionnaire, the participants in the study had to

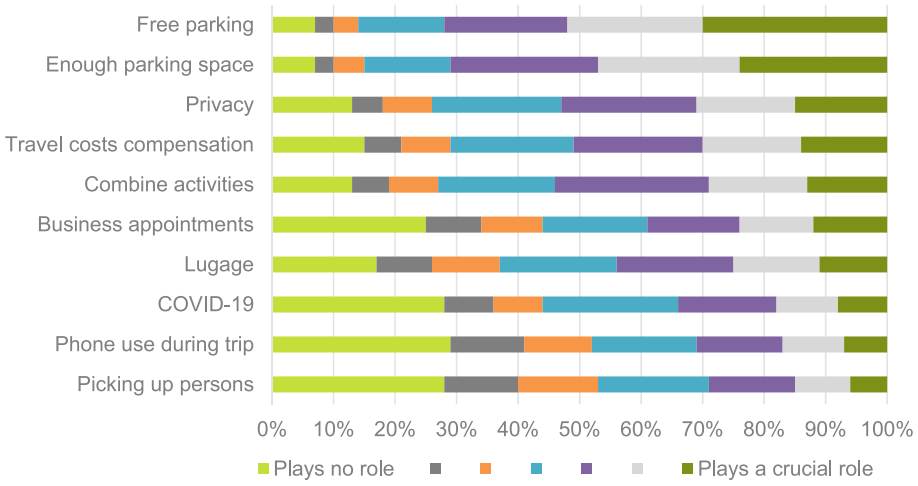

Fig. 7. Aspects in deciding to use car for commuting.

determine which situation was applicable for them. Therefore, all these variables are "filled" with subjective data. The same holds for the difference in car-commuting days, the dependent variable. The number of days the car is used in the current year ("last week") and previous year ("a similar week in October last year") were asked in the same questionnaire, so the observation for the previous year is determined retrospective.

Furthermore, (dummy-)variables were added for the sector people work in, their commuting distance and household characteristics. In the 2020 and 2021 study, several additional variables were added to cover for the COVID-19 situation that led to major changes in commuting compared to 2019. This are variables that measure to what extend people do or do not use the car for commuting due to COVID-19 and reasons to work (more) at home (e.g.: "Imposed by the government" or "Imposed by my employer" or "I don't like to travel anymore"). In total, dozens of variables were tested for their explanatory power. In the final 2020-model 47 variables were included and in the final 2021-model 65 variables (including some extra interaction variables).

Model results

In this section, we focus on 2020 and 2021, since these models also show what impact the COVID-19 related variables had on the (relative big) changes in the number of days people used their car for commuting compared to 2019. The 2020-model was estimated on 5,511 observations (people that use their car for commuting at least 1 day in 2020 or 2019) and 5,528 observations for the 2021-model. In the final 2020-model the adjusted R^2 had a value of 0.421, for the 2021-model the adjusted R^2 was 0.662.

We do not show all the individual estimates here, but present the results of two impacts: 1. the effect on the average number of days per week the car is used per person and 2. the effect on the total number of commuting trips and total distance the car is used. The second estimate is done for the total (working) population, for each "class" of variables in the analysis. We assumed that using the car on a certain day results in two trips and the total distance is calculated as the sum over all respondents of the number of car-trips times the distance from home to work for each respondent.

For trips and distance, we have to emphasize that these are *indicative* results. Originally, the NTS was intended to give representative results for the whole year in which the study was conducted. Therefore, a normal, "average" month for travel behaviour (October) was selected for the data collection. However, obviously, 2020 and 2021 were far from average years and October was not an average month in both years. Both years were characterized by many (big) changes in travel behaviour during the year, because of the COVID-19 pandemic and the associated (government) measures on travel in general and commuting in particular.

The results for the analysis for 2020 in comparison with 2019 are shown in Table 2. On average, employees used the car about one trip per week less in 2020 compared to 2019. Changes in work or residential circumstances (changing jobs or moving to another place) account for 0.41 trip of this change and a decrease of 0.20 is the result of changes in employer related arrangements. COVID-19 related variables have, as expected, a relative big impact on car travel. People who use their car more than in 2019 due to COVID-19 (e.g., because they are afraid to travel by public transport) use their car on average 0.53 trips a week more often. The recommendation to work from home by the government or because the employer required it, also had a relative big impact. These factors account for 0.52 respectively 0.40 less car trips per week. The impact of the other (combined) factors is relatively low.

For total commuting this means a decrease of almost 6 million car trips and over 167 million car kilometres for commuting a week in the Netherlands in 2020. These numbers correspond remarkably well with another national survey conducted yearly (CBS, 2021). This survey records in detail one day of travel of a respondent through a travel diary. For 2020, almost 50,000 respondents filled in this diary. For this survey in 2020, about 5.9 million less trips were made for commuting and about 190 million less car kilometres. Therefore, the number of trips is almost the same for both surveys, but there is difference in distance travelled.

The results for the analysis of 2021 compared with 2020 are shown in Table 3. Almost 1 extra commute trip per person per week was made in 2021, mainly due to a change in personal circumstances. Other important variables were COVID-19 related, including working from home, although the impact was not as large as in 2020.

Table 2
Results of analysis on commuting car trips per person per week, total commuting car trips and total car kilometres per week (2020 vs 2019).

Variable type	Trips/ person	Total trips [a]	Total kms [b]
External (living and working)	−0.41	−2,420	−39,480
Employer arrangements	−0.20	−1,180	−35,040
Travel route	0.00	−20	−1,170
Sustainable travel behaviour	0.02	100	1,580
COVID-19 related (directly)	0.50	3,000	73,750
Using the car due to COVID-19	0.53	3,160	78,200
Other COVID-19 factors	−0.03	−160	−4,450
Working from home	−0.92	−5,440	−167,010
Recommended by the government	−0.52	−3,060	−90,720
Mandatory by employer	−0.40	−2,380	−76,290
Total	**−1.01**	**−5,960**	**−167,370**

a: per week × 1,000 trips.
b: per week × 1,000 km.

Table 3
Results of analysis on commuting car trips per person per week, total commuting car trips and total car kilometres per week (2021 vs 2020).

Variable type	Trips/person	Total trips [a]	Total kms [b]
External (living and working)	0.81	4,780	140,400
Employer arrangements	−0.06	−330	−9,050
Travel route	0.01	40	1,030
Sustainable travel behaviour	−0.01	−30	−530
COVID-19 related (directly)	0.15	910	23,710
Using the car due to COVID-19	0.03	190	4,700
Other COVID-19 factors	0.12	720	19,010
Working from home	−0.15	−880	−28,270
External reason	−0.02	−100	−24,720
Personal reason	−0.13	−780	−3,550
Other	0.22	1,280	37,200
Total	**0.97**	**5,770**	**164,490**

a: per week × 1,000 trips.
b: per week × 1,000 km.

For our survey in 2020 over 40 % of the decrease in number of trips and 56 % of the decrease in kilometres (compared with 2019) are a direct result of the COVID-19 pandemic. This effect is much smaller and even slightly positive in 2021 compared with 2020. Other factors contribute more to the increase in trips and kilometres, especially the changes in living and working.

For 2020, part of the effect for the employer arrangements can also be attributed to COVID-19, since many companies have made it easier to work from home or to allow having more flexible working hours. Furthermore, some people decided to move in 2020, since living close to the work location has become less necessary when working from home became more accepted and common. Finally, some people started working somewhere else, because they lost their yob due to COVID-19. Therefore, here also is an (indirect) effect of the pandemic. For 2021 the impact of the employer arrangements are much lower.

In total, we estimated that the number of commuting car-kilometres decreased in 2020 with 18 % compared to 2019 and that this led to a reduction of 20 % in CO_2 emissions. For 2021, we estimated that the number of commuting car kilometres increased with 21 % and this affected the CO_2 emissions, which increased with an estimated 19 % compared with 2020. In both cases, the estimated levels in 2021 still lie below those in 2019.

4.3. Analysis of main road traffic

Also from other sources, we know that less car trips has led to less kilometres driven and also to less congestion. From the loop detectors on the Dutch main roads we have derived the distance travelled in vehicle kilometres and the delay, measured in vehicle hours lost. If we compare the years 2019, 2020 and 2021, we obtain Fig. 8.

From the graphs, it is clear that a relatively small amount of traffic less gives a lot less delay. In total, there was 17 % less traffic on the main roads in 2020 compared with 2019, but there was 70 % less delay. This trend continued in 2021: there were 15 % less vehicle kilometres driven and 65 % less delay than in 2019. Compared with 2020 there were 3 % more kilometres driven and 18 % more delay.

5. Conclusion and discussion

Since the COVID-19 pandemic, we have seen major changes in our commuting behaviour. In 2020, teleworking increased, and there was a significant decrease in commuting trips. Commuting trips increased again in 2021, but not to the same level as it used to be. There is a higher potential for teleworking than previously thought. In 2019, 25 % of the working population worked one day or more from home. Right after the first lockdown, April 2020, this increased to 69 %, in October 2020, it was 42 % and this was still up to 42 % in October 2021. These developments have increased the opportunities for teleworking in different

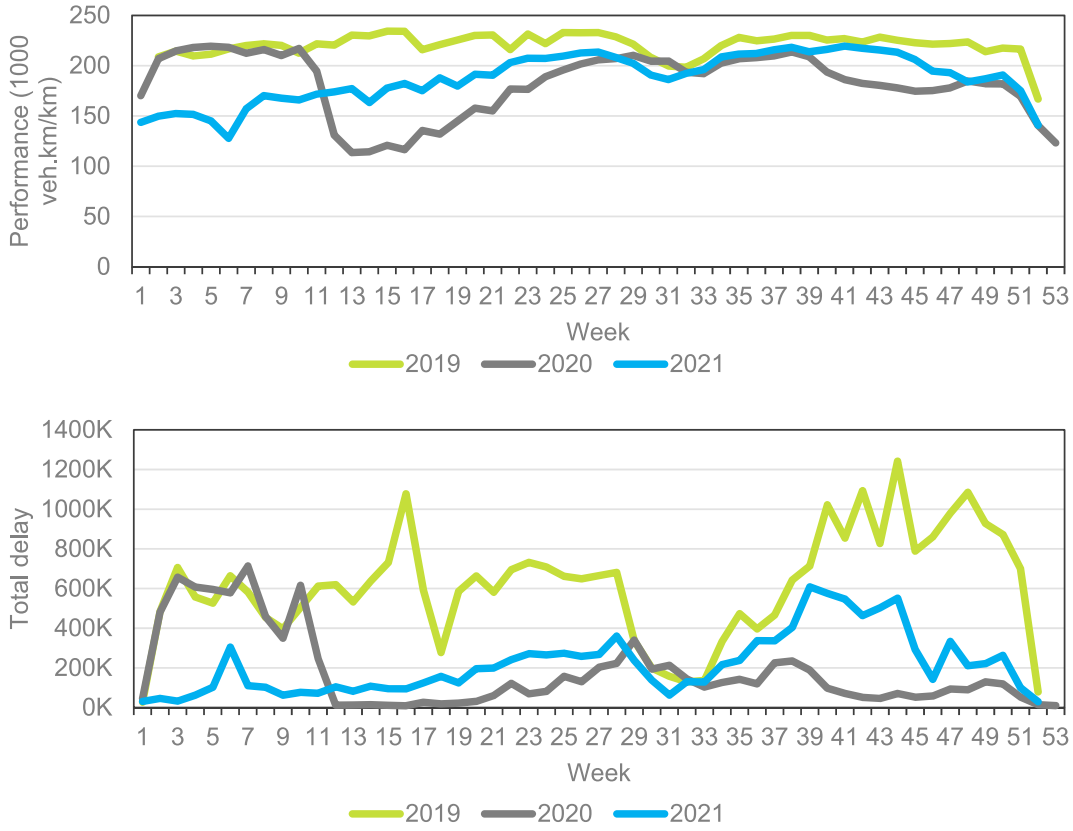

Fig. 8. Distance travelled and delay for the main roads (source: Rijkswaterstaat).

professions. Almost half of the employed population expressed they want to keep working from home. However, there is no guarantee that this intention will lead to structural changes in our commuting behaviour. Stimulating and facilitating working from home, both by the government and employers, remains necessary to ensure the positive impact of teleworking relating to accessibility and sustainability. Now that we have not yet returned to the situation pre-COVID-19, this is the right moment for national and regional authorities and employers to act.

The large reduction of commuting trips, mainly during the peak hours, resulted in 17 % less vehicle kilometres and 70 % congestion reduction (expressed in lost vehicle hours) on the main road network in 2020 compared with 2019, as measured by the loop detectors on the main roads. A reduction of 65 % in vehicle kilometres and 65 % in congestion was measured in 2021, also compared with 2019. An important conclusion we can draw from this is that a relative small decrease in traffic during peak hours leads to a substantial reduction of congestion on the main road network.

Therefore, the Ministry of Infrastructure and Water Management continues to improve the accessibility and spreading mobility during the day and avoiding peak hours can contribute to this. An effort is made to keep the current momentum by supporting and stimulating the possibilities for hybrid working (partially at home and partially at the office). This is done in cooperation with other governmental entities, umbrella organisations for employers and employees and educational institutes. On a regional level, also other large organisations using road and public transport will participate.

However, the increasing share of teleworking also has negative consequences. The decrease in the total number of commuting trips, and therefore also the use of active transport modes (i.e., cycling and walking), implies that employees more often do not meet the norms for sufficient exercise. To ensure healthy and fit personnel, it is essential to focus on additional activity among employees, for instance, cycling and walking for recreational purposes.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The data collection for this research was funded by the Dutch Ministry of Infrastructuur and Water Management.

References

Ajzen, I., 1991. The theory of planned behaviour. Organ. Behav. Hum. Decis. Process. 50, 179–211.

Begheijn, D. (2021). *Implementing policy strategies to stimulate teleworking - Long-term impacts of COVID-19 related attitude changes towards teleworking*, MSc Thesis, Delft University of Technology, ITS Edulab, April 2021.

CBS (2020), *Documentation survey 'En Route in the Netherlands'*, Central Bureau for Statistics, report, July 2020.

CBS (2021), *En Route in the Netherlands – Plausibility Report*, Central Bureau for Statistics, report, June 2021, available through https://www.cbs.nl/nl-nl/longread/rapportages/2021/onderweg-in-nederland–odin—2020-plausibiliteitsrapportage, accessed on August 23rd, 2021.

Climate Consultation (2019), *Climate Agreement*, policy document, June 2019, https://www.klimaatakkoord.nl/binaries/klimaatakkoord/documenten/publicaties/2019/06/28/klimaatakkoord/klimaatakkoord.pdf, accessed on April 1st, 2022, in Dutch.

Copolla, P., De Fabiis, F., 2020. Evolution of mobility sector during and beyond Covid-19 emergency: a viewpoint of industry consultancies and public transport companies. TeMA – J. Land Use, Mobility Environ. 81–90.

Gkiotsalitis, K., Cats, O., 2020. Public transport planning adaption under the COVID-19 pandemic crisis: literature review of research needs and directions. Transp. Rev. 41 (3), 374–392.

Hale, T.h., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., Tatlow, H., 2021. A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nat. Hum. Behav. 5 (4), 529–538.

Netherlands Institute for Transport Policy Analysis (2021), *The Netherlands Mobility Panel*, available through https://english.kimnet.nl/the-netherlands-mobility-panel, accessed on August 23rd, 2021.

Kroesen, M., Handy, S., Chorus, C., 2017. Do attitudes cause behavior or vice versa? An alternative conceptualization of the attitude-behavior relationship in travel behavior modelling. Transp. Res. Part A 101, 190–202.

MinIenW (2019), *MaaS-pilots – Optimising the Mobility System, Ministry of Infastructure and Water Management*, May 2019, available through https://www.rijksoverheid.nl/binaries/rijksoverheid/documenten/brochures/2019/05/31/maas-pilots—optimaliseren-van-het-mobiliteitssysteem/Brochure+MaaS-pilots+NL+190522.pdf, accessed on April 5th, 2022, in Dutch.

Molloy, J., Schatzmann, T., Schoeman, B., Tchervenkov, C., Hintermann, B., Axhausen, K.W., 2021. Observed impacts of the Covid-19 first wave on travel behaviour in Switzerland based on a large GPS panel. Transp. Policy 104, 43–51.

MuConsult (2020), *National Traveller Survey 2019*, report for the Dutch Ministry of Infrastructure and Water Management, February 2020, in Dutch.

MuConsult (2021), *National Traveller Survey 2020*, report for the Dutch Ministry of Infrastructure and Water Management, February 2021, in Dutch.

MuConsult (2022), *National Traveller Survey 2021*, report for the Dutch Ministry of Infrastructure and Water Management, February 2022, in Dutch.

OECD (2021), *Teleworking in the COVID-19 Pandemic: Trends and Prospects*, OECD Policy Responses to Coronavirus (COVID-19), September 2021.

Olde Kalter, M.J.T., La Paix Puello, L., Geurs, K.T., 2020. Do changes in travellers' attitudes towards car use and ownership over time affect travel mode choice? A latent transition approach in the Netherlands. Transp. Res. Part A: Policy Practice 132, 1–17.

Shamshiripour, A., Rahimi, E., Shabanpour, R., Mohammadian, A.K., 2020. How is COVID-19 reshaping activity travel behavior? Evidence from a comprehensive survey in Chicago. Transp. Res. Interdisciplinary Perspectives 7, 100216.

Taale, H., 2006. *Analysing Loop Data for Quick Evaluation of Traffic Management Measures*, paper for the European Transport Conference 2006. Strasbourg, France.

Tirachini, A., Cats, O., 2020. COVID-19 and Public Transportation: Current Assessment, Prospects, and Research Needs. J. Public Transportation 22 (1).

Ton, D., Arendsen, K., de Bruyn, M., Severens, V., van Hagen, M., van Oort, N., Duives, D., 2022. Teleworking during COVID-19 in the Netherlands: Understanding behaviour, attitudes, and future intentions of train travellers. Transp. Res. Part A: Policy Practice 159, 55–73.

Tour de Force (2019), *National Vision on the Future of Cycling*, March 2021, https://open.overheid.nl/repository/ronl-b8dfde44-a4b3-4351-a9c5-5ce5191b27b6/1/pdf/bijlage-nationaal-toekomstbeeld-fiets-op-hoofdlijnen.pdf, accessed on April 5th, 2022, in Dutch.

Van Cranenburgh, S., Chorus, C., Van Wee, B., 2012. Substantial Changes and Their Impact on Mobility: A Typology and an Overview of the Literature. Transport Reviews 32 (5), 569–597.

Van der Drift, S., Wismans, L., Olde Kalter, M.J.T., 2021. Changing mobility patterns in the Netherlands during COVID-19 outbreak. J. Location Based Services 16 (1), 1–24.

Van Wee, B., Vos, J., Maat, K., 2019. Impacts of the built environment and travel behaviour on attitudes: Theories underpinning the reverse causality hypothesis. J. Transp. Geogr. 80, 102540.