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Post-pandemic trends in urban mobility

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Abstract

The Covid-19 pandemic triggered significant changes in lifestyles and mobility patterns which are still evident at the end of 2022 and may still raise challenges for transport policy in the short to medium term. While changes in lifestyles - mainly as regards work patterns - have decreased total urban transport activity, the gradual return to pre-pandemic levels suggests that traffic and congestion levels may soon exceed their 2019 levels. Apart from the question of total transport activity, the trends identified in this report can influence modal choice and trip distances, with possible negative repercussions in terms of transport costs, congestion and emissions. The analysis combines a range of data sources and methodologies. Changes in mobility patterns are identified using the JRC Travel Survey 2021. The evolution of traffic congestion levels is monitored through daily TomTom data from 178 cities in the EU. The evolution of public transport activity is measured with up-to-date statistics from national and local sources. The role of active mobility is discussed using a model to estimate the potential uptake and benefits in terms of external costs. Information provided by the candidates for the EU Mission on Climate-Neutral and Smart Cities allows an extensive review of transport policy measures adopted at city level. Finally, a case study for 40 European cities using multiple data sources provides an empirical confirmation of the main findings.

Authors

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Executive summary

The Covid-19 pandemic triggered significant changes in lifestyles and mobility patterns which are still evident at the end of 2022 and may still raise challenges for transport policy in the short to medium term. While changes in lifestyles -mainly as regards work patterns- have decreased total urban transport activity, the gradual return to pre-pandemic levels suggests that traffic and congestion levels may soon exceed their 2019 levels. Apart from the question of total transport activity, the trends identified in this report can influence modal choice and trip distances, with possible negative repercussions in terms of transport costs, congestion and emissions. The analysis combines a range of data sources and methodologies.

Policy context

The European Commission has adopted the 'Sustainable and Smart Mobility Strategy' (European Commission, 2020a) together with an Action Plan of 82 initiatives that will guide the work for the next four years. This strategy lays the foundation for the EU transport system to achieve its green and digital transformation and become more resilient to future crises. In the aftermath of the Covid-19 pandemic, urban mobility has witnessed far reaching changes that may constitute obstacles or opportunities for this transformation. Monitoring the emerging trends can assist in fine tuning future policy measures and initiatives.

Main findings

The JRC Travel Survey 2021 measured the impact of the Covid-19 pandemic on lifestyle and mobility patterns. Even after most restrictions were lifted, a significant share of the respondents was still working from home or avoided situations that increased health risks. As a result, compared to 2019, mobility choices were still affected in terms of trip frequency, destination and mode used. Cars increased their share as the preferred means of transport, while active mobility maintained a large part of the momentum gained during the pandemic. Public transport and emerging mobility options (ride hailing, car sharing, etc.) lost a significant number of users and saw their modal shares decrease. These trends can raise a triple challenge for urban transport, since they reflect an increased degree of car dependency, a weakening role for public transport and uncertainty for innovative transport options.

Traffic congestion was still milder at the end of 2022 compared to pre-pandemic levels. This is, however, mainly the effect of the decrease in the total number of trips due to a high share of users still working from home. That share is, nevertheless, gradually getting closer to 2019's levels. On the other hand, car usage has increased (to the detriment of public transport) and car traffic is back on the rise. The current trend implies that - for most of the 178 monitored cities - congestion levels in 2023 or 2024 will be comparable to those in 2019 if no measures are taken.

Across the EU, public transport was particularly affected by the pandemic with several operators experiencing a decrease of more than 50% in transport performance during year 2020. Ridership is slowly recovering, but for most of the cities where data is available the difference with year 2019 levels is still in the order of 20%-30%. This gap in demand causes significant financial and operational concerns and may threaten the sustainability of several service providers.

Active mobility, on the other hand, benefitted from the behavioural changes stimulated by the pandemic. Many urban residents were introduced to cycling as a main means of transport and a large share appears to maintain this choice by the end of 2022. Walking also gained thrust as a mobility option, especially for short trips. A further positive development is that a growing number of cities used the momentum to expand cycling infrastructure and pedestrian areas, attracting even more potential users.

Apart from the short to medium terms challenges for urban transport raised by the pandemic, the long term challenges of improving local transport and achieving climate neutrality also require concerted efforts. The extensive sample of the 362 candidate cities for the EU Mission on Climate-Neutral and Smart Cities provides several examples of how a combination of measures –technological, planning and regulatory- are needed, and how the pandemic has increased the need for investment in public transport and active mobility.

The case study in 40 EU cities compared mobility data from a range of emerging data sources with the trends identified in the JRC Travel Survey, confirming the direction and extent of the impacts on mobility.

Related and future JRC work

The JRC has a long track record of analyses on the socio-economic and technological trends related to transport and mobility. The JRC Flagship report on the Future of Road Transport (Alonso Raposo, and Ciuffo,

2019) mapped the emerging trends and challenges for all modes of transport. At the urban level, The JRC Flagship report on the Future of Cities (Vandecasteele, et al., 2019), discusses how transport policy can be adapted to the changing urban context. During the Covid-19 pandemic, a dedicated JRC Task Force combining expertise from a wide range or areas applied and developed methods to - among others - use mobile phone data to monitor mobility and its relation with the evolution of the pandemic (P. Christidis et al., 2022).

The JRC Work Programme for 2023-2024 addresses urban transport issues through two portfolios of activities. The portfolio on Decarbonized, Smart and Safe Mobility will address the challenges raised by the Green and Digital Twin Transition. A Science for Policy Brief on the research perspective on future policy needs will be published in early 2024. The portfolio on Cities and Buildings for Better Lives will provide support to the EU Mission on Climate-Neutral and Smart Cities and will collect data, develop methodologies and create tools for urban transport policy. The policy support work of the JRC will be complemented by a number of scientific research activities that aim at ensuring the quality of the underlying methodologies used.

Quick guide

The report is divided into sections, each addressing a specific challenge using suitable data and methodologies. Section 2 identifies the changes in mobility patterns based on the JRC Travel Survey 2021. Section 3 analyses the evolution of traffic congestion levels using daily TomTom data from 178 EU cities. Section 4 evaluates the evolution of public transport activity through up-to-date statistics from national and local sources. Section 5 discusses the role of active mobility and applies a model to estimate its potential uptake and benefit in terms of external costs. Section 6 summarizes the measures adopted at city level using the information provided by the candidates for the EU Mission on Climate-Neutral and Smart Cities. Finally, Section 7 provides a case study for 40 European cities for which multiple data sources are combined.

1 Introduction

The European Commission has adopted the 'Sustainable and Smart Mobility Strategy' (European Commission, 2020a) together with an Action Plan of 82 initiatives that will guide the work for the next four years. This strategy lays the foundation to help the EU transport system achieve its green and digital transformation and become more resilient to future crises. In the aftermath of the Covid-19 pandemic, urban mobility has witnessed far reaching changes that may constitute obstacles or opportunities for this transformation. Monitoring the emerging trends can assist in fine tuning future policy measures and initiatives.

The Covid-19 pandemic triggered significant changes in lifestyles and mobility patterns which are still evident at the end of 2022 and may still raise challenges for transport policy in the short to medium term. While changes in lifestyles - mainly as regards work patterns - have decreased total urban transport activity, the gradual return to pre-pandemic levels suggests that traffic and congestion levels may soon exceed their 2019 levels. Apart from the question of total transport activity, the trends identified in this report can influence modal choice and trip distances, with possible negative repercussions in terms of transport costs, congestion and emissions. The analysis combines a range of data sources and methodologies. Changes in mobility patterns are identified using the JRC Travel Survey 2021. The evolution of traffic congestion levels is monitored through daily TomTom data from 178 cities in the EU. The evolution of public transport activity is measured with up-to-date statistics from national and local sources. The role of active mobility is discussed using a model to estimate the potential uptake and benefits in terms of external costs. Information provided by the candidates for the EU Mission on Climate-Neutral and Smart Cities allows an extensive review of transport policy measures adopted at city. Finally, a case study for 40 European cities using multiple data sources provides an empirical confirmation of the main findings.

2 Changing mobility patterns

Transport activity is showing a gradual return to normality, with the pandemic getting under control and mobility restrictions being lifted, even though new waves and variants are emerging (Christidis et al., 2021). The shock for society and economy has, however, caused a number of behavioural changes that can influence the evolution of the transport sector. New remote work patterns or personal risk avoidance attitudes can lead to increased levels of car ownership and use (Lopez Soler et al., 2021). Public policy priorities in the aftermath of the pandemic would need to address the emerging challenges and adopt measures that can sustain the shift to active travel, support public transport, railways and aviation, and stimulate innovation in transport technologies and services.

The impact of the pandemic on mobility has been already monitored and analysed extensively, at least as regards its early stages. In the Netherlands, data for the March-April 2020 period indicate a drastic decrease of mobility during the 'intelligent lockdown' strategy (de Haas et al., 2020). In Spain, the avoidance of public transport due to fear of contagion was already evident in April 2020 (Echaniz et al., 2021). In India, two different surveys (Das et al., 2021; Thombre and Agarwal, 2021) in the period March-June 2020 observed an increased car dependency and a generalized avoidance of public transport in large urban areas, across all income groups, the main reason appearing to be the perception of high contagion risk in mass transit. Similar trends were observed at later stages of the pandemic, as for example in the October-December 2020 period in Toronto (Wang et al., 2021). In the USA, public transport was also affected, but users with lower income changed their mobility patterns to a lesser extent (Parker et al., 2021), probably due to the lack of alternatives.

In China, where the first wave of the pandemic was brought under control relatively early in 2020, a lasting impact on mobility choices was observed throughout the rest of the year. A widespread shift from public to private transport modes was accompanied by an increased willingness to purchase a car (Zhou et al., 2021). The decrease in demand for public transport was independent of the pandemic's evolution in all Chinese cities analysed (Xin et al., 2021), indicating that the risk perception can last significantly longer than the actual health emergency. Similarly, in Australia - where the pandemic had a slow evolution - confidence in public transport fell rapidly during March and April 2020 (Beck and Hensher, 2020). A pre-emptive change in mobility was also observed in Switzerland (Hackl et al., 2019), with cycling attracting a significant share of activity for all trip purposes.

2.1 The JRC mobility survey 2021

In 2021, the JRC carried out a survey in 20 cities across 11 Member States of the European Union addressing the impacts of the pandemic on personal mobility choices (Navajas Cawood et al., 2023). The goal was to identify the changes in activity, lifestyles and preferences that may lead to a prolonged effect on the urban transport system, especially as regards demand and modal split. The survey explored the changes introduced by the pandemic in transport habits as well as the ensuing expectations of citizens regarding public transport policy and urban planning.

The survey covered the Functional Urban Area (FUA) of each city, which includes the core urban area and its commuting zone. For each FUA, 500 respondents completed a detailed questionnaire:

- Demographic information: age, sex, level of education, income, number of household members
- Employment information: employment status, change of employment status due to pandemic, frequency of teleworking, reasons for not being able to telework
- Mobility patterns before the pandemic:
  - Frequency of use of transport avoidance options: work from home, video calls to family and friends, phone/video-conferencing for work, use of phone and video calls for health and medical services, purchase of goods online, use of home delivery services for groceries
  - Frequency of use of transport modes: walking, private bike/e-bike, shared bike/e-bike, private scooter/e-scooter, shared scooter services, private motorbike/moped, shared motorbike/moped, private car as driver, private car as passenger, shared car as driver,

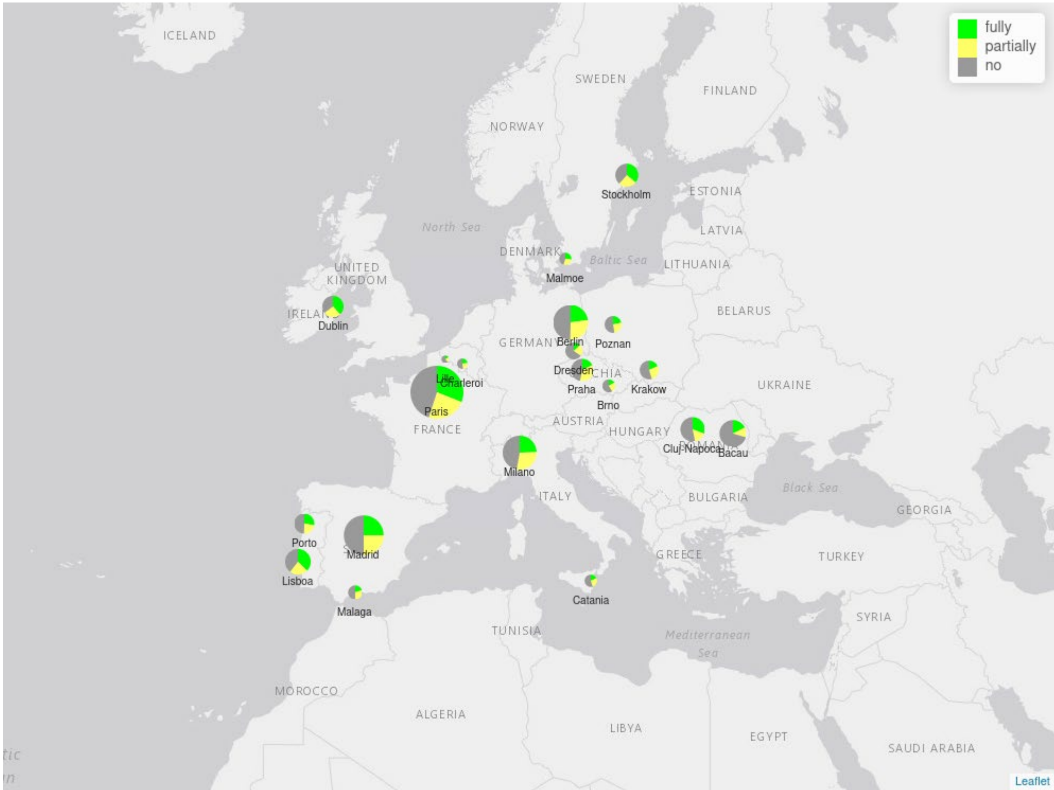
shared car as passenger, taxi, ride-hailing services, urban public transport (bus, tram, metro, rail, etc.)

  - Frequency of use of each mode for each trip purpose: commuting, business, education, visiting relatives/friends, accompanying children to/from school, accompanying family and friends, purchasing groceries, other shopping, leisure

- Specific changes of mobility patterns due to the pandemic: use of transport avoidance options, level of comfort with using transport avoidance options, type of change in mobility patterns (number of trips, transport mode, trip schedule, destination), trip purposes affected, frequency of use of each mode, reasons for change in most frequent mode used
- User expectations as regards future mobility patterns: change in frequency of use of transport avoidance options, change in frequency of each transport mode
- Change in vehicle ownership due to the pandemic: purchase of cars (new, second-hand), bicycles, electric bicycles, motorbikes/mopeds, scooters/e-scooters
- Accessibility of public transport: distance, availability, frequency, changes in preferences due to the pandemic

The mix of cities covered by the survey was intentionally diverse, in order to include a variety of city sizes and socio-economic profiles across Europe. This diversity is reflected in most of the behavioural changes and mobility patterns observed in the survey. The shift to teleworking was one of the main responses during the pandemic and a key disruptor for urban transport demand. The share of employed respondents who teleworked to some extent in June 2021 varied considerably, ranging from 30% in Bacau to 65% in Dublin (Figure 1). Cities where more than 30% of the respondents fully teleworked include Dublin, Lisbon, Stockholm, Paris and Cluj-Napoca, as opposed to only 13% in Dresden and 15% in Lille. These differences are the result of several factors that include the economic profile of each city, the intensity of the pandemic at local or national level, the share of jobs that can be performed remotely, the measures put in place in each case to address the pandemic, the perceived risk by the employees, the flexibility offered by employers, technological preparedness, social and cultural norms, as well as the pre-existing frequency of telework before the pandemic.

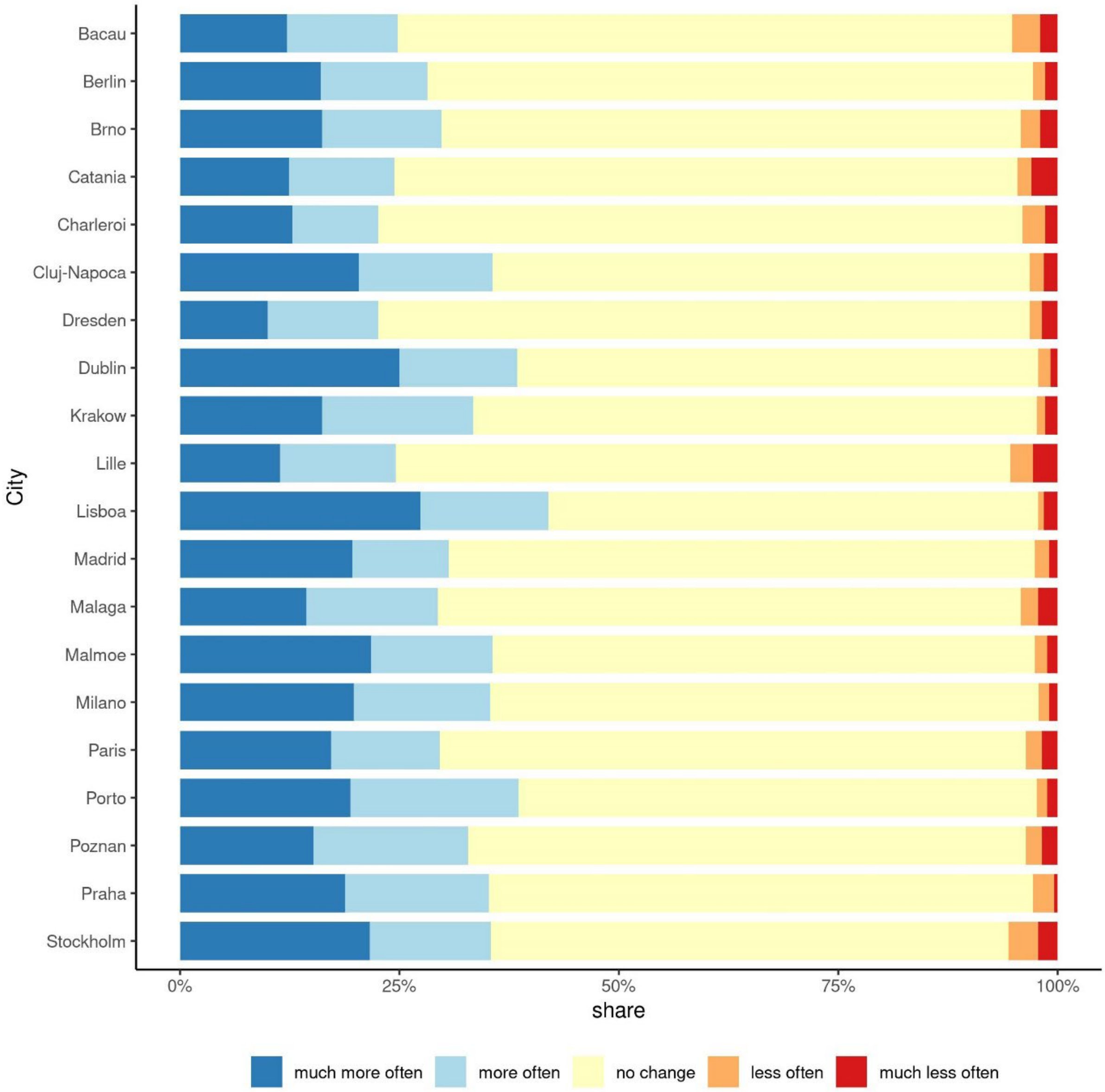
Figure 1. Cities covered by the survey and share of employed respondents currently teleworking (June 2021)



Source: (Panayotis Christidis et al., 2022)

The change in teleworking frequency as a result of the pandemic can be further explained when comparing it with the levels before the pandemic (Figure 2). Lisbon, Porto and Dublin had the highest share of respondents who increased their frequency of telework. In both Ireland and Portugal telework was not frequent before 2020, but was adopted as a main measure to fight the pandemic at country level. In contrast, Paris, Madrid and Stockholm showed a more moderate increase in frequency but still high telework levels in June 2021, a result of the already high uptake of remote work before 2020. The average share of respondents who teleworked much more often in the 20 cities is 17.4% (ranging from 10% in Dresden to 27.4% in Lisbon), while that of respondents who telework at least more often is 31.4% (ranging from 22.6% in Charleroi and Dresden to 42% in Lisbon). There is also a small share of respondents who stated that they teleworked less frequently during the pandemic than they did before, but in most cases this is the result of changes in the respondents' jobs during the period.

Figure 2. Frequency of work from home compared to pre-pandemic levels



Source: (Panayotis Christidis et al., 2022)

The other five main behavioural changes brought by the pandemic - and potentially influencing transport and mobility - also appear to increase in frequency, at different degrees among the 20 cities (Figure 3).

Online shopping was already quite popular in most European cities before the pandemic, but the behavioural shift in this domain is the one (out of the six main ones covered by the survey) that increased the most during the pandemic. On average, across the 20 cities, 31% of the respondents shopped online more often and 15% much more often. In Dublin, Málaga and Lisbon the share of respondents who resorted to online shopping much more often exceeded 20%, while in Berlin, Dresden and Charleroi the corresponding share was between 8% and 9%. The change in the frequency of online shopping has a low correlation with that of teleworking (correlation coefficient = 0.14) or the other four behavioural shifts (0.14 to 0.24). The increased frequency is probably caused by a large share of the population becoming accustomed to online shopping during the early stages of the pandemic – especially when lockdowns were imposed - and maintaining the habit still in June 2021. At the same time, the familiarity/skillsets of online retailers and conventional retailers with delivery services improved drastically during the pandemic and would now be considered as an option for a larger market segment. Especially in countries where there was limited presence of online retailers before 2020, such as Ireland and Portugal, the pandemic accelerated the introduction of new online retailers or the digitalisation of conventional brick-and-mortar businesses.

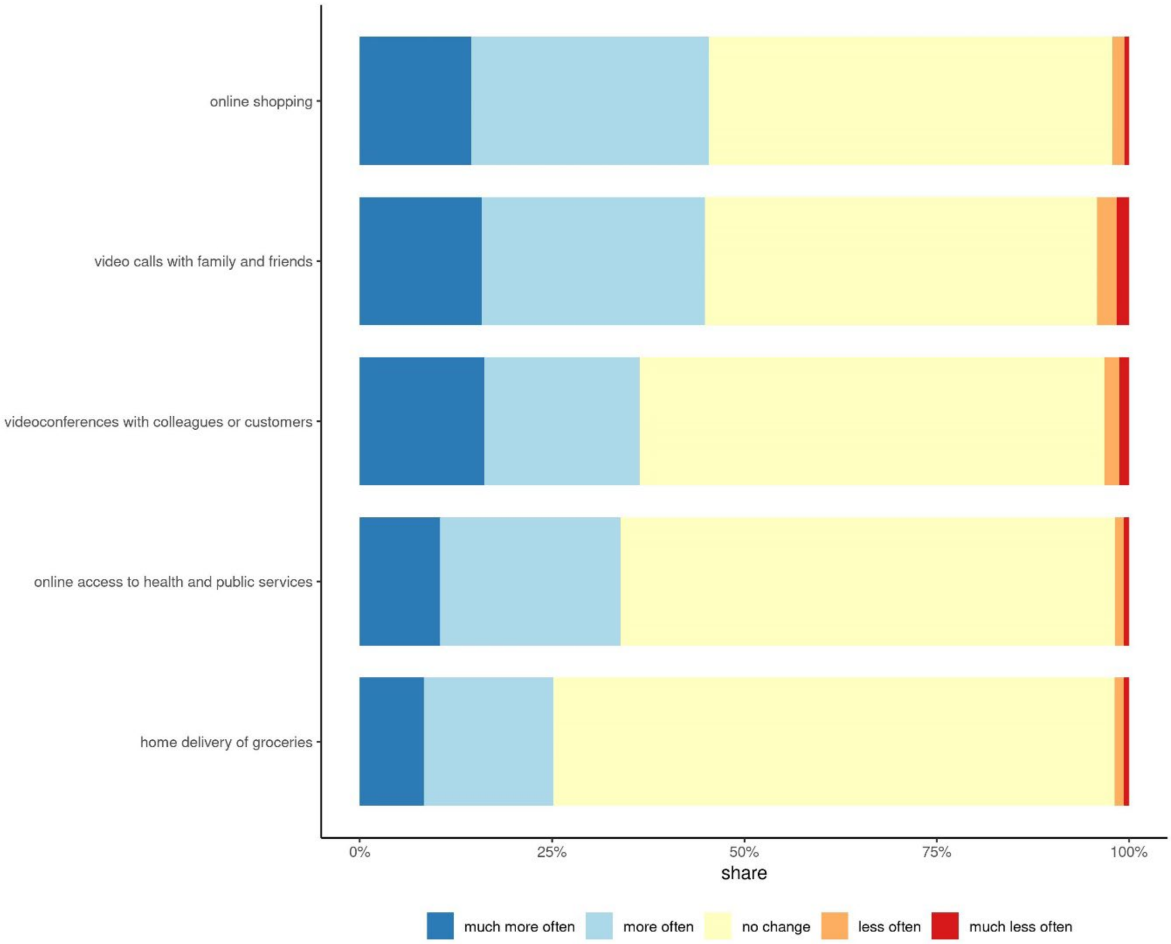
Video calls with family and friends increased at a comparable degree: 29% of respondents used them more often and 16% much more often. The variation among the 20 cities is considerable in this case too. Only 7.6% of the respondents in Berlin stated that they used video calls much more often, while in Lisbon the corresponding share is 24%. Video calls were already common before the pandemic, but the mobility restrictions in most cities greatly contributed to their transformation into a daily routine element. As in the case of online shopping, the familiarization with the technology during the early phases of the pandemic led to levels of adoption that can be probably sustained in the longer term. As for the impacts on transport demand, the question is whether video calls are a substitute for travel and mobility. Especially for long distance interactions, the increase in video calls can be attributed to the restrictions in travel during the first phase of the pandemic and the slow recovery of both intra-national and international activity. Visiting friends and family is a main purpose for travel in Europe (about 30% of total tourism activity) and the unfulfilled demand probably increases digital interactions. At urban level, there are fewer reasons to suggest that there is a correlation between video calls to friends or family and mobility. There is probably still a certain degree of risk aversion that limits social activity, but it should be safe to assume that once the pandemic situation is completely under control video calls will be a complement – and not a substitute - of mobility related to social activity.

In contrast, technological substitutes for work- and business-related activity may have a more prolonged impact on urban (and long-distance) mobility. The correlation between the responses regarding the change in frequency of teleworking and those of video conferencing is particularly high (correlation coefficient = 0.58). The wide adoption of video-conferencing and remote collaboration tools during the pandemic allowed the familiarisation of many employees and employers with work methods that do not require physical presence at the workplace. Better and easily accessible tools, in turn, contributed to teleworking becoming an option for a larger share of the workforce than before the pandemic. On average, 36% of the respondents used videoconferences with colleagues or customers more often or much more often compared to the pre-pandemic period. While this share is lower than the respective share for video calls with family and friends (45%), it is still remarkable considering that only some of the respondents had jobs that could be performed remotely. Similarly to the other indicators, there is a significant variation among cities, with the share of respondents increasing the frequency of work-related videoconferencing ranging from 25% (Dresden) to 50% (Lisbon).

The pandemic also stimulated an increase in the offer and use of online health and public services (e-health and e-government). Even after the initial confinement in the first half of year 2020, the share of respondents who increased their online access to such services is considerable (23% more often and 10% much more often). The variation among cities reveals certain country-level patterns. The two German cities in the sample reported the lowest increase in frequency (11% in both Berlin and Dresden), while the Spanish and Polish cities presented the highest increases (50% in Krakow, 46% in Poznan, 47% in Madrid, 49% in Málaga). There are obviously differences in the pre-existing level of e-health and e-government availability and use, as well as in the measures taken in each country during the pandemic. It is, nevertheless, reasonable to assume that the improved infrastructure and user uptake of online health and public services will remain in the future, at least partially. This can have an appreciable impact on transport demand. For example, 4% of total trips in Madrid are related to health services (Consorcio Transportes de Madrid, 2019).

The increase in the frequency of home delivery of groceries was less pronounced than for the other 5 technology-based patterns. On average, 25% of respondents increased their frequency (17% more and 8% much more compared to the pre-pandemic period), which still represents a considerable change in daily activity. Respondents in the two German cities appear to have increased frequency the least (11% in Berlin and 8% in Dresden). At the other extreme, 40% of the respondents in Lisbon increased their use of home delivery for groceries.

Figure 3. Change in frequency of technology-based alternatives compared to pre-pandemic levels



Source: (Panayotis Christidis et al., 2022)

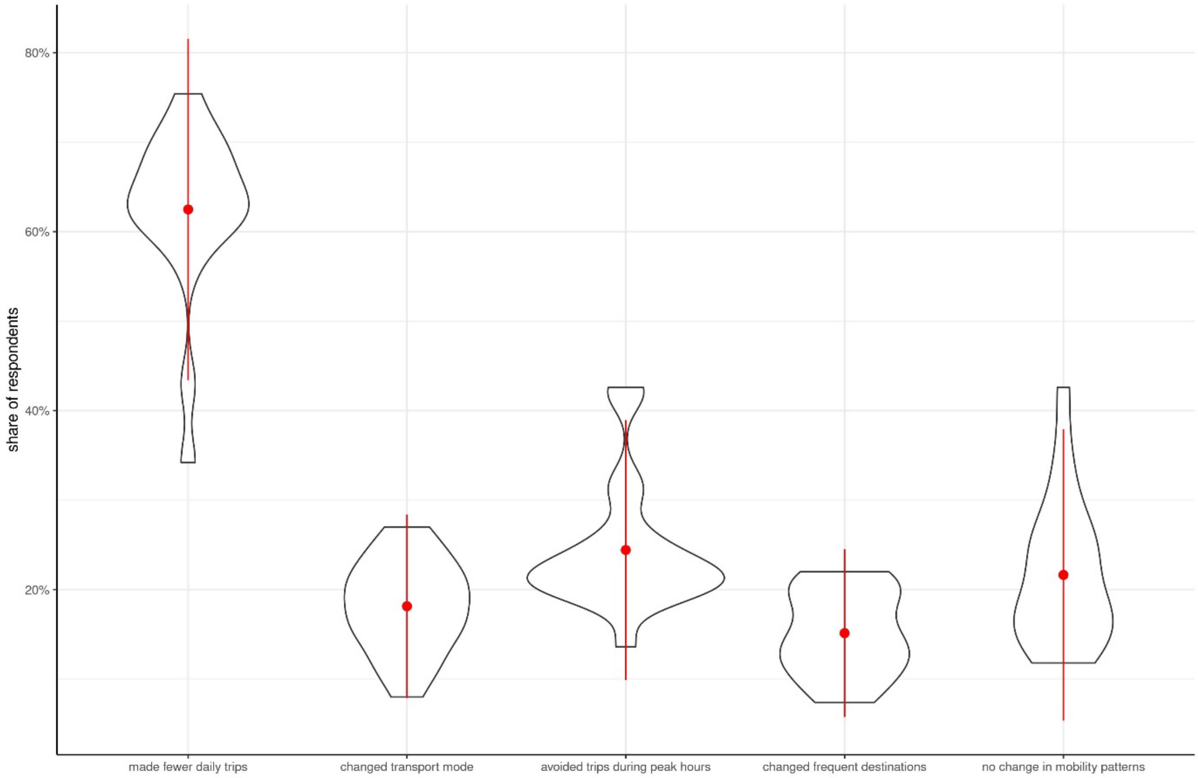
Apart from the increased uptake of technology-based alternatives that substitute the need for physical trips, the survey results suggest that the impact on mobility patterns also remained significant in June 2021, even though mobility restrictions were not active (Figure 4).

The majority of respondents across the 20 cities made fewer daily trips after the first phase of the pandemic compared to the pre-pandemic period. Dresden and Berlin are outliers with the share of respondents who made fewer trips at 34% and 43% respectively. The decrease in daily trips is- on aggregate terms- only weakly correlated with the technology-led changes in behaviour discussed above. The correlation between decreasing daily trips and teleworking frequency is 0.17, while the correlation with video-calls to friends and family is 0.18. The responses concerning the reasons for the reduced number of trips allow further elaboration: while 38% of the respondents who decreased their daily trips commuted less, 68% decreased their trips to visit relatives and friends, and 52% decreased leisure trips. It can be therefore deduced that a large share of the decrease in the number of trips is the result of lower levels of social activity and leisure, still affected by self-distancing choices or restrictions in the offer of leisure-related establishments.

Changes in modal choice were more moderate, with an average 18% across all respondents. The correlation with teleworking is even lower than in the case of making fewer trips (0.08). But patterns can be identified as regards the trip purpose for which the mode was changed: commuting (41% of respondents who changed mode), visiting relatives and friends (52%), leisure (64%), but also purchase of groceries and supermarket visits (40%). The latter is accompanied by a tendency to increase car use, either by respondents who already used car as their main mode, or by users of other transport modes who after the pandemic showed increased preference for car use.

For most cities in the sample, the share of respondents who rescheduled their trips in order to avoid peak hours was between 20% and 25%. The trip purposes for which respondents avoided peak hours the most were groceries/supermarket shopping (62% of those avoiding peak hours) and other shopping trips (43%). For comparison, the corresponding shares of respondents who teleworked more frequently after the pandemic were 55% and 38% respectively. This difference suggests that the choice to avoid busy times for grocery and other shopping activities is driven mainly by the preference to maintain social distancing rather than the flexibility that remote working provides.

Figure 4. Change in mobility patterns, June 2021 compared to 2019, distribution among the 20 cities



Source: (Panayotis Christidis et al., 2022)

The changes in lifestyle and mobility patterns are also reflected in the frequency of use of each transport mode (Figure 5). For all transport modes, a considerable share of respondents used the specific mode less than before the pandemic, a direct repercussion of the decrease in the number of daily trips. There is, however, a significant modal shift, with a number of respondents using specific modes with higher frequency than before the pandemic.

The highest increase in frequency is observed for walking (34% of all respondents) and can be attributed to users avoiding public transport and other shared means of transport, such as taxis and hailing services. The number of respondents who increased the frequency of walking is substantially higher than those who decreased it (18%), presumably because they performed fewer daily trips in general. The use of car – both as driver and as passenger - also increased for a considerable number of users (21% and 15% respectively), but was counterbalanced by a comparable share of respondents who decreased their frequency of using a car as a driver (22%) or as a passenger (28%). These shares suggest that, in spite of a visible impact on car use as a result of the decreasing number of daily trips, the shift to car use from other modes dampens the net effect. In addition, the difference in the reaction of car drivers compared to car passengers implies that less carpooling takes place and the average load factor for cars decreases.

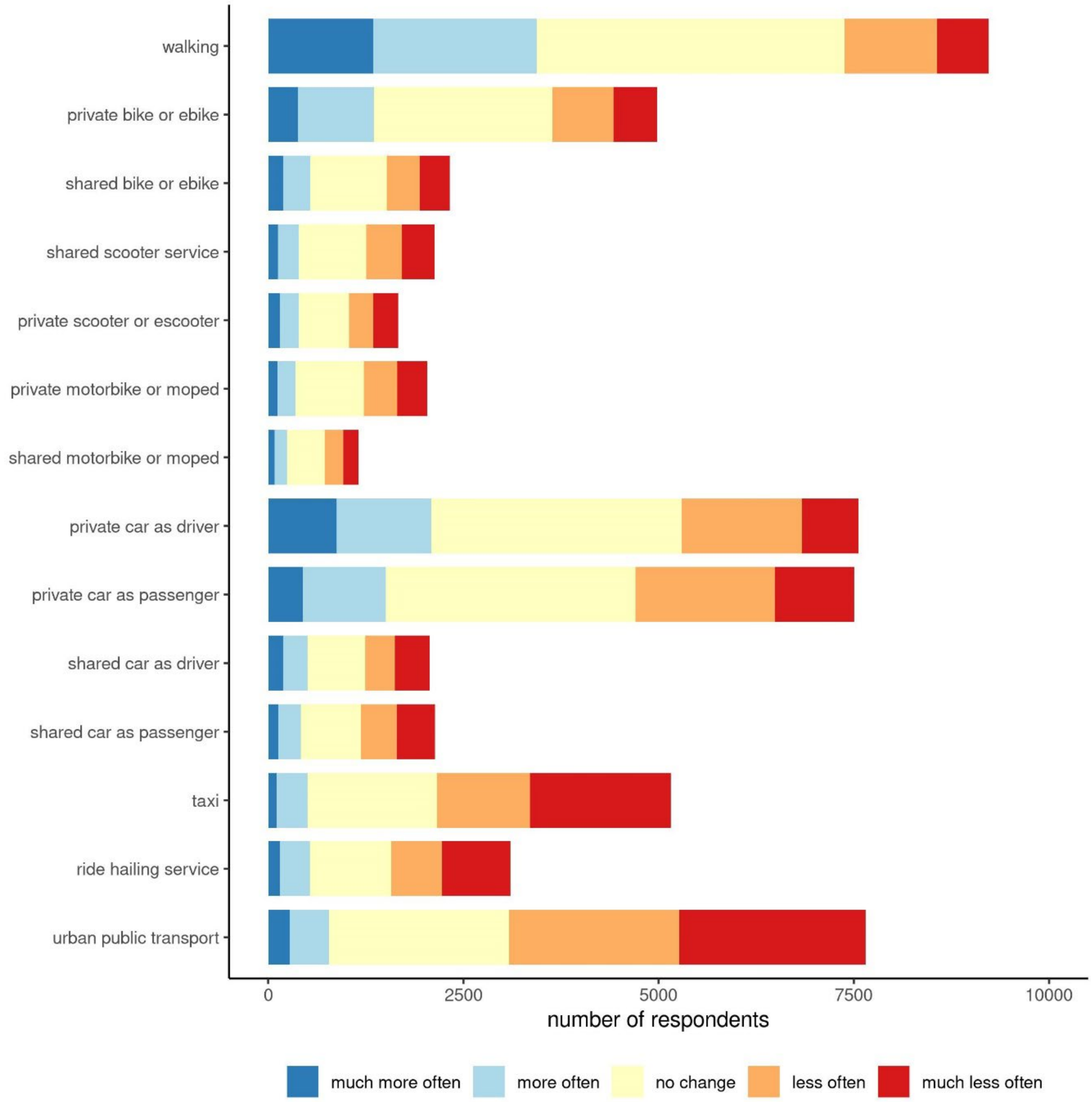
The pandemic also induced – at least judging from anecdotal evidence - an increased use of bicycles, conventional or electric, across Europe. The survey results corroborate this to a certain extent, with 14% of the respondents increasing the frequency of cycling. A comparable share, however, decreased the frequency

(13%). The other options of two-wheeled transport, either private of shared, address different target markets in an urban context and had lower shares before the pandemic. For shared cycling, scooters, mopeds and motorcycles, conventional or electric, the number of users who decreased the frequency of use outweighs the number of those who increased it.

Demand for taxis was affected by both the falling number of daily trips and the modal shift towards modes allowing social distancing. As a consequence, 58% of taxi customers reduced their use, while only 10% of taxi users (4% of respondents) increased it, most probably shifting from public transport. The main competitor to taxis, ride hailing services such as Uber, faced a similar – though softer - market shock. Almost half of their customers (49%) decreased their frequency, but 17% increased it, proportions comparable to those of car-sharing users.

The most noteworthy change in frequency of use was that of public transport. An alarming 46% of respondents, corresponding to 60% of public transport users, decreased their frequency of use of public transport. Such behavioural change is by far more profound than any other lifestyle or mobility change captured by the survey. It is obviously a consequence of users performing fewer trips as part of their daily activity, but the decline in the total demand for public transport is reinforced by a massive shift of the remaining daily trips to other modes. In fact, the survey results indicate that 35% of the respondents felt less comfortable with using public transport compared to the pre-pandemic period, a feeling that can be attributed mainly to the contagion risk aversion.

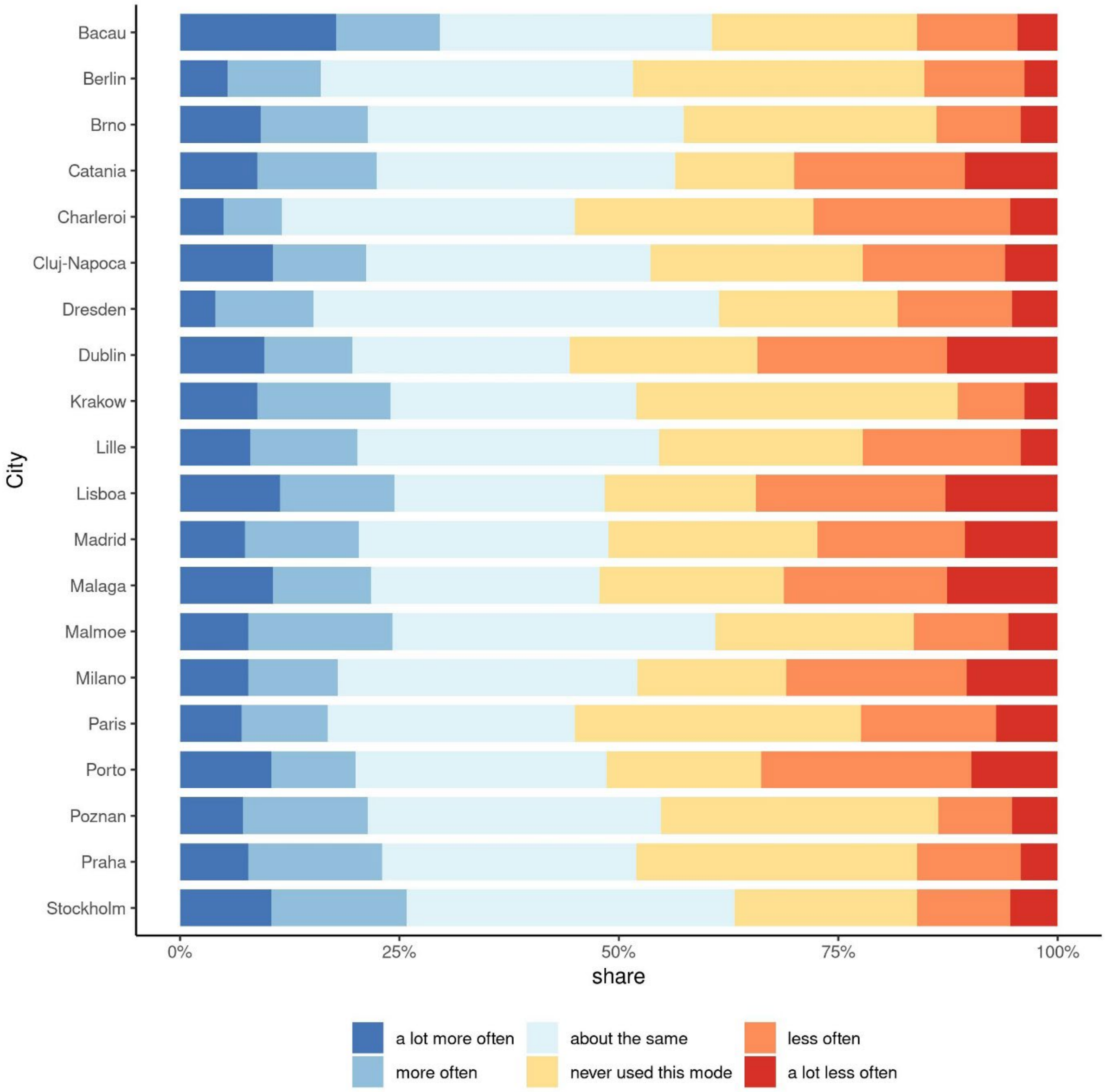
Figure 5. Change in frequency of use compared to before pandemic, all modes (for users of mode either before or during pandemic)



Source: (Panayotis Christidis et al., 2022)

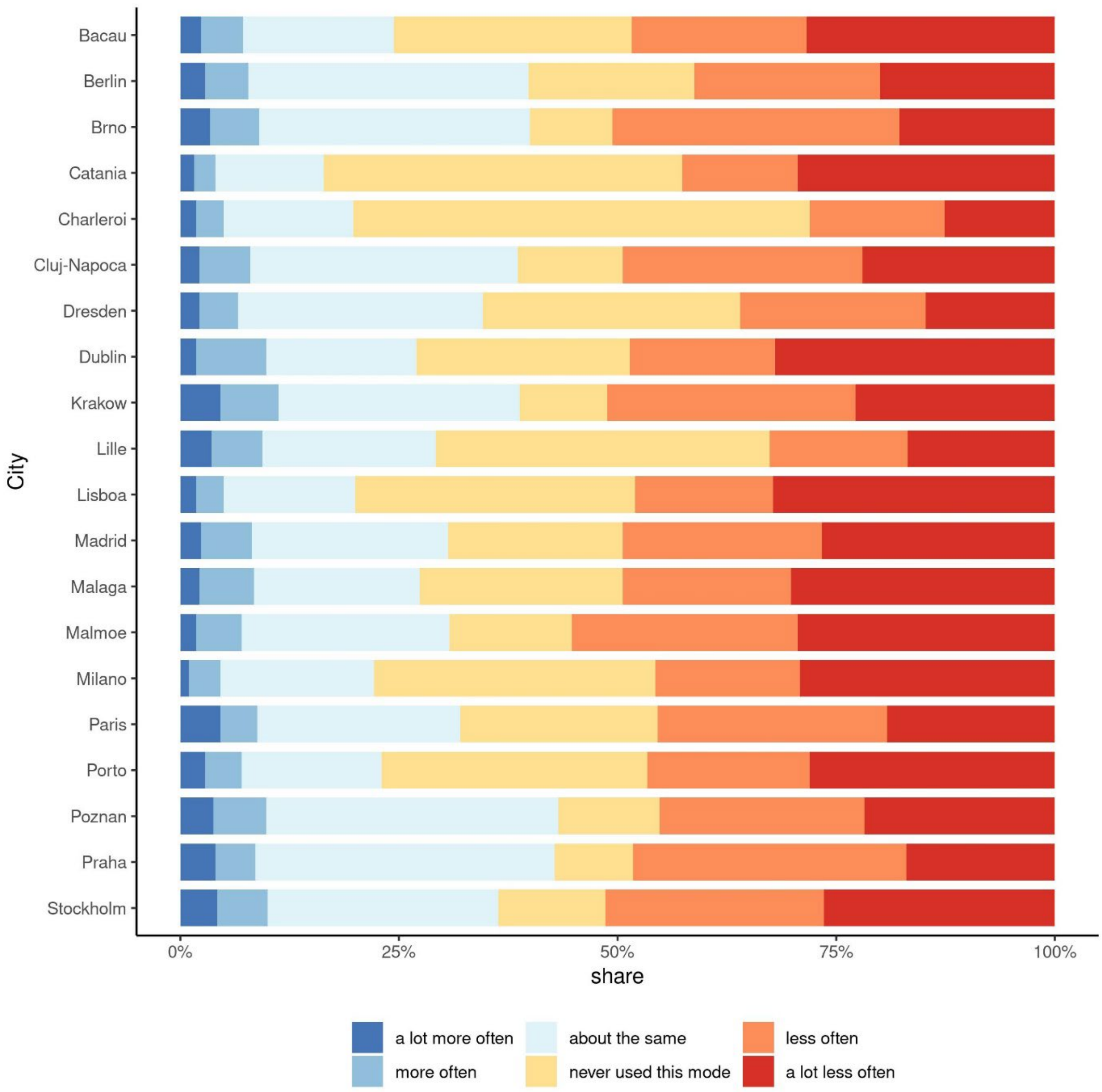
Figure 6 and Figure 7 compare the changes in each city regarding trip frequency for car and public transport use, respectively, as opposed to the status quo before the pandemic. Generally, the share of respondents who decreased car use is proportional to the share of respondents who also decreased their daily trips. The share of those who increased car use frequency, combined with the share of those who decreased public transport use, reveal the existence of a shift from public transport to car use that is persistent in all 20 cities covered by the survey. This shift should be considered as worrying from the transport policy point of view, since it may lead to sustained or increased levels of car dependency that may continue even after the return to normal levels of total mobility demand. We further elaborate on the possible drivers of this shift in the following section.

Figure 6. Change of trip frequency as car driver after pandemic restrictions



Source: (Panayotis Christidis et al., 2022)

Figure 7. Change of public transport trip frequency after pandemic restrictions



Source: (Panayotis Christidis et al., 2022)

2.2 Factors driving car use

In order to explain how each user characteristic or preference influences the choice of transport mode during the pandemic, we constructed a classification model based on the gradient boosting method, a machine learning technique with numerous applications in predictive modelling (Christidis and Focas, 2019). The classification model uses the full dataset of the responses to the survey as input. The dependent variable is a binary variable (0/1) indicating whether the respondent used car more frequently during the pandemic, after the confinement restrictions were lifted.

The survey shows a tendency of a large share of respondents to use the car more frequently after the pandemic restriction, even though their lifestyle and mobility patterns lead to a lower level of trip generation. We constructed a classification model that used car driving frequency as a dependent, binary, variable that indicates higher frequency. The independent variables included the user characteristics and preferences revealed through the survey questions. The tree-based classification algorithm ensures that collinearity and endogeneity are accounted for, a property that allows the quantification of the impact of each independent variable on the variation of the dependent variable.

The independent variables with the highest impact on the choice to increase car driving frequency, as well as the degree and direction of their impact, are visualized in Figure 8. The most important indicator is - not surprisingly - whether the respondent used a car as a driver before the pandemic. The majority of those who were car drivers before the pandemic tend to use the car after the pandemic restrictions more frequently. This suggests that the pandemic in fact increased personal dependency on car use, regardless of other changes in lifestyle patterns. The second most important indicator is whether the user is comfortable with using the car after the pandemic. The vast majority of respondents feel at least as comfortable with driving a car as before the pandemic (74%) and have higher odds of increasing its use.

Whether the respondent used public transport before the pandemic is high on the list of important variables and is the main explanation of why car use maintained high shares even though the total number of trips declined. The users of public transport before the pandemic have a high chance – compared to users of other modes of transport - to shift to cars after the pandemic.

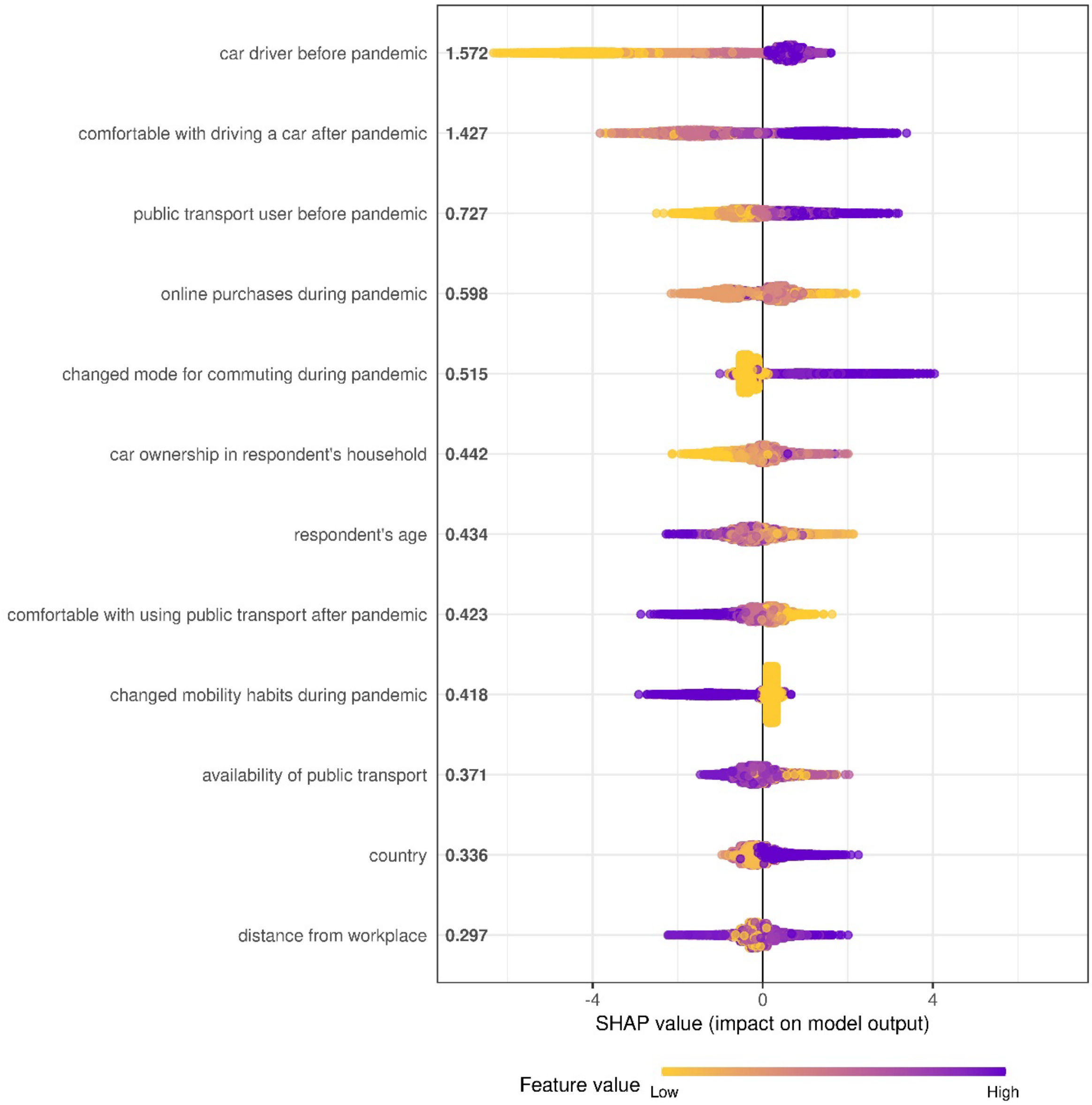
In terms of lifestyle changes as a result of the pandemic, the most relevant appears to be the frequency of online purchases. Respondents who increased their frequency have a lower chance of increasing car use, an indication of the impact of online shopping on trip demand. Another behavioural change, in this case concerning mobility choices, is whether the respondent changed transport mode for commuting during the pandemic. The majority of those who shifted to car use during the pandemic plan to continue using the car in the future. A related indicator, lower in the ranking of importance, concerns the respondents who did not change their mobility patterns (trip frequency, mode, time or destination). They tend to drive more, while the ones who did change their behaviour - excluding the ones who changed modes and are treated separately - tend to use the car less.

Car ownership in the respondent's household before the pandemic is relatively important and in line with expectations. However, the fact that respondents from non- or low-car ownership households increased car use may conceal a trend of increased car purchases as a result of the pandemic. This interpretation is further supported by the next variable in terms of importance, the respondent's age. The model suggests that the lower the age of the respondent, the higher the chances for increased car use frequency after the pandemic. This may sound counter-intuitive, but can be explained by the fact that the users of most other alternatives to cars are of lower age than car drivers, on average. The combination of the two observations can lead to the hypothesis that the pandemic accelerated car ownership or use at younger ages.

Still among the relatively important variables, the level of comfort in using public transport after the pandemic explains to a large extent the reason for the observed shift from public transport to car use. Respondents who feel less comfortable - as already mentioned, 35% of the total - have a higher chance of shifting to car. It is also striking that – apart from the one concerning cars - the level of comfort with no other mode of transport appears in the list of the most important indicators. In addition, the availability of public transport does make a difference, whereas the availability of the other modes does not appear as important in the model. The hypothesis that can be derived is that the pandemic led to a decrease in the supply side of public transport that, subsequently, led to increased car use.

Geography plays a role in two aspects. Country-specific characteristics related to the intensity of the pandemic and the measures applied to confront it can explain differences in the impacts on mobility (in addition to other economic, cultural and infrastructure availability differences). Finally, the distance to the respondent's workplace may cause physical limitations to the available mobility options, as well as to the trip frequency.

Figure 8. Relative impact of user characteristics and preferences on the choice to increase the frequency of driving a car



Source: (Panayotis Christidis et al., 2022)

2.3 Changes in transport demand and modal split

The results show significant variability at city level for most questions, since the evolution of the pandemic, the measures adopted and the population's reaction differed considerably across the EU. In addition, the socio-economic profile of each city affected the adoption of alternatives such as teleworking or online shopping. In terms of mobility choices, while overall activity has fallen, the impact at modal level is mixed. Car use appears to have risen to levels close to those before the pandemic, at the cost of mainly public transport. Walking and cycling have increased their share, as a consequence of users maintaining social distance. The results confirm to a large extent the findings of (Abdullah et al., 2020) that identify significant changes in trip purpose and modal choice. Even though the survey analysed here took place at a much later stage (June 2021), the shift from public transport to cars appears to be persistent. Mobility as a Service (MaaS) applications have been also negatively influenced by the fluctuations in mobility and risk aversion in the long term (Hensher, 2020).

While cycling in general increased its share, there is a considerable number of respondents who now consider cars as their preferred mode. This trend is accompanied by increased car ownership, especially by younger respondents, and reinforces car dependency in the long term. The most alarming trend revealed by the survey is the low level of comfort of users as regards the use of public transport. Combined with the overall decrease in trip demand, it may cause serious survival risks for public transport systems.

Operators and local authorities realized early-on that the decrease in demand and revenue could threaten the financial viability of public transport services. In the Netherlands, the criticality of the outlook triggered a coordinated approach between the national government and most regional and local stakeholders. The resulting actions, nevertheless, focused on the short-term provision of state aid in the form of an 'availability fee', without addressing the longer-term policy challenges as regards the role of public transport (Hirschhorn, 2021). In Rome, social distancing rules in the metro system significantly reduced capacity and increased queues and waiting times. As a response, additional supply was added in order to avoid excessive travel times (Carrese et al., 2021). Such support measures provide a temporary solution to one side of the problem, i.e. maintaining the level of service even within a shrinking market. They do not address the other main challenge revealed by our results, i.e. the risk aversion that may keep users away from public transport or other modes that cannot ensure social distance. Psychological factors can play an important role on the perception of safety for passengers (Dong et al., 2021) and more should be done in order to increase the public's confidence in public transport after the pandemic. An example is the approach followed in Japan, where an extensive information campaign involving central and local governments, experts, and medical institutes has proven successful in influencing the general perception of information reliability (Ding and Zhang, 2021). In this context, our results agree with the conclusion of (Vickerman, 2021) concerning the need to re-think the public transport model. The abrupt shock in demand and the longer-term hesitance of users to return to public transport will require significant efforts from operators and public authorities for the services to remain viable.

The behavioural changes (teleworking, video-calls, video-conferences, online shopping, e-health, e-government, home delivery of groceries) decrease demand for mobility, but the survey results suggest that the gradual return to normality is also reducing the extent to which they are adopted as an alternative to physical trips. How long can those changes stimulated by the pandemic be maintained remains an open question. Our results suggest that most of the behavioural changes were the consequence of restrictions that did not allow certain activities to occur, rather than a deliberate choice of individuals.

As highlighted in (Marsden, G. et al., 2020), disruptive events such as the Covid-19 pandemic can change travel behaviour and can be an opportunity for policy action. The challenge for transport policy is to ensure that the favourable changes - especially the substitution of physical trips with technology-based alternatives - are nourished, while the undesirable effects on modal shift are reversed. The momentum of active transport during the pandemic can be further exploited through measures that facilitate walking and cycling. For example, the extension of pedestrian zones or of cycling infrastructure can contribute to maintaining or increasing demand for active modes. Emerging urban planning concepts, such as the 15-minute city can also influence modal split at the local scale. The establishment of low/zero emission zones can combine the objectives of achieving climate neutrality through the discouragement of conventional car traffic and the provision of alternatives for mobility. Public transport can benefit from extended networks and services that can steer demand away from passenger cars. New concepts such as mobility hubs, integrated multi-modal ticketing, micro-mobility services, and Mobility-as-a-Service applications can curb car dependency and further stimulate innovation in mobility solutions. In terms of mobility patterns, the changes in daily activity have a direct repercussion on transport demand, both quantitative and qualitative. The number of daily trips is still lower than before the pandemic, mainly as a result of fewer trips related to work. Almost half of the survey respondents telework more frequently than before the pandemic. Limitations in public activities also led to a decrease in the number of trips for entertainment and recreation. The impact of individual preferences is also evident, mainly in relation to risk aversion that can be attributed to the pandemic evolution. Social activity - for example visits to friends and relatives - appears to still be lower than before the pandemic.

The observed risk aversion has a direct repercussion on mobility patterns, especially as regards modal choice. A clear trend in favour of car use is visible. Even though the total number of daily trips has decreased, the increased car use frequency is enough to bring passenger car demand back to levels comparable to those in the pre-pandemic period. In contrast, more than 50% of the respondents decreased their use of public transport. The frequency of use of taxis, ride hailing services or other shared modes of transport also fell considerably. The respondents who used the car as their main transport mode before the pandemic are still comfortable in doing so, even though they may have reduced their trips for specific purposes such as shopping. Nevertheless, those who used public transport or other shared modes before are much less confident in persevering, and tend to shift to cars. The trend is reinforced by the increased levels of car ownership - especially by younger respondents - which can signify a reversal for policies promoting public transport and other alternatives.

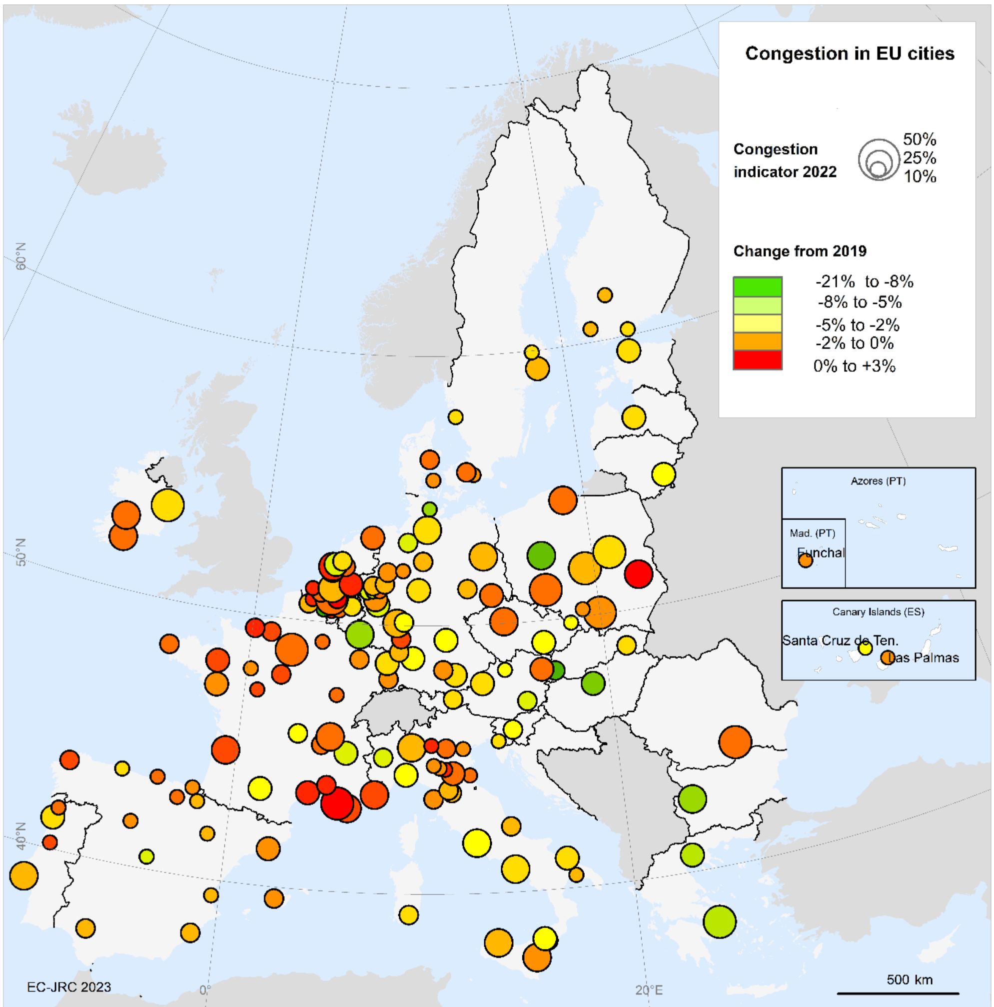
3 Rebound in congestion levels

Road congestion in urban areas has long been a major challenge for transport policy and traffic management (Christodoulou et al., 2020). One of the 'silver linings' of the Covid-19 pandemic was a decrease in transport demand and visibly lower congestion levels in most European cities. Transport activity is already showing a gradual return to year 2019 levels, with the lifestyles and work patterns adopted during the pandemic returning to normality. Some of the behavioural changes –such as remote work- may still partially continue, probably at a lower degree than in the height of the pandemic (but still more commonly than before). The new patterns may lead, however, also to increased levels of car ownership and use (Lopez Soler et al., 2021), resulting in a rebound in the levels of congestion.

The JRC maintains a database of TomTom congestion indicators on a daily basis for 178 cities in the EU, from 2019 to 2022 (Christidis and Ibanez Rivas, 2012; Christodoulou and Christidis, 2020).

Congestion levels were still lower in 2022 compared to 2019, for the majority of the cities covered. There is, however, a strong trend towards recovering past levels, mainly due to the gradual return to physical presence at work. The decrease in transport demand brought by higher rates of tele-working is still visibly in 2022. However, the trend implied by the data suggests that the share and frequency of teleworking are gradually retroceding to levels closer (but still higher than) those in 2019. Other activities, such as retail and entertainment, appear to have returned to similar – or higher - levels than in 2019. The observed trends suggest that - unless specific measures are adopted - congestion will soon return to 2019 levels in several EU cities.

Figure 9. Urban road congestion levels in the EU, change 2019-2022



Source: JRC calculations, based on TomTom data

Table 1. Urban road congestion, 2019-2022 (JRC calculations using TomTom data)

Country	City	congestion 2019	congestion 2020	congestion 2021	congestion 2022	change 2019-20 (p.p.)	change 2019-21 (p.p.)	change 2019-22 (p.p.)
Austria	Graz	26%	23%	22%	19%	-3	-4	-6
	Innsbruck	23%	17%	19%	19%	-6	-4	-4
	Linz	22%	17%	17%	16%	-5	-5	-5
	Salzburg	27%	23%	23%	23%	-4	-4	-4
	Vienna	28%	26%	29%	27%	-2	1	-1
Belgium	Antwerp	32%	24%	26%	29%	-8	-6	-3
	Bruges	16%	12%	18%	16%	-4	2	1
	Brussels	38%	29%	34%	36%	-9	-4	-1
	Charleroi	13%	12%	13%	13%	-1	0	1
	Ghent	20%	18%	20%	18%	-2	0	-1
	Kortrijk	15%	15%	14%	16%	0	-1	1
	Leuven	20%	21%	22%	21%	1	2	2
	Liege	24%	16%	21%	20%	-8	-3	-4
	Mons	34%	20%	13%	13%	-14	-21	-21
	Namur	19%	16%	18%	17%	-3	-1	-1
Bulgaria	Sofia	36%	30%	30%	28%	-6	-6	-8
Czechia	Brno	30%	22%	24%	25%	-8	-6	-5
	Ostrava	20%	13%	15%	15%	-7	-5	-5
	Prague	29%	23%	27%	28%	-6	-2	-1
Denmark	Aarhus	22%	20%	20%	21%	-2	-2	-1
	Copenhagen	22%	18%	20%	21%	-4	-2	-1
	Odense	18%	15%	16%	16%	-3	-2	-2
Estonia	Tallinn	31%	26%	27%	27%	-5	-4	-4
Finland	Helsinki	19%	15%	16%	15%	-4	-3	-4
	Tampere	15%	13%	15%	12%	-2	0	-3
	Turku	19%	18%	19%	16%	-1	0	-3
France	Avignon	18%	17%	19%	19%	-1	1	1
	Bordeaux	32%	27%	32%	32%	-5	0	0
	Brest	23%	21%	24%	22%	-2	1	-1
	Clermont-Ferrand	26%	21%	22%	21%	-5	-4	-5
	Dijon	17%	16%	17%	16%	-1	0	-1
	Grenoble	32%	26%	27%	26%	-6	-5	-6
	Le Havre	21%	20%	23%	22%	-1	2	1
	Le Mans	18%	16%	18%	16%	-2	0	-2
	Lille	25%	20%	22%	22%	-5	-3	-3
	Lyon	30%	25%	29%	29%	-5	-1	-1
	Marseille	34%	30%	35%	36%	-4	1	2
	Montpellier	26%	24%	27%	27%	-2	1	1
	Nancy	21%	18%	20%	19%	-3	-1	-2
	Nantes	27%	22%	25%	25%	-5	-2	-2
	Nice	31%	25%	28%	31%	-6	-3	0
	Orleans	20%	18%	21%	20%	-2	1	0
	Paris	39%	32%	36%	38%	-7	-3	-1
	Reims	16%	15%	16%	15%	-1	0	n/a
	Rennes	24%	20%	24%	24%	-4	0	0
	Rouen	22%	18%	21%	22%	-4	-1	0
	Saint-Etienne	20%	17%	19%	19%	-3	-1	-1
	Strasbourg	28%	22%	26%	24%	-6	-2	-4
	Toulon	29%	26%	33%	29%	-3	4	0
	Toulouse	28%	21%	23%	23%	-7	-5	-5
	Tours	16%	15%	16%	16%	-1	0	0

Table 1. Urban road congestion, 2019-2022 (JRC calculations using TomTom data)

Country	City	congestion 2019	congestion 2020	congestion 2021	congestion 2022	change 2019-20 (p.p.)	change 2019-21 (p.p.)	change 2019-22 (p.p.)
Germany	Augsburg	22%	19%	20%	19%	-3	-2	-2
	Berlin	32%	30%	30%	29%	-2	-2	-3
	Bielefeld	18%	17%	18%	16%	-1	0	-2
	Bonn	29%	21%	24%	23%	-8	-5	-6
	Bremen	27%	19%	19%	20%	-8	-8	-6
	Cologne	26%	21%	24%	24%	-5	-2	-2
	Dresden	25%	23%	25%	23%	-2	0	-1
	Dusseldorf	24%	19%	16%	17%	-5	-8	-7
	Frankfurt am Main	27%	20%	20%	22%	-7	-7	-5
	Freiburg	23%	20%	21%	21%	-3	-2	-2
	Hamburg	34%	29%	31%	30%	-5	-3	-4
	Hannover	21%	19%	20%	18%	-2	-1	-3
	Karlsruhe	22%	19%	17%	19%	-3	-5	-3
	Kassel	28%	24%	26%	24%	-4	-2	-4
	Kiel	26%	23%	22%	17%	-3	-4	-8
	Leipzig	24%	23%	23%	21%	-1	-1	-3
	Mannheim	21%	18%	20%	21%	-3	-1	0
	Monchengladbach	22%	18%	16%	16%	-4	-6	-6
	Munich	30%	24%	26%	26%	-6	-4	-4
	Munster	21%	19%	19%	19%	-2	-2	-2
	Nuremberg	30%	25%	26%	24%	-5	-4	-5
	Ruhr region east	21%	18%	19%	18%	-3	-2	-3
	Ruhr region west	23%	20%	20%	20%	-3	-3	-3
	Stuttgart	30%	25%	25%	25%	-5	-5	-5
	Wiesbaden	32%	26%	31%	29%	-6	-1	-3
	Wuppertal	17%	16%	16%	16%	-1	-1	-1
Greece	Athens	43%	34%	37%	37%	-9	-6	-7
	Thessaloniki	30%	22%	25%	24%	-8	-5	-7
Hungary	Budapest	37%	27%	30%	27%	-10	-7	-9
Ireland	Cork	33%	26%	29%	32%	-7	-4	-1
	Dublin	48%	38%	36%	46%	-10	-12	-4
	Limerick	31%	28%	27%	30%	-3	-4	-1

Table 1. Urban road congestion, 2019-2022 (JRC calculations using TomTom data)

Country	City	congestion 2019	congestion 2020	congestion 2021	congestion 2022	change 2019-20 (p.p.)	change 2019-21 (p.p.)	change 2019-22 (p.p.)
Italy	Bari	28%	23%	25%	24%	-5	-3	-4
	Bologna	25%	18%	23%	24%	-7	-2	-1
	Brescia	14%	11%	14%	15%	-3	0	1
	Cagliari	23%	19%	21%	19%	-4	-2	-4
	Catania	29%	23%	30%	28%	-6	1	-2
	Florence	25%	17%	24%	22%	-8	-1	-3
	Genoa	30%	27%	28%	25%	-3	-2	-5
	Livorno	20%	17%	19%	18%	-3	-1	-2
	Messina	31%	25%	32%	26%	-6	1	-5
	Milan	31%	23%	28%	29%	-8	-3	-3
	Modena	14%	12%	15%	15%	-2	1	1
	Naples	32%	25%	29%	29%	-7	-3	-4
	Padua	17%	13%	15%	15%	-4	-2	-2
	Palermo	36%	29%	36%	34%	-7	0	-3
	Parma	17%	14%	15%	15%	-3	-2	-2
	Pescara	23%	17%	22%	20%	-6	-1	-3
	Prato	24%	18%	21%	21%	-6	-3	-3
	Ravenna	17%	14%	16%	16%	-3	-1	-1
	Reggio Calabria	27%	21%	23%	22%	-6	-4	-4
	Reggio Emilia	18%	14%	17%	17%	-4	-1	-2
	Rome	38%	27%	33%	34%	-11	-5	-5
	Taranto	20%	16%	18%	17%	-4	-2	-3
	Trieste	21%	18%	20%	17%	-3	-1	-4
	Turin	27%	20%	22%	21%	-7	-5	-6
	Verona	20%	16%	19%	19%	-4	-1	-1
Latvia	Riga	27%	22%	22%	24%	-5	-5	-4
Lithuania	Vilnius	32%	26%	27%	27%	-6	-5	-5
Luxembourg	Luxembourg	36%	25%	28%	28%	-11	-8	-8
Netherlands	Almere	10%	10%	10%	9%	0	0	-1
	Amersfoort	20%	16%	18%	21%	-4	-2	1
	Amsterdam	26%	18%	18%	22%	-8	-8	-4
	Apeldoorn	20%	20%	21%	23%	0	1	3
	Arnhem	26%	19%	21%	26%	-7	-5	0
	Breda	21%	19%	20%	24%	-2	-1	3
	Den Bosch	17%	13%	15%	19%	-4	-2	2
	Eindhoven	22%	18%	19%	23%	-4	-3	1
	Groningen	24%	20%	22%	24%	-4	-2	-1
	Haarlem	27%	25%	28%	27%	-2	1	1
	Leiden	30%	21%	21%	23%	-9	-9	-6
	Nijmegen	27%	21%	21%	23%	-6	-6	-3
	Rotterdam	25%	19%	21%	24%	-6	-4	0
	The Hague	28%	24%	26%	29%	-4	-2	1
	Tilburg	20%	19%	20%	21%	-1	0	1
	Utrecht	22%	15%	15%	20%	-7	-7	-1
	Zwolle	18%	16%	16%	16%	-2	-2	-1

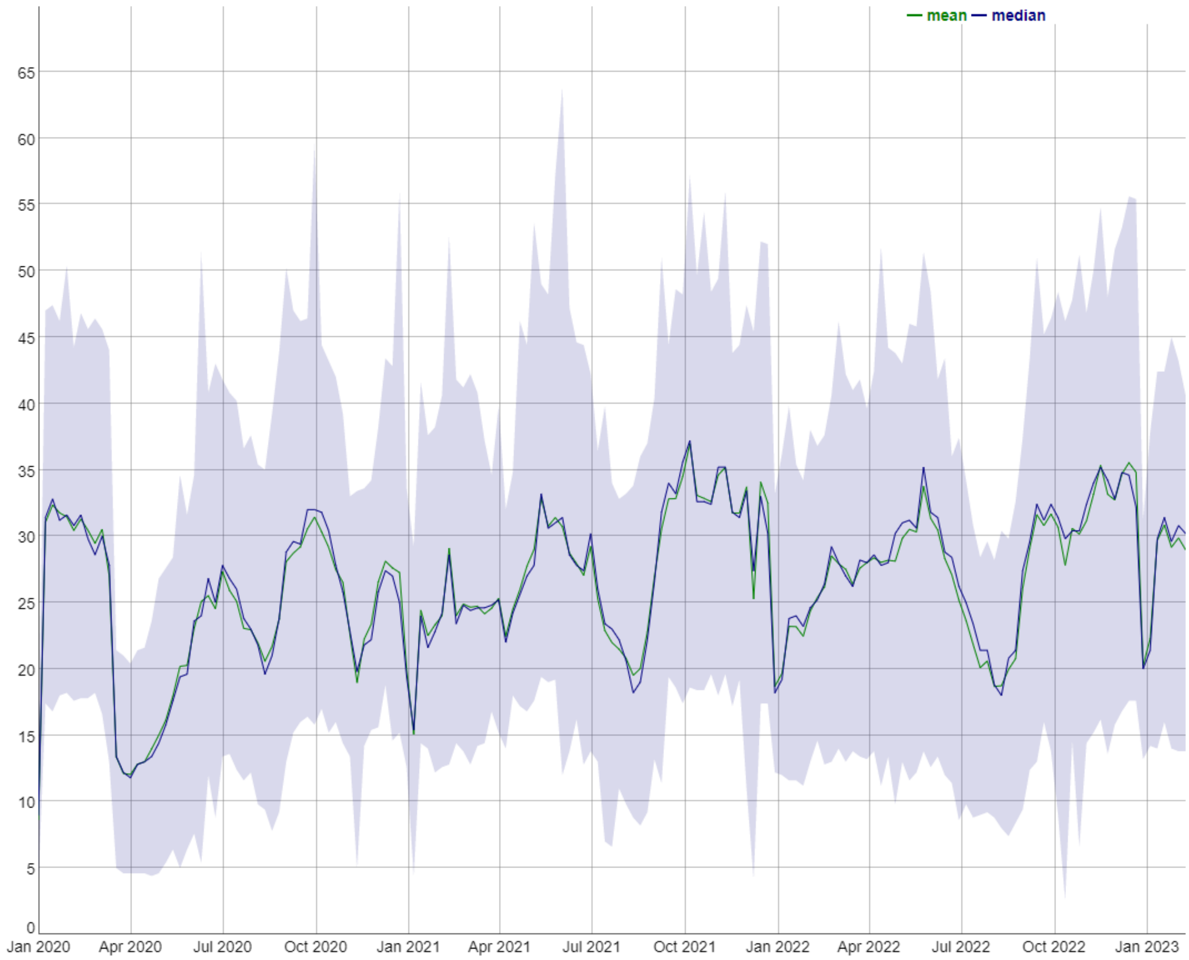
Table 1. Urban road congestion, 2019-2022 (JRC calculations using TomTom data)

Country	City	congestion 2019	congestion 2020	congestion 2021	congestion 2022	change 2019-20 (p.p.)	change 2019-21 (p.p.)	change 2019-22 (p.p.)
Poland	Bialystok	26%	22%	25%	23%	-4	-1	-2
	Bielsko-Biala	21%	18%	19%	18%	-3	-2	-2
	Bydgoszcz	34%	27%	27%	22%	-7	-7	-11
	Gdansk	33%	29%	34%	32%	-4	1	-1
	Katowice	19%	16%	17%	17%	-3	-2	-2
	Krakow	45%	36%	42%	42%	-9	-3	-2
	Lodz	47%	42%	45%	43%	-5	-2	-3
	Lublin	27%	26%	29%	28%	-1	2	2
	Poznan	44%	31%	37%	34%	-13	-7	-10
	Szczecin	30%	27%	36%	27%	-3	6	-2
	Warsaw	40%	31%	37%	36%	-9	-3	-4
	Wroclaw	39%	35%	41%	38%	-4	2	-1
Portugal	Braga	18%	15%	15%	17%	-3	-3	-1
	Coimbra	15%	12%	13%	15%	-3	-2	0
	Funchal	17%	12%	15%	15%	-5	-2	-2
	Lisbon	33%	23%	22%	33%	-10	-11	-3
	Porto	31%	24%	23%	27%	-7	-8	-4
Romania	Bucharest	52%	42%	50%	51%	-10	-2	-1
Slovakia	Bratislava	36%	27%	23%	21%	-9	-13	-14
	Kosice	26%	23%	26%	20%	-3	0	-4
Slovenia	Ljubljana	26%	17%	22%	20%	-9	-4	-5
Spain	A Coruna	19%	15%	20%	19%	-4	1	0
	Alicante	18%	14%	17%	16%	-4	-1	-2
	Barcelona	29%	22%	26%	27%	-7	-3	-2
	Bilbao	13%	12%	13%	9%	-1	0	-4
	Cadiz	10%	8%	11%	9%	-2	1	-1
	Cartagena	14%	12%	14%	11%	-2	0	-3
	Cordoba	14%	12%	14%	10%	-2	0	-3
	Gijon	16%	13%	16%	12%	-3	0	-4
	Granada	25%	20%	22%	21%	-5	-3	-4
	Las Palmas	18%	15%	18%	16%	-3	0	-2
	Madrid	23%	15%	18%	16%	-8	-5	-6
	Malaga	20%	15%	18%	17%	-5	-2	-3
	Murcia	21%	16%	20%	18%	-5	-1	-3
	Oviedo	13%	11%	16%	13%	-2	3	0
	Palma de Mallorca	24%	16%	26%	22%	-8	2	-2
	Pamplona	16%	15%	16%	13%	-1	0	-3
	San Sebastian	14%	11%	14%	11%	-3	0	-2
	Santa Cruz de Ten.	23%	18%	21%	17%	-5	-2	-5
	Santander	17%	16%	18%	16%	-1	1	-1
	Seville	21%	15%	19%	18%	-6	-2	-3
	Valencia	20%	17%	19%	17%	-3	-1	-3
	Valladolid	13%	13%	14%	10%	0	1	-2
	Vigo	15%	13%	15%	12%	-2	0	-2
	Vitoria-Gasteiz	14%	14%	17%	13%	0	3	-1
	Zaragoza	14%	13%	14%	11%	-1	0	-3
Sweden	Gothenburg	18%	14%	15%	14%	-4	-3	-4
	Malmo	15%	14%	14%	14%	-1	-1	-2
	Stockholm	27%	23%	26%	24%	-4	-1	-3
	Uppsala	21%	19%	18%	17%	-2	-3	-4

Source: Own calculations using TomTom data

The variance of congestion levels across cities is high, but the overall pattern of their evolution reveals a clear trend. Figure 10 compares the average daily congestion level on weekdays (Monday to Friday) by month and year. The indicators reached their minimum in April 2020, at the height of the pandemic, and have been gradually recovering up to June 2022. Comparing September-December in 2021 and 2022 shows a new decrease in congestion levels, probably caused by the increased fuel prices and the economic recession in the period.

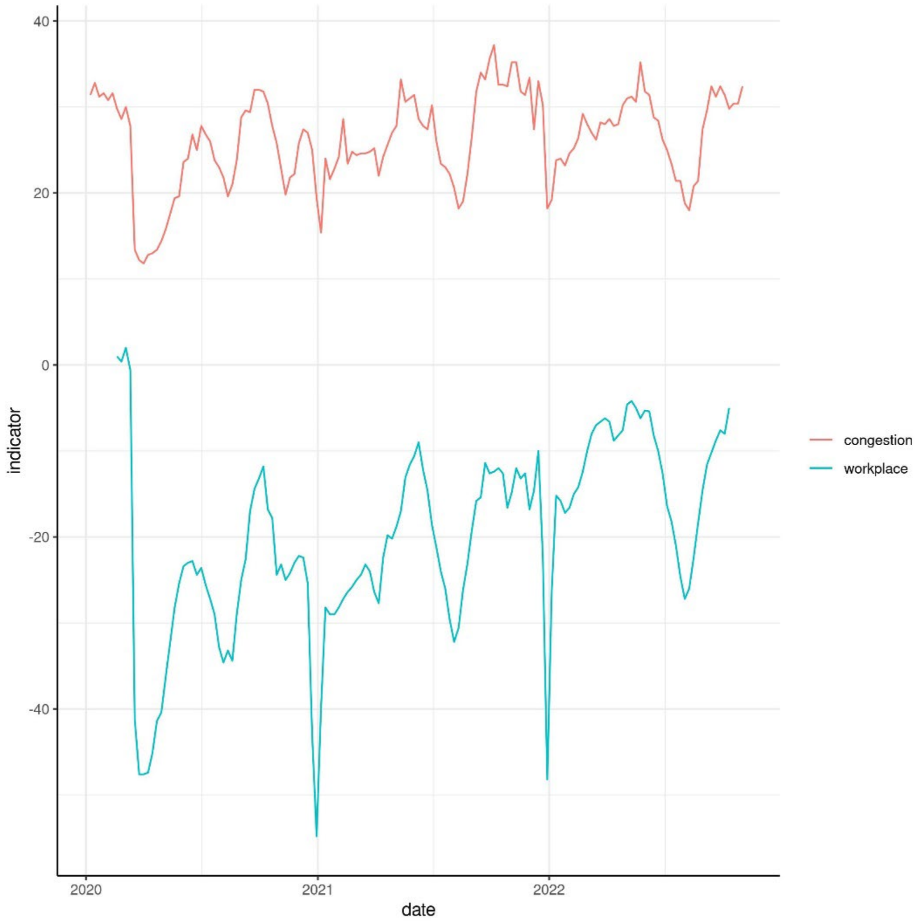
Figure 10. Comparison of variance of average monthly congestion across EU cities, January 2020- February 2023



Source: Own calculations

A main driver for the fluctuations in congestion levels is the presence at the workplace. Telework can lead to a reduction in traffic congestion, as fewer people are travelling to their workplace during peak times. Comparing the median of the weekly average of congestion on weekdays for the 178 cities covered by TomTom, with the corresponding median for the Google workplace indicator (Google, 2020) highlights the correlation and suggests that a possible continued increase in workplace presence may lead to higher traffic congestion levels (Figure 11).

Figure 11. Comparison of evolution of congestion and workplace indicators, 2020-2022



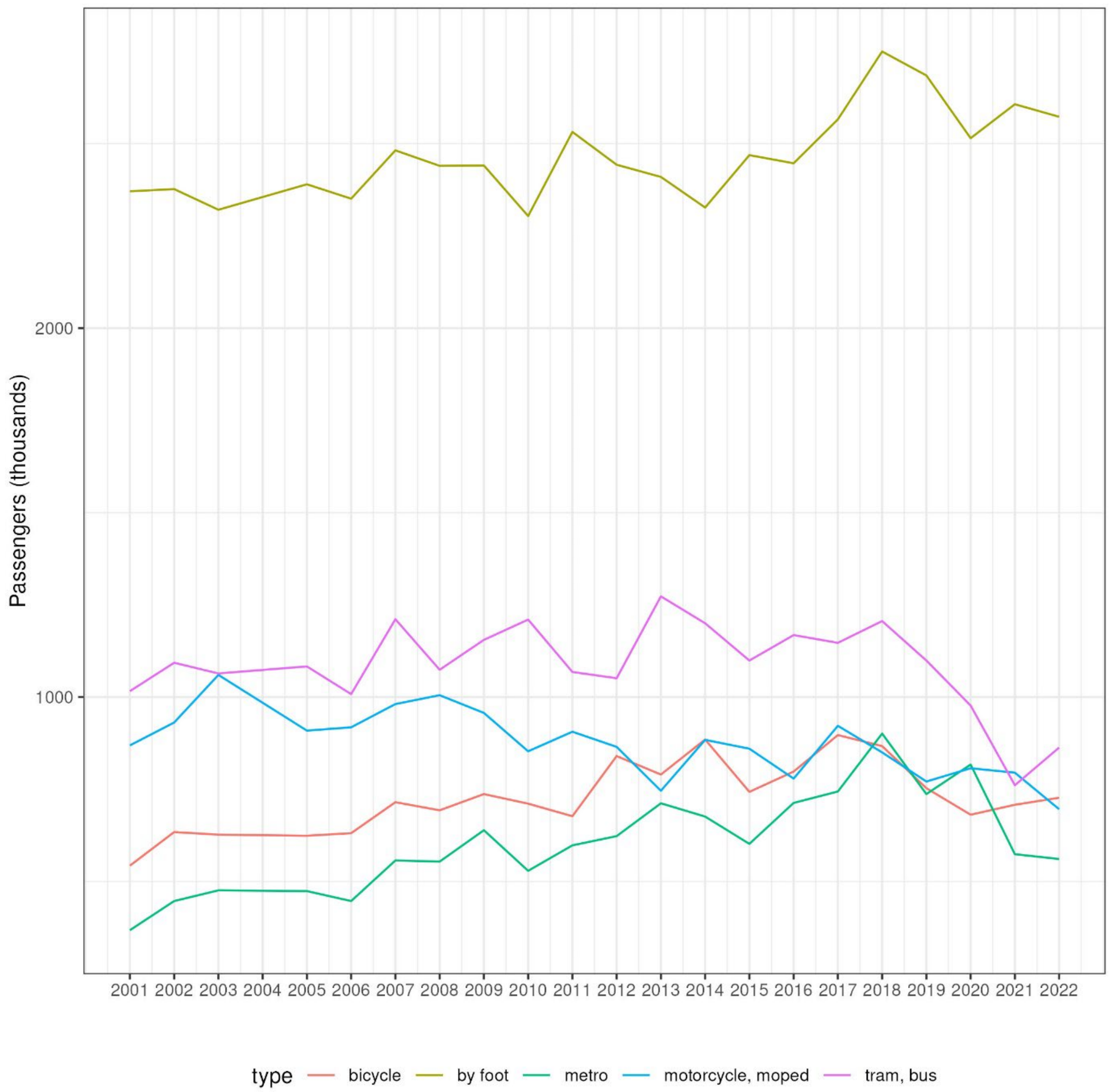
Source: Own calculations

4 Slow recovery of public transport

While car use and traffic congestion levels are gradually recovering to levels comparable to those of 2019, public transport shows an important lag. The still lower total demand, the continued risk aversion of potential passengers, and the increased levels of car use and active mobility have a persistent impact on the modal share of public transport.

Statistics on the use of public transport at EU level for 2021 and 2022 are not yet available, but several MS, cities or operators provide detailed data that allow the general trends to be monitored.
For Italy, Istat provides estimates on the number of users of each transport mode for trips to work, at regional and national level. Figure 12 shows the evolution of the non-car modes for Italy as a whole, with a clear drop after the pandemic - in absolute numbers as well as modal shares - for the two main public transport categories (tram & bus and metro). While the total number of people going to work has probably decreased after the pandemic (as a result of remote work), public transport saw a proportionally higher decrease. In addition, a significant part of users now seem to prefer cars as means of transport, which gained 2 percentage points on top of its already high share (Table 2).

Figure 12. Evolution of total number of users per mode in Italy, usual way of getting to work, urban non-car modes, 2001-2022



Source: data from Istat, Italy, http://dati.istat.it/Index.aspx?QueryId=16502&lang=en#

Table 2. Change in urban transport modal shares in Italy, usual way of getting to work, 2019-2022

	2019	2022	difference 2019-22 (percentage points)
metro	3.2%	2.5%	-0.7
bicycle	3.3%	3.3%	
tram, bus	4.8%	3.9%	-0.9
motorcycle, moped	3.3%	3.1%	-0.2
private car as passenger	5.5%	5.4%	-0.1
by foot	11.7%	11.6%	-0.1
private car as driver	67.9%	70.0%	2.0

Source: data from Istat, Italy, http://dati.istat.it/Index.aspx?QueryId=16502&lang=en#

In Germany, all three reported categories of public transport (bus, tram, rail) experienced a steep decrease in activity during the initial phases of the pandemic (2nd quarter 2020) that only appears to start recovering in the 2nd quarter of 2022 (Figure 13). The average trip distances by trams and buses were virtually unchanged during the 2020-2022 period (4.3 km and 7.1 km, respectively), but the average trip distance by train/rail increased from a range of 17-19 km to 21.4 km in the 2nd quarter of 2022. This suggests that the more urban part of the demand, covered by tram and bus, may be slower to recover than rail transport (which is more dependent on commuting). One explanation may be that even with more employees returning to the workplace, urban public transport is still not attractive enough as an alternative. In contrast, rail transport competes only with cars and can more easily regain its lost market share.

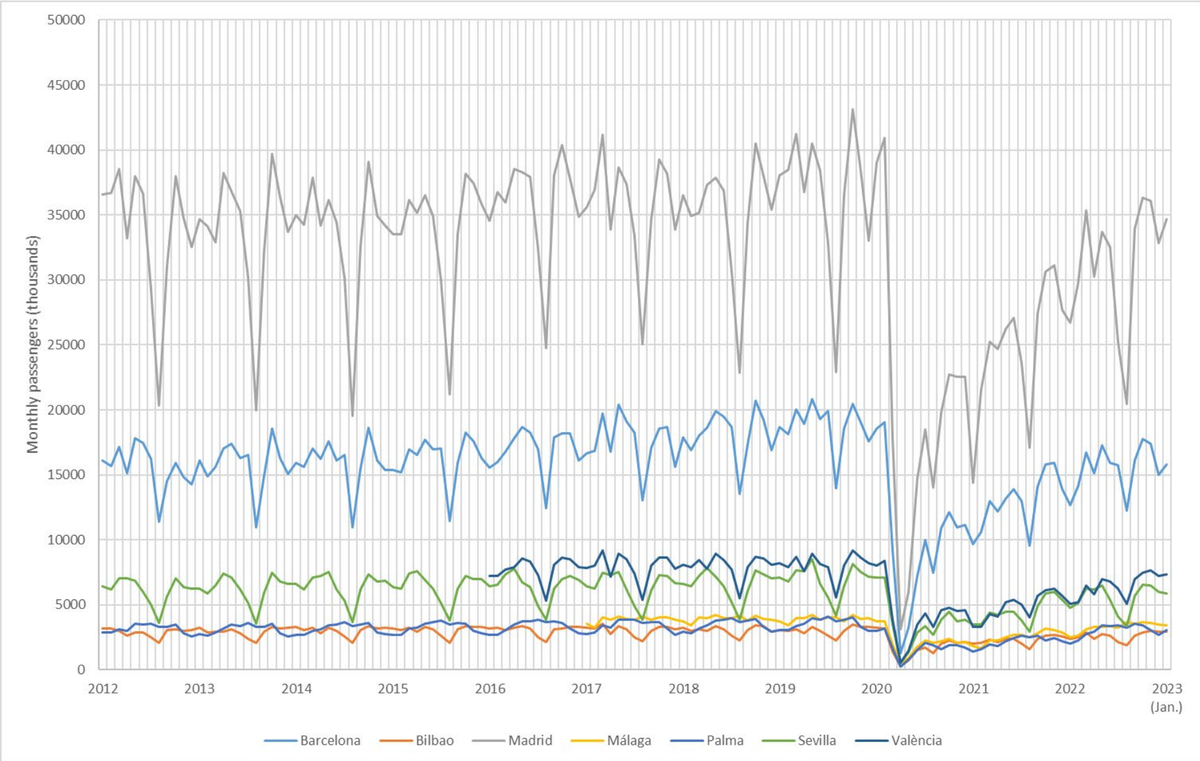
Figure 13. Evolution of public transport activity, Germany, 2019-2022 (quarterly data)

Source: data from Destatis, Germany, https://www.destatis.de/EN/Themes/Economic-Sectors-Enterprises/Transport/Passenger-Transport/Tables/passengers-carried.html

For Spain, data on the number of passengers carried by bus (Figure 14) or metro (Figure 15) are available on a monthly basis, for the seven cities where both modes exist. In both cases, a strong drop in activity is evident after March 2020, and a slow recovery appears to start by the end of 2020. The recovery follows a similar pattern in all 7 cities, but is much slower for bus transport than for metro.

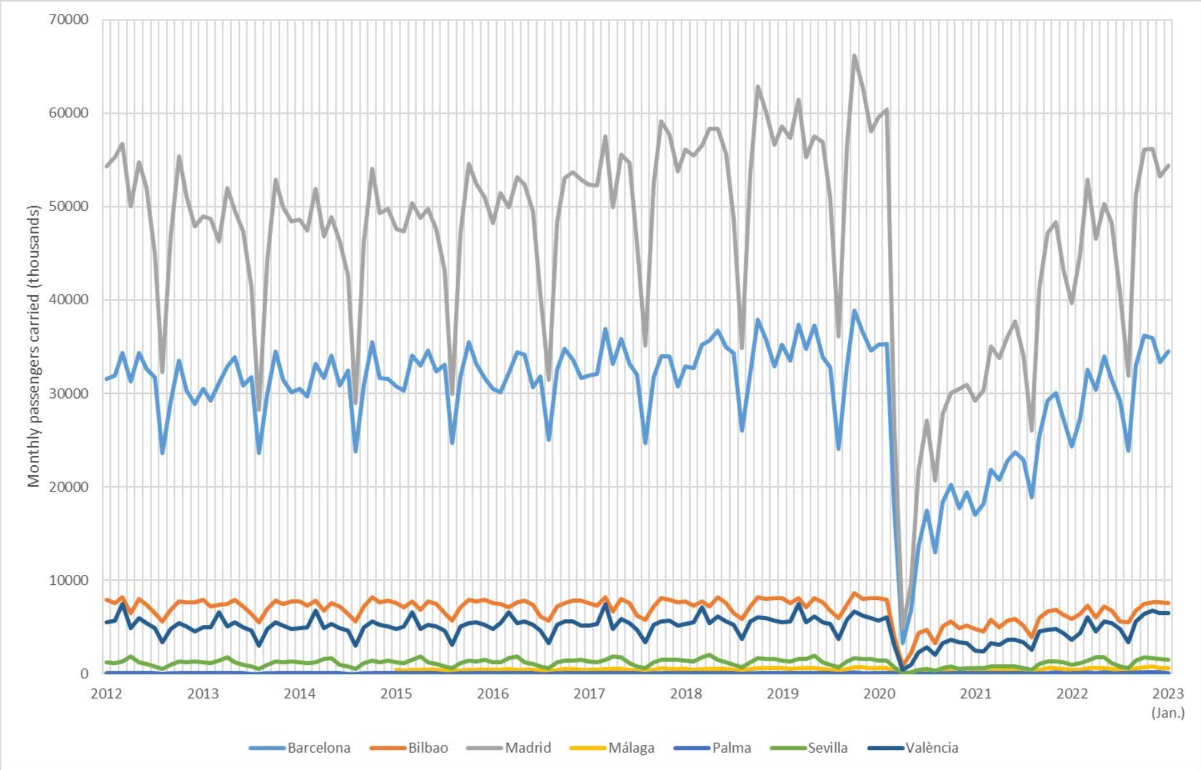
For example, comparing activity levels between May 2022 and May 2019 (Table 3) shows a decrease ranging from 16.5% to 23.9% for buses and from 7.9% to 12.5% for metro (Palma is an outlier, with a more moderate decrease of 15% for buses and an increase of 10.9% for metro).

Figure 14. Evolution of monthly number of passengers carried by bus, selected Spanish cities, 2012-2022



Source: data from Instituto Nacional de Estadística, Spain, https://www.ine.es/jaxiT3/Tabla.htm?t=20193

Figure 15. Evolution of monthly number of passengers carried by metro, selected Spanish cities, 2012-2022



Source: data from Instituto Nacional de Estadística, Spain, https://www.ine.es/jaxiT3/Tabla.htm?t=20193

Table 3. Change in number of carried passengers, May 2022 compared to May 2019, selected Spanish cities

	bus	**metro**
Barcelona	-17.2%	-8.9%
Bilbao	-16.5%	-11.6%
Madrid	-16.8%	-12.5%
Málaga	-20.8%	-8.3%
Palma	-15.0%	10.9%
Sevilla	-23.9%	-7.9%
València	-21.7%	-9.4%

Source: data from Instituto Nacional de Estadística, Spain, https://www.ine.es/jaxiT3/Tabla.htm?t=20193

The data provided by StatLine for the Netherlands allow a comparison of the evolution of both performance by mode and modal shares to be carried out. Table 4 shows that total passenger transport performance decreased dramatically in 2020 and only partially recovered in 2021. However, at modal level, the trends demonstrate significant differences. All modes except walking decreased in 2020, but the change was more pronounced for trains and bus/metro (well exceeding 50%). In a similar fashion, signs of recovery are visible in 2021, but at slower rates for public transport.

The evolution of modal shares in the same period is more telling (Table 5). The share of car activity increased during the pandemic in 2020, and is still higher in 2021 than in 2019. The share of bus/metro and trains decreased in 2020 and stabilized in 2021, probably as a result of a shift to active modes. Cycling, which in the Netherlands traditionally holds an important share of transport activity, decreased in absolute numbers in 2020 (and was still lower than normal levels in 2021), but has increased its share of the total considerably. Walking, on the other hand, continued increasing in both absolute and relative terms during 2020 and 2021. It therefore appears that even though total transport activity is slowly returning to pre-pandemic levels, the role of public transport continues being weak.

Table 4. Evolution of transport performance in the Netherlands, population 12 years and older, 2018-2022 (billion passenger kms)

	2018	**2019**	**2020**	**2021**
Passenger car (driver)	108.8	108.5	79.4	85.6
Passenger car (passenger)	33.4	34	22	26
Train	22.6	23.9	9.5	10.2
Bus/metro	6.3	6.4	2.9	3.4
Bike	17.5	16.8	14.6	15.1
Walking	4.8	4.8	6.2	7.7
Other	17.3	17.6	11.8	14.4
Total	**210.8**	**211.9**	**146.6**	**162.4**

Source: StatLine, the Netherlands, https://opendata.cbs.nl/#/CBS/en/dataset/84687ENG/table?ts=1667897742171

Table 5. Evolution of modal share in the Netherlands, population 12 years and older, 2018-2022 (as share of total billion passenger kms)

	2018	**2019**	**2020**	**2021**
Passenger car (driver)	51.6%	51.2%	54.2%	52.7%
Passenger car (passenger)	15.8%	16.0%	15.0%	16.0%
Train	10.7%	11.3%	6.5%	6.3%
Bus/metro	3.0%	3.0%	2.0%	2.1%
Bike	8.3%	7.9%	10.0%	9.3%
Walking	2.3%	2.3%	4.2%	4.7%
Other	8.2%	8.3%	8.0%	8.9%

Source: StatLine, the Netherlands, https://opendata.cbs.nl/#/CBS/en/dataset/84687ENG/table?ts=1667897742171

In Sweden, the impacts of the pandemic on mobility and modal shares were more limited (Table 6). Total transport performance initially fell by a relatively modest 5.5% in 2020 (from 113.5 billion to 107.3 billion passenger kms) to eventually fall further to an aggregate 6.9% in 2021 (compared to 2019). The modal shares were relatively stable, with changes of less than 1 percentage point. The most noticeable difference is observed for cycling, which briefly increased its share in 2020, to return to roughly its pre-pandemic levels in 2021. Bus performance in 2021 was 12% below its 2019 levels, with a corresponding loss of 0.5 percentage points in terms of modal share.

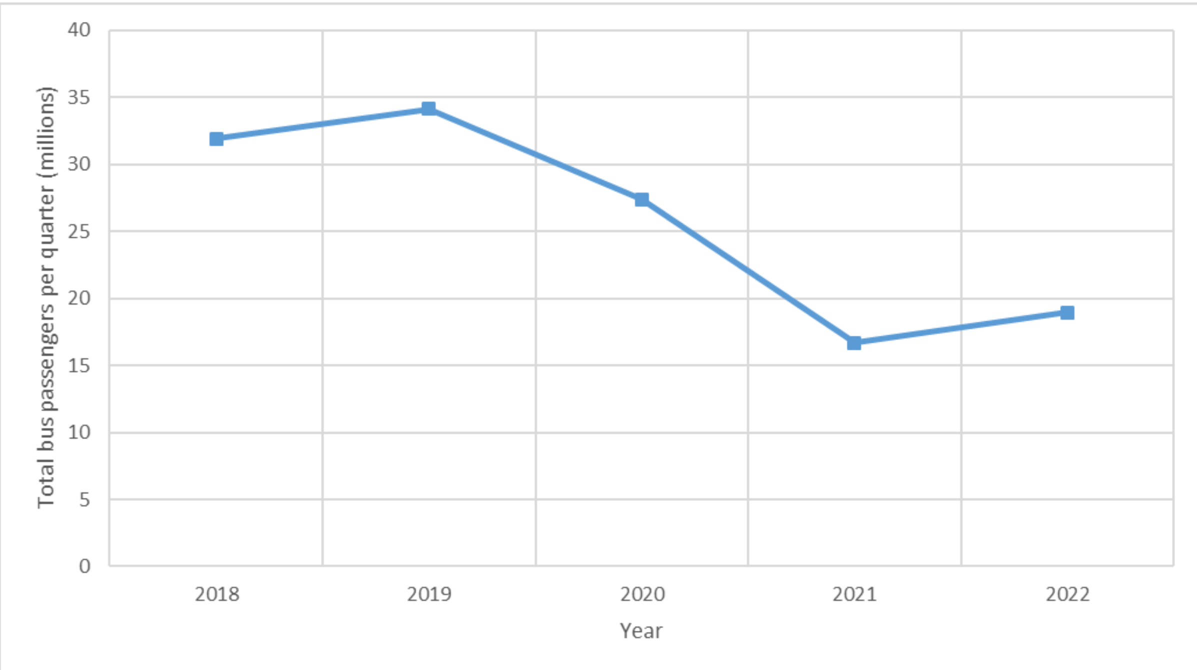
Table 6. Evolution of transport performance and modal split in Sweden, 2017-2021

Year	**Total**	**car**		**bus**		**motorcycle/ moped**		**bicycle**		**walking**		**light trucks**	
	billion passkm	billion passkm	share	billion passkm	share	billion passkm	share	billion passkm	share	billion passkm	share	billion passkm	share
2017	112.1	95.4	85.2%	10.0	8.9%	0.9	0.8%	2.1	1.9%	1.7	1.5%	2.0	1.8%
2018	113.5	96.3	84.9%	10.0	8.8%	0.9	0.7%	2.4	2.1%	2.0	1.8%	1.9	1.7%
2019	113.5	95.6	84.2%	10.1	8.9%	0.9	0.8%	2.7	2.4%	2.3	2.1%	1.9	1.7%
2020	107.3	90.1	84.0%	9.0	8.4%	0.9	0.8%	3.2	3.0%	2.1	1.9%	2.0	1.9%
2021	105.7	89.5	84.7%	8.9	8.4%	0.9	0.8%	2.2	2.1%	2.3	2.1%	2.0	1.9%

Source: Trafik Analys, Sweden, https://www.trafa.se/en/otherstatistics/passenger-and-goods-transport/transportarbete-2000-2021-2022-10-04.xlsx

For Estonia, data on the number of bus passengers for each quarter of the year are available (Figure 16). As in the other cases, bus activity fell by over 50% during the initial phases of the pandemic, and stagnated during 2021 and 1st quarter 2022. The 2nd and 3rd quarters of 2022 show some signs of recovery, but still at significantly lower levels than in 2019.

Figure 16. Bus passengers in Estonia, 2018-2022 (quarterly)



Source: Statistics Estonia, https://www.stat.ee/en/find-statistics/statistics-theme/energy-and-transport/transport

The impact of the pandemic was much more pronounced in Hungary (Table 7). All public transport options showed a decrease in performance that ranged from 33% to 40%. It is interesting to note that the average trip distance for public transport in the period 2017-2021 remained virtually constant at 3.8 km per trip.

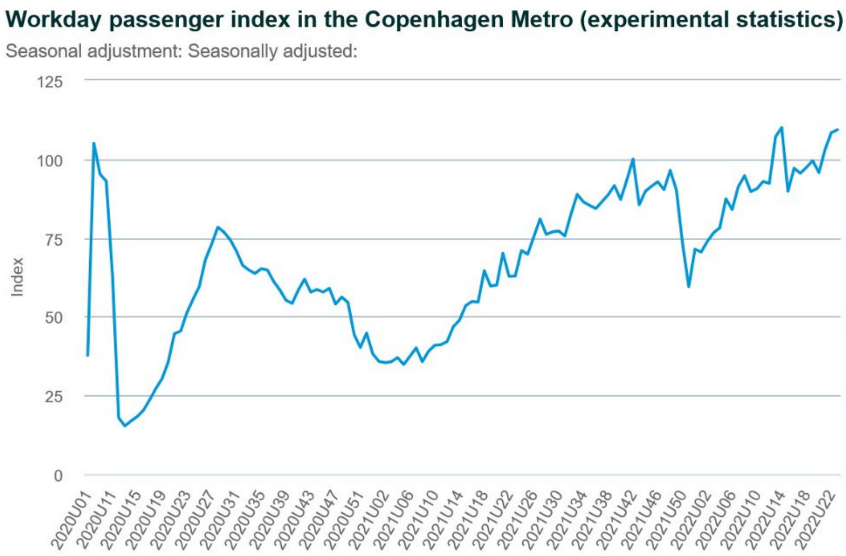
Table 7. Evolution of urban public transport performance in Hungary, 2017-2022 (millions of passengers carried)

Year	**Bus**	**Tram**	**Trolleybus**	**Metro, underground**	**Suburban train**
2017	1100.8	467.3	101.9	410.6	73.0
2018	1150.3	483.9	101.6	321.4	73.3
2019	1116.5	471.8	101.2	354.0	73.3
2020	761.5	312.1	67.6	232.8	48.6
2021	744.8	314.7	67.0	211.6	48.5
change 2021/2019	*-33.3%*	*-33.3%*	*-33.8%*	*-40.2%*	*-33.8%*

Source: Hungarian Central Statistical Office (KSH), https://www.ksh.hu/stadat_files/sza/en/sza0021.html

The only example of growth in passenger transport (from the limited sources of data available at the moment) comes from the Copenhagen Metro (Figure 17). Weekly data show a drastic decrease in the number of passengers in 2020, which persisted for most of year 2021. Nevertheless, the gradual recovery that started in early 2022 resulted in the seasonally adjusted index to surpass its pre-pandemic level by week 20, 2022.

Figure 17. Evolution of Copenhagen Metro passenger index, 2020-2021



Source: Statistics Denmark, www.statbank.dk/METROX1

5 Increase in active mobility

As a consequence of the pandemic, active mobility (walking and cycling) became a more frequent choice, and a part of this trend may be maintained in the future. To a large extent, active transport replaced other means, especially public transport, as a form of social distancing but also benefited from the shift in mobility patterns during the pandemic. Fewer trips to work, school, or shops appear to have left room for more trips for exercise, recreation, or simply psychological well-being. One can expect a relative decline in active transport activity once all other mobility options and destinations are again available, but it is likely that some of the users who 'discovered' walking or cycling during the pandemic would continue considering them as their main transport mode. In addition, given the environmental and health benefits, local authorities are expected to promote active transport in the future and build on the current momentum (Pisoni et al., 2019).

There is a scarcity in data sources as regards actual performance levels for active transport modes (a few sources were already mentioned in Section 4). In terms of infrastructure, Eurostat provides detailed city-level data that can help identify some trends (summarized at country level in Table 8). Both the pre-existing situation and the infrastructure policy adopted after the pandemic vary significantly among the 7 MS for which data are available. Most MS increased their cycling infrastructure by more than 10%, with the exceptions of Germany (which already had a quite developed network of urban cycling infrastructure) and Hungary.

Table 8. Length of cycling lanes in 7 EU MS, 2019-2021

Member State	**2019**	**2021**	**change 2019-2021**
Belgium	2 916	3 297	13.1%
Croatia	540	632	17.0%
Germany	23 658	24 635	4.1%
Hungary	739	771	4.3%
Latvia	173	232	34.5%
Lithuania	537	598	11.5%
Poland	15 539	18 510	19.1%
Total (7 MS)	**44 102**	**48 675**	**10.4%**

Source: Eurostat, table URB_CTRAN; for Poland: Statistics Poland, https://bdl.stat.gov.pl/bdl/dane/podgrup/tablica

Table 9. Active mobility by EU-27 Member State

	active mobility (walking + cycling)		walking		cycling	
	trips	activity (passkm)	trips	activity (passkm)	trips	activity (passkm)
Netherlands	30.9%	9.1%	3.2%	0.5%	27.8%	8.6%
Hungary	28.2%	8.8%	13.6%	2.4%	14.5%	6.4%
Finland	27.6%	8.4%	12.0%	2.0%	15.5%	6.3%
Sweden	24.2%	7.2%	11.3%	1.8%	12.9%	5.4%
Denmark	24.7%	5.1%	5.5%	0.6%	19.2%	4.5%
Czechia	21.5%	5.0%	13.8%	1.9%	7.7%	3.2%
Latvia	21.7%	4.9%	16.5%	2.1%	5.2%	2.7%
Belgium	19.2%	4.8%	8.6%	1.2%	10.6%	3.6%
Germany	19.7%	4.7%	9.8%	1.1%	9.9%	3.6%
Estonia	19.8%	4.2%	14.9%	2.3%	4.9%	1.9%
Greece	15.8%	4.0%	12.5%	2.2%	3.3%	1.8%
Ireland	16.5%	3.7%	12.5%	1.5%	4.0%	2.1%
France	14.6%	3.5%	12.0%	2.0%	2.6%	1.5%
Romania	23.8%	3.5%	20.5%	2.0%	3.3%	1.5%
Slovakia	13.6%	3.5%	9.2%	1.5%	4.3%	2.0%
Spain	21.7%	3.5%	19.8%	2.7%	1.9%	0.8%
Bulgaria	19.3%	3.4%	15.5%	2.0%	3.8%	1.3%
Poland	13.1%	3.2%	7.4%	0.7%	5.7%	2.5%
Austria	15.3%	3.1%	8.4%	0.9%	6.9%	2.2%
Lithuania	11.8%	2.6%	8.8%	1.3%	3.0%	1.3%
Croatia	14.4%	2.5%	10.1%	1.2%	4.3%	1.2%
Slovenia	12.6%	2.5%	7.8%	1.1%	4.8%	1.4%
Italy	11.2%	2.3%	8.0%	0.9%	3.3%	1.4%
Portugal	9.3%	2.2%	8.4%	1.2%	0.8%	1.0%
Malta	5.6%	1.4%	5.1%	0.7%	0.5%	0.7%
Luxembourg	7.4%	1.2%	4.0%	0.5%	3.4%	0.7%
Cyprus	4.2%	0.7%	3.1%	0.5%	1.1%	0.2%
EU 27 average	**18.0%**	**4.1%**	**10.6%**	**1.4%**	**7.4%**	**2.7%**

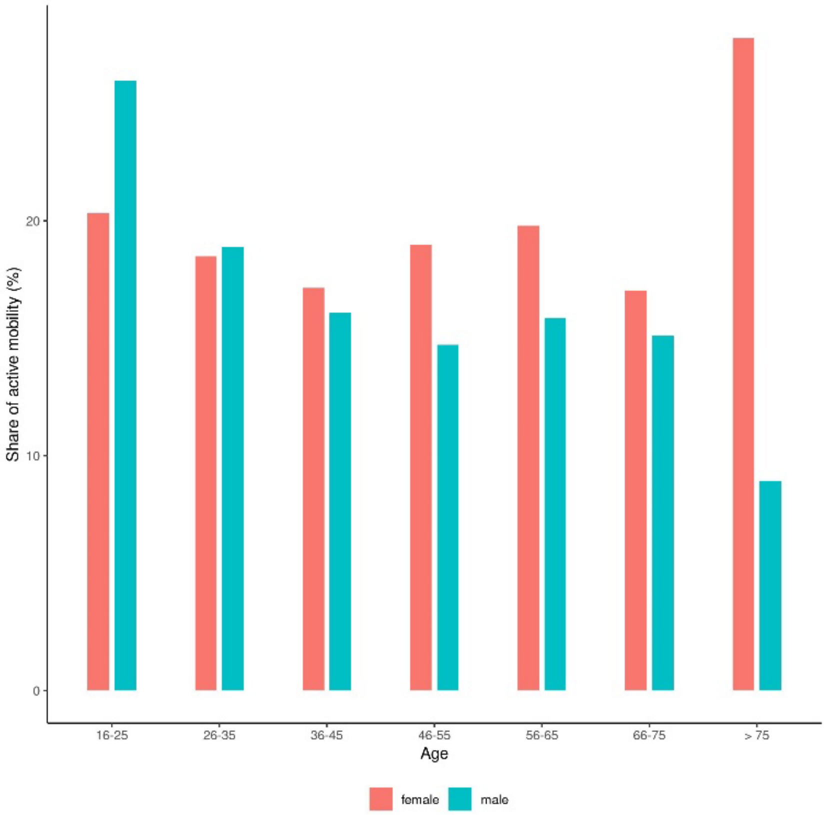
Source: JRC estimates (Pisoni et al., 2022)

For the work presented here, the trip matrices of the TRIMODE model (Fiorello et al., 2018) were adapted in order to allow the reproduction of historical transport activity data for the period for which aggregate statistics are available (years 2016 to 2018, (Christidis et al., 2021)). Active mobility represents 18% of passenger trips in EU-27 but - since those trips are of a relative short distance - a lower share of total passenger transport activity is associated with this share, namely 4.1% (Table 9). Walking corresponds to 10.6% of trips and 1.4% of activity, while cycling to 7.4% and 2.7% respectively. There is a large variance among EU-27 Member States though, reflecting the differences in the culture and infrastructure for active mobility (especially as regards cycling) as well as in the socio-economic and demographic profiles of the population, urban structure, topography and weather conditions. It is interesting to note that countries with a high adoption rate of cycling tend to have a substitution effect for walking (e.g. the Netherlands and Denmark). For most Mediterranean countries, cycling appears to compete with motorized 2 wheelers such as motorcycles and mopeds.

The Netherlands, Denmark and Sweden show high levels of active mobility mainly due to high cycling shares. On the other hand, in Italy and Greece the extensive use of motorcycles and mopeds appears to act as a competitor to cycling. City size and structure, car ownership levels and availability of public transport affect the variation among countries.

The EU Travel Survey, 2018 wave, is a CAWI (Computer Aided Web Inter-view) survey with 26500 responses across the EU (Fiorello et al., 2016). The analysis of the survey responses allows the disaggregation of mobility choices by a large range of variables. For example, the use of active transport modes varies significantly depending on the sex and the age of the respondent (Figure **18**). While, on average, female respondents are more prone to walk or cycle than male (18.6% versus 17.3%), the opposite is observed in age groups below 35, especially below 25. The trends for neither sex are linear. Active transport shares tend to decrease for both males and females after the age of 35 and recover – at different rates - after the age of 46. Another change in the trend is visible after the age of 65, with male respondents decreasing their active mobility share to a minimum, while female respondents maintain or even increase their shares. Such differences in activity profiles are well documented in literature and - to a large extent - are due to the differences in economic and social activity between the two sexes. For example, men tend to drive to work at a higher proportion than women and on average work at a longer distance from home. In addition, while the overall level of physical activity among men is higher than among women in younger ages, it appears to be lower when they get older (either for social or health reasons).

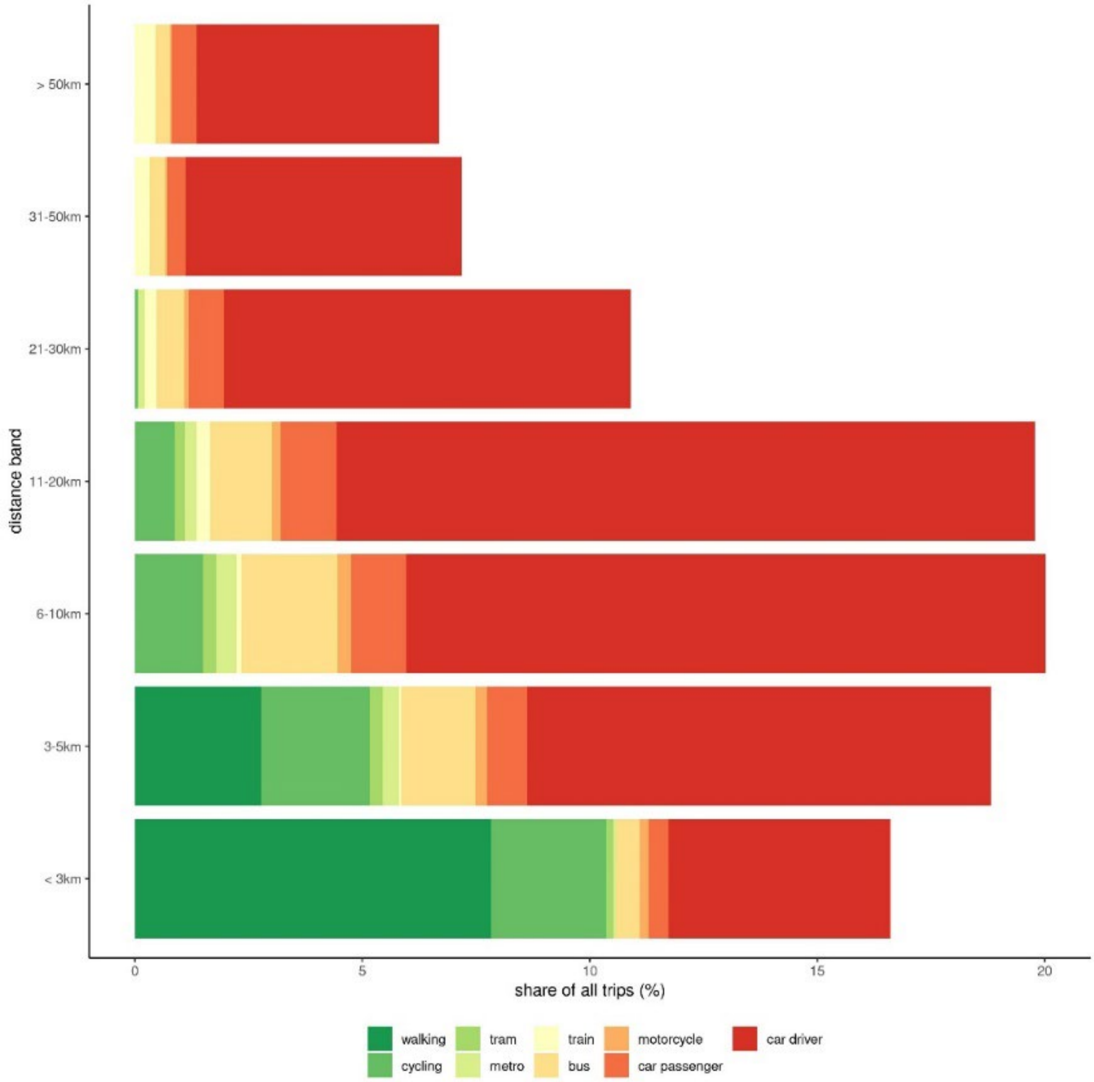
Figure 18. Active mobility share by age and sex



Source: JRC EU travel survey (Fiorello et al., 2016; Pisoni et al., 2022)

The transport mode preferences according to trip distance are summarized in Figure 19. There is an evident correlation, with shorter trips having a higher share of active mobility modes and car becoming the dominant mode as trip distance increases. The distribution of trip distances is also interesting. The majority of trips has a length of under 20 km and a significant share is within a range where active mobility can be considered as an option (10 km for cycling or 5 km for walking).

Figure 19. Modal split by trip distance band, EU-27.



Source: JRC estimates (Pisoni et al., 2022)

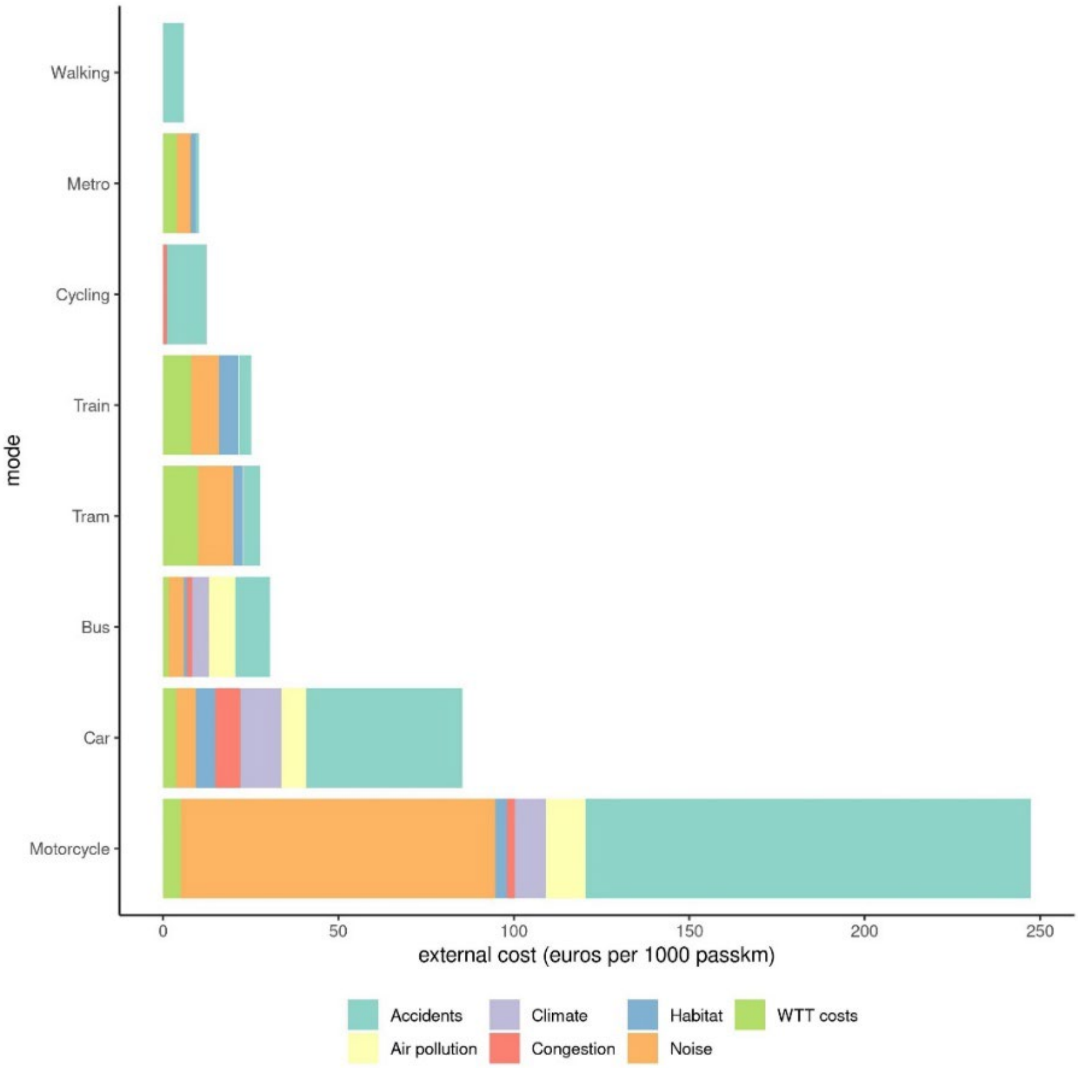
The Handbook on the External Costs of Transport is a methodological guide developed by the European Commission for the estimation of the monetary value of transport externalities across the EU (European Commission, 2020b). External costs of transport correspond to the differences between the social costs (all costs that are generated by transport activity and are borne by society as a whole) and internal costs (the costs borne directly by the individual user of transport services). The monetarization of external costs with a uniform methodology is particularly useful for the comparison of the impact of different externalities across different geographic areas and for the analysis of costs and benefits of a large range of measures, technologies or practices related to transport.

The total costs of an externality at country level are allocated to specific combinations of transport mode, vehicle technology and context of operation, depending on the share of each combination in overall transport activity. External cost values are available for all main passenger and freight transport modes at EU Member

State level, differentiating between specific vehicle technologies, type of network (e.g. highway or local road) and geographic typologies (e.g. urban or rural area).

Figure 20 compares the average external cost by transport mode at EU level and its breakdown by externality. Motorcycles are the means of transport with the highest external costs, mainly because of their accident and noise costs, in both cases considerably larger than any other mode. Passenger cars, the most frequently used mode, causes significant external costs. Almost half can be attributed to accidents, however, climate change, congestion and pollution costs are substantial, even though a lot of progress has been made during the last decade in improving car technologies. Active mobility modes also cause external costs, mainly due to accidents.

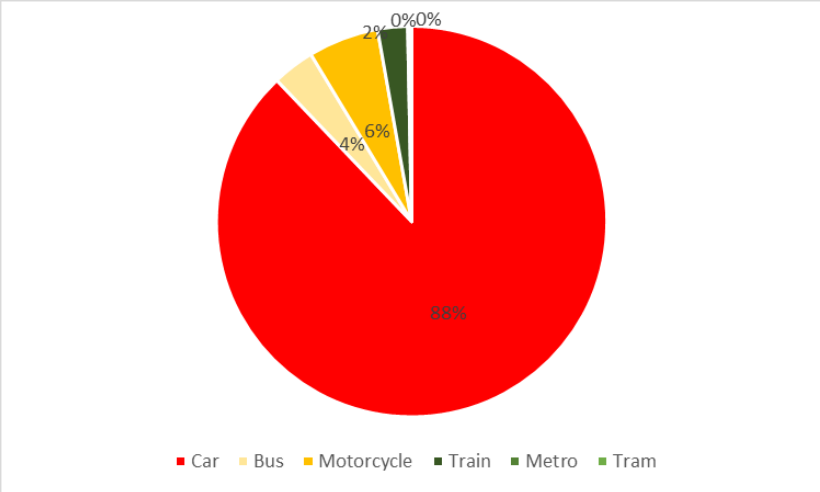
Figure 20. Average external costs by transport mode and externality, EU27, year 2018 values.



Source: JRC estimates (Pisoni et al., 2022)

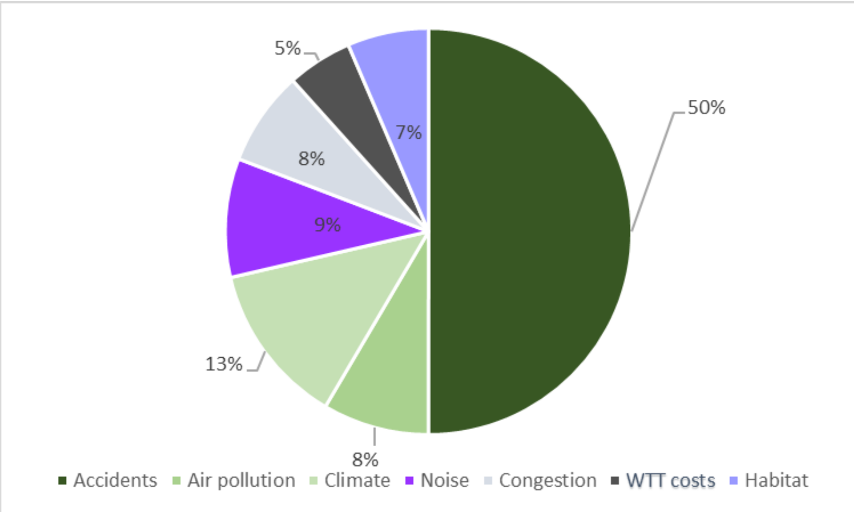
Applying those values to transport activity in EU as a whole, the total cost of externalities is estimated to be €412 billion/year, a value that would correspond to €937 per capita. Car passenger activity is by far the largest contributor, responsible for 88% of total external costs (Figure 21). Half of the total external cost of passenger transport can be attributed to accidents, but each of the other 6 main externalities has a considerable share, i.e. between 5% and 13% of the total (Figure 22).

Figure 21. Distribution of external costs of passenger transport by mode, EU-27, year 2018 values.



Source: JRC estimates (Pisoni et al., 2022)

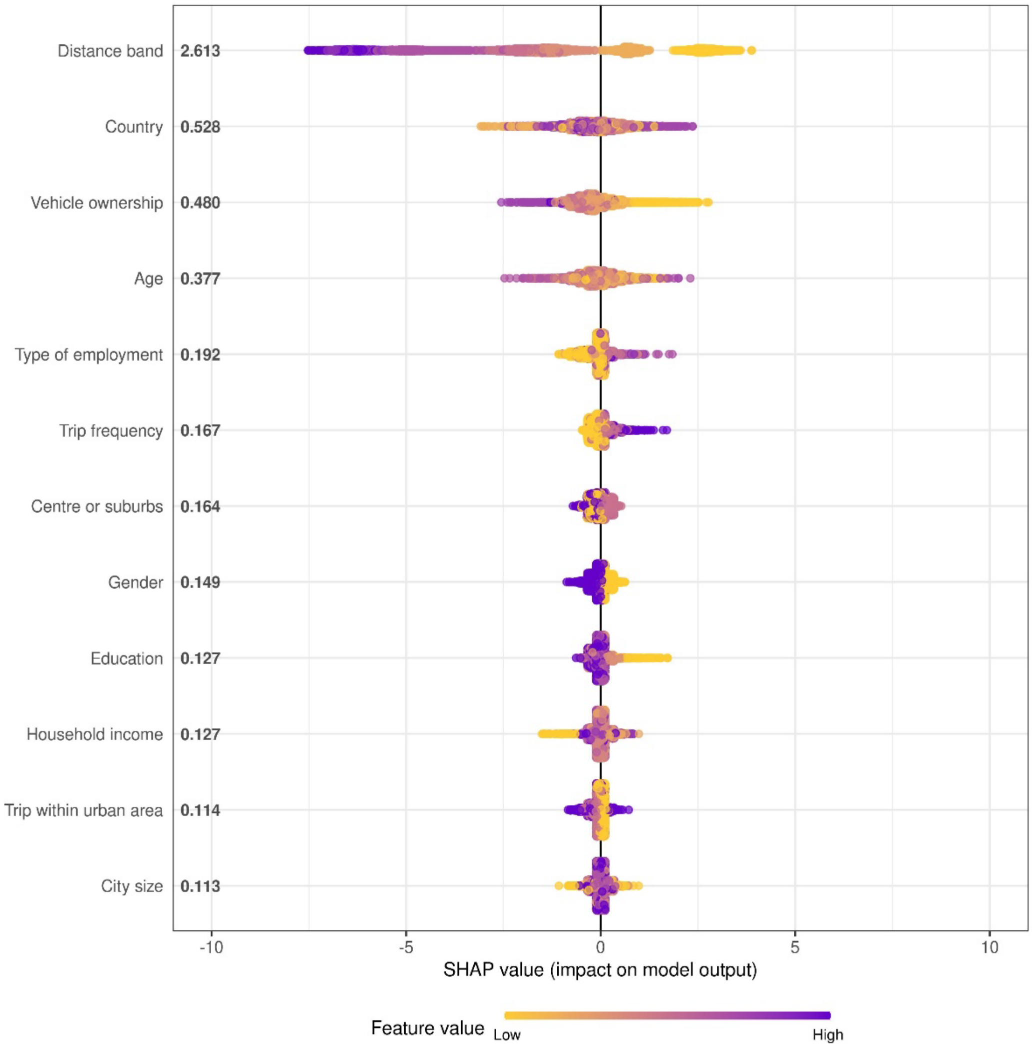
Figure 22. Distribution of external costs of passenger transport by main externality, EU-27, year 2018 values.



Source: JRC estimates (Pisoni et al., 2022)

The importance of the factors influencing the choice of an active mobility mode was explored through the application of a classification model based again on the gradient boosting (BGML) method. The classification model uses the EU Travel Survey as input. The dependent variable is a binary variable (0/1) indicating whether the respondent uses active modes as the most frequent means of transport. As a first step, all 34 variables (questions) in the survey were used as features (independent variables) and more than 200 additional variables were constructed following standard feature engineering practices. The modelling setup followed the standard practice of randomly splitting the dataset into training, testing, and validation sets (40%, 40% and 20% respectively). The model was fit on the training set and its precision was evaluated using the test set. The structure of the final model and the importance of its variables are shown in Figure 23.

Figure 23. Importance of each variable in the classification model



Source: JRC estimates (Pisoni et al., 2022)

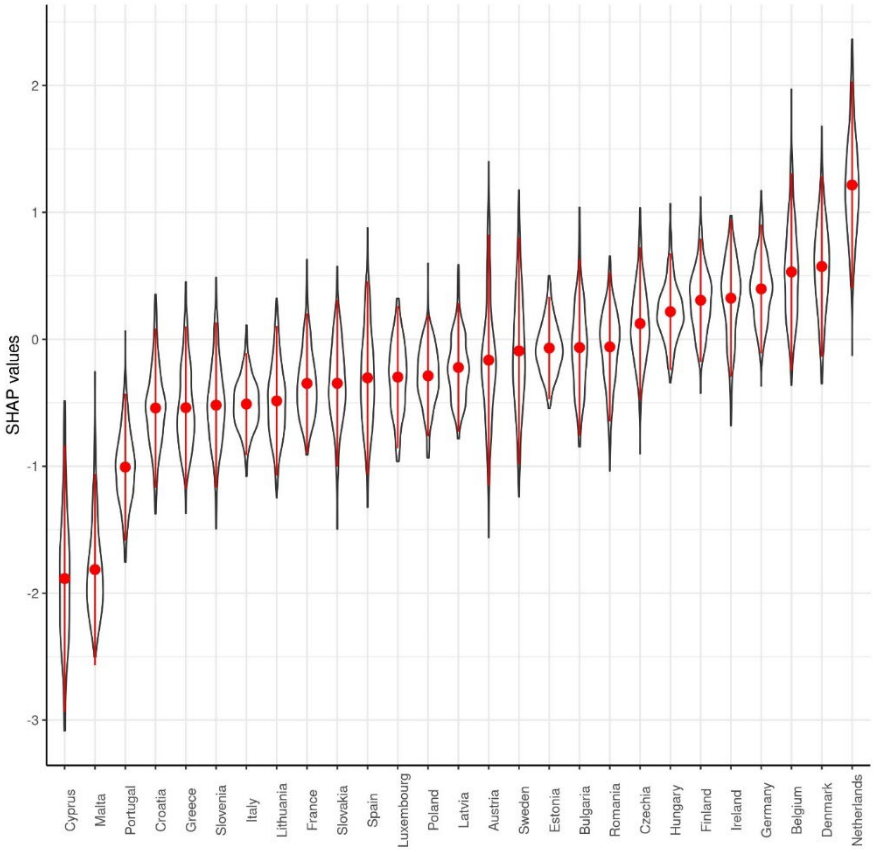
In Figure 23, the numbers on the y-axis represent the relative importance of the different factors in explaining the active mobility choice (i.e. the highest value is 2.613 for 'distance', meaning that 'distance' is the main factor influencing the choice). The colours show the 'feature importance' distribution. Again, for 'distance', the darker colour on the left means that in the majority of cases a higher distance means not choosing an active mobility. On the contrary, short distances (light colour) lead to a higher probability of a respondent preferring active mobility options.

It is evident that the main determinant is trip distance. The higher the trip distance is, the lower the probability of a user choosing an active mode becomes. In practice, this means that there is a physical limit over which active mobility is not an option to be considered. This is also reflected in the frequency statistics as regards modal share by trip distance (Figure 19), which shows an increasing use of car as trip distance increases.

The second important factor is the country of the respondent. The SHAP dependence plot in Figure 24 shows that – ceteris paribus - the country of the respondent may suggest a higher or lower propensity to use active mobility modes. The Netherlands is a clear case of positive impact, while Denmark and, possibly, Belgium can also be considered as countries where culture and infrastructure favour active mobility.

Vehicle ownership, calculated in the model as the ratio of owned vehicles per number of household's members has a clear impact: users from households with more vehicles are less likely to walk or cycle. Age does not have a linear or monotonous impact, with older users being more or less prone to active mobility than the average, depending on other factors. As already seen in the descriptive statistics, sex also plays a role, though limited. But holding the other variables used in the model constant, it appears that female respondents have a higher propensity towards active mobility than men.

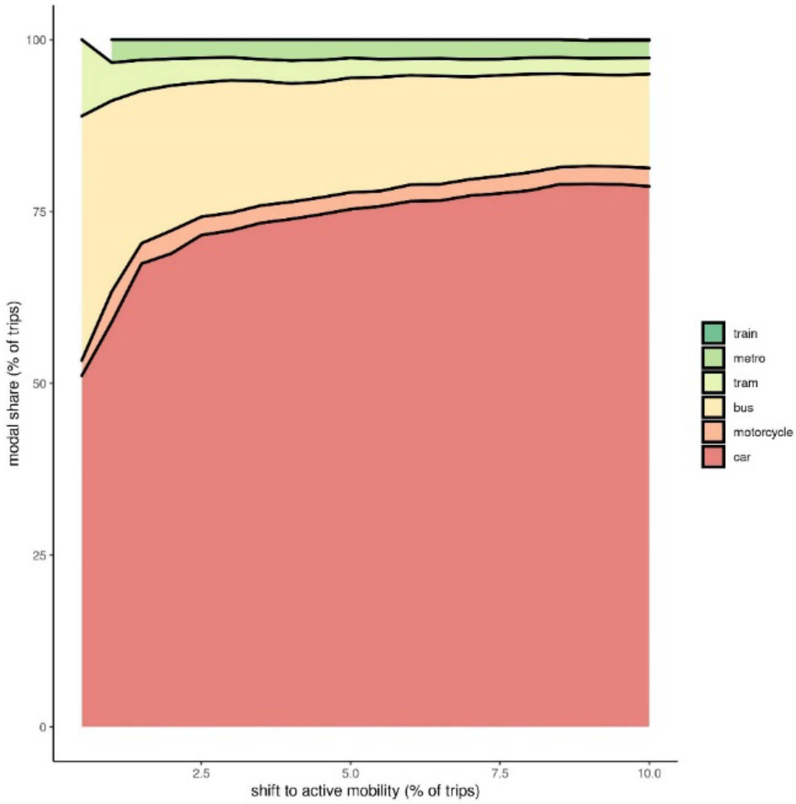
Figure 24. Country impact on choice of active mobility.



Source: JRC estimates (Pisoni et al., 2022)

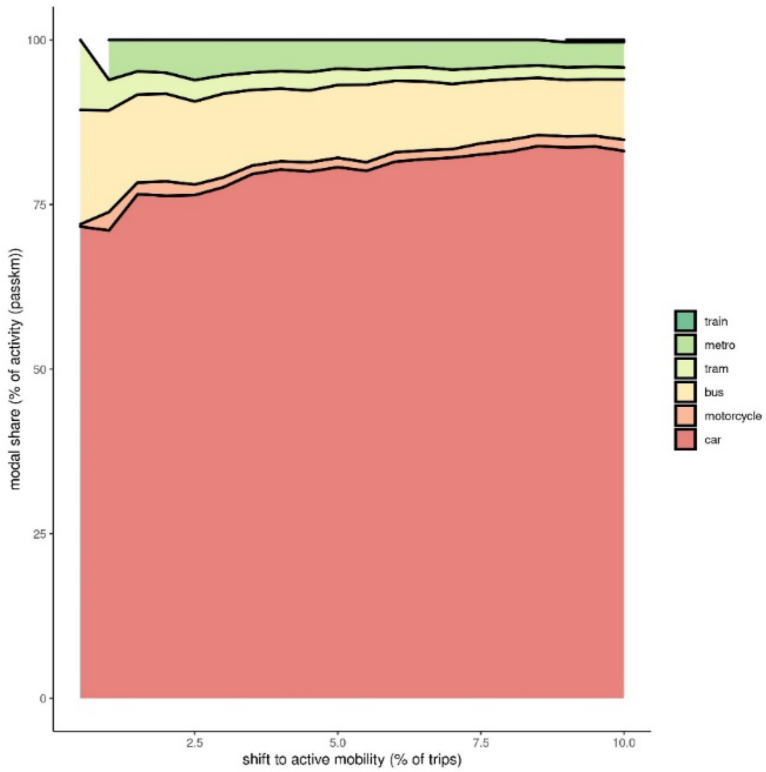
Applying the classification model to the test and validation datasets returns a modelled probability of each respondent choosing an active mobility mode. Ranking the probability in descending order allows the identification of the type of users with the highest probability of shifting from other modes to either walking or cycling. A stepwise approach is followed, using 0.5% increments in the adoption of active mobility. The result is an estimate of the distribution of the trips that can be expected to shift to active modes in terms of actual modes. Figure 25 and Figure 26 visualize the expected distribution for a range of shifts to active mobility between 0.5% and 10%. For lower modal shift values (left side of the x-axis), active mode trips are expected to substitute both car and public transport trips and gradually substitute a proportionally higher number of car trips. This suggests that the first trips to be converted into active mobility have a higher relative probability of coming from bus and other public transport modes and that higher adoption rates are required before active mobility becomes an alternative for a large number of car users.

Figure 25. Progressive shift to active mobility, by trips



Source: JRC estimates (Pisoni et al., 2022)

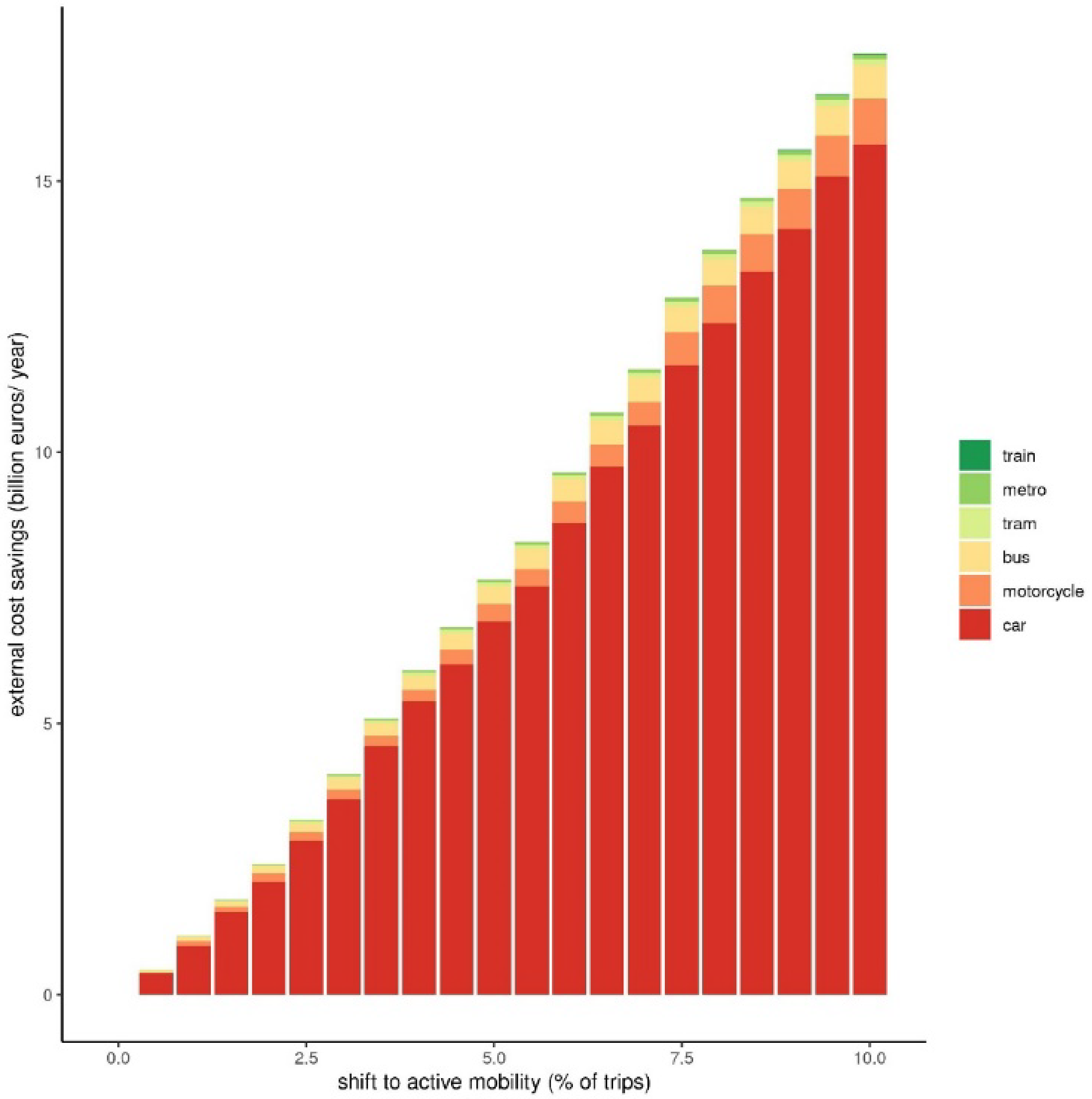
Figure 26. Progressive shift to active mobility, by transport activity



Source: JRC estimates (Pisoni et al., 2022)

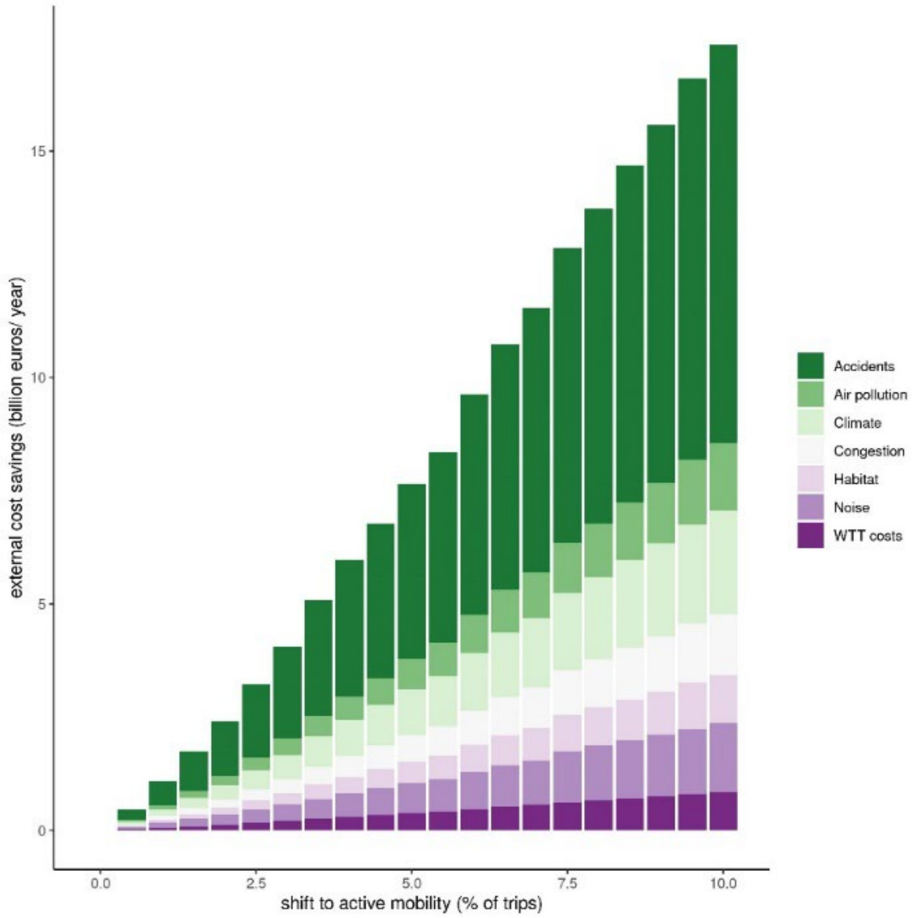
The alternative modal shift changes were introduced into the transport demand module and complemented with the external cost indicators from the Handbook. This allows the estimation of the savings in terms of external costs by an increase in active mobility (in the range of 0.5% to 10%). The largest share of savings would come from the substitution of trips by car (Figure 27). In terms of externalities, the distribution is shown in Figure 28. The total benefits in terms of external costs can exceed 10 Billion Euro/year, when considering an increase of 10% in active mobility share.

Figure 27. Expected savings in external costs, by substituted mode



Source: JRC estimates (Pisoni et al., 2022)

Figure 28. Expected savings in external costs, by externality



Source: JRC estimates (Pisoni et al., 2022)

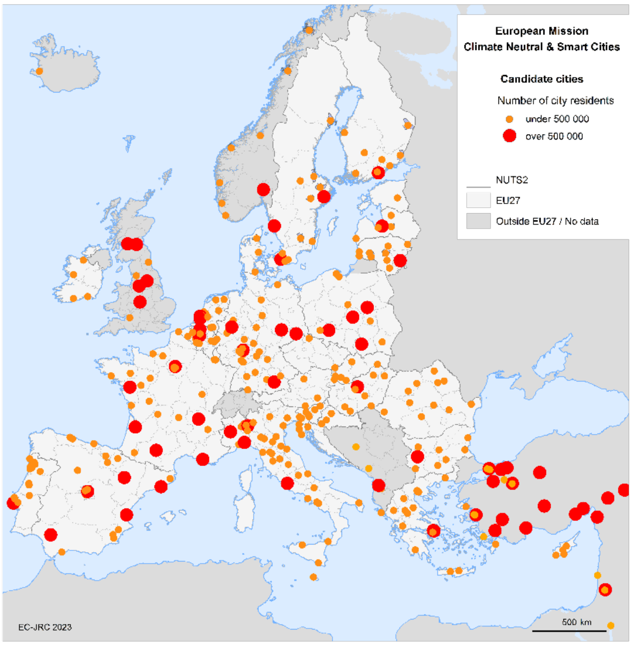
6 Achieving climate neutrality for urban transport

Apart from the impact of the Covid-19 pandemic or rising energy and transport costs, urban transport policy needs to address longer term issues such as climate change. While achieving climate neutrality for transport is already a major challenge, the post-pandemic situation can influence the type of measures that can be adopted. Several elements of transport policy at urban level can help in addressing the challenges discussed above while also preparing the path for a transition to climate neutrality. The data collected from the candidate cities for the EU Mission on Climate-Neutral and Smart Cities allow a quite detailed mapping of the challenges ahead at city level and the possible measures to address them (Christidis et al., 2023; Vetters et al., 2023).

The Mission is one of the five EU missions that address grand societal challenges (Mazzucato, 2018). The European Commission launched the first call for expression of interest in the Cities Mission on 25 November 2021. Within the call, cities were invited to fill up a comprehensive questionnaire to state their interest in becoming climate-neutral by 2030 as part of the Mission and to submit information on their current situation, ongoing work, and future plans with regard to climate neutrality (Vetters, N. et al., 2021). The call received 362 eligible expressions of interest: 314 from cities within EU-27 (which encompass a remarkable 18% of total EU-27 population) and 48 from cities from Associated Countries (or in the process of negotiating association) to Horizon Europe (Turkey, United Kingdom, Norway, Israel, Albania, Iceland, Montenegro and Bosnia-Herzegovina) as displayed in Figure 29. The central feature of the Mission will be the implementation of Climate City Contracts by a group of about 100 cities, selected on the basis of diverse criteria including the ambition, preparedness and impact demonstrated in their expressions of interest. The contracts will set out plans for the cities to achieve climate neutrality by 2030 and will include an investment plan. While not legally binding, these contracts will constitute a clear and highly visible political commitment to the EU, national and regional authorities and citizens.

The majority of the applicant cities have already adopted a GHG emissions reduction target for the future (266 out of 362, 73.5%) and have identified the relevant sectors of intervention (263 out of 362, 72.7%). Transport has a visibly central role, flagged by 97.7% of these cities (257 out of 263). Stationary energy - representing the energy consumption associated with buildings, equipment, facilities and public lighting - is also close in importance. Since the priorities and the profiles of the applicant cities differ significantly, the other main sectors responsible for GHG emissions may vary substantially in terms of the share of cities that directly address them.

Figure 29. Map of eligible applicant cities

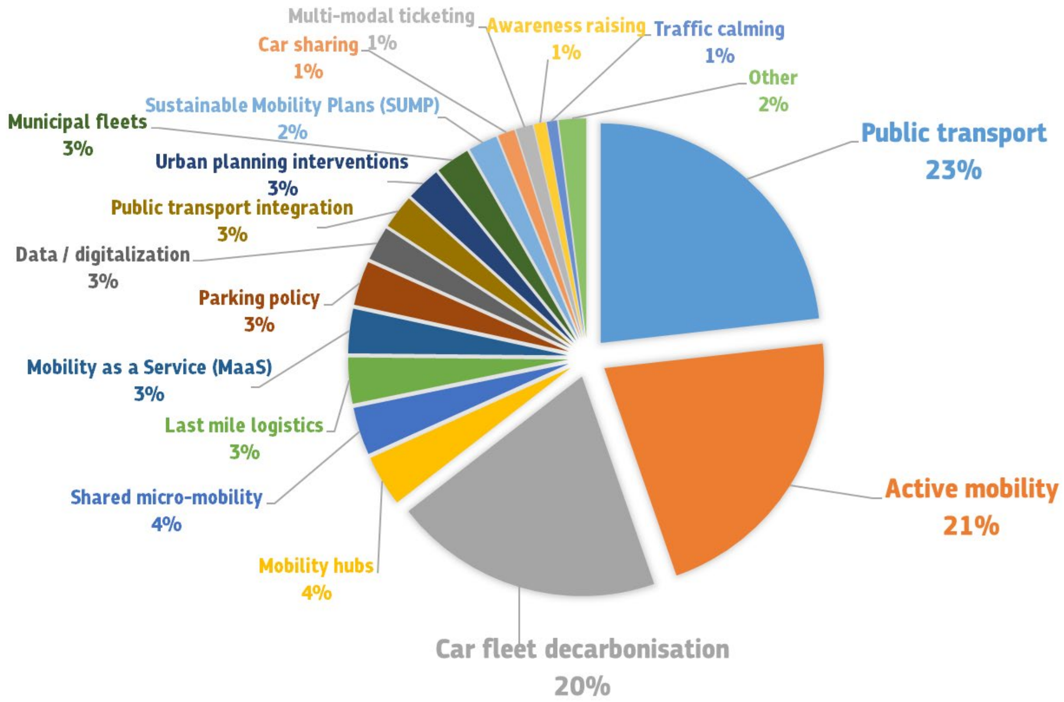


Source: Own work

Eligible cities were asked to describe up to 3 interventions that can be scaled up by 2030 in different sectors. As concerns transport, the number of interventions stated by each city varied, but the majority did include three. Out of the 362 eligible cities, 202 introduced 3 scalable interventions, 73 introduced 2 interventions, 45 only a single intervention, while 42 candidates did not report any scalable intervention for transport.

In total, 797 cases were provided by the 320 cities with at least a scalable intervention. They represent a wide range of interventions with the potential for decarbonizing transport at urban level. The interventions can be grouped in a number of categories, depending on the transport service or infrastructure issue that they address.

Figure 30. Main categories of scalable interventions for transport

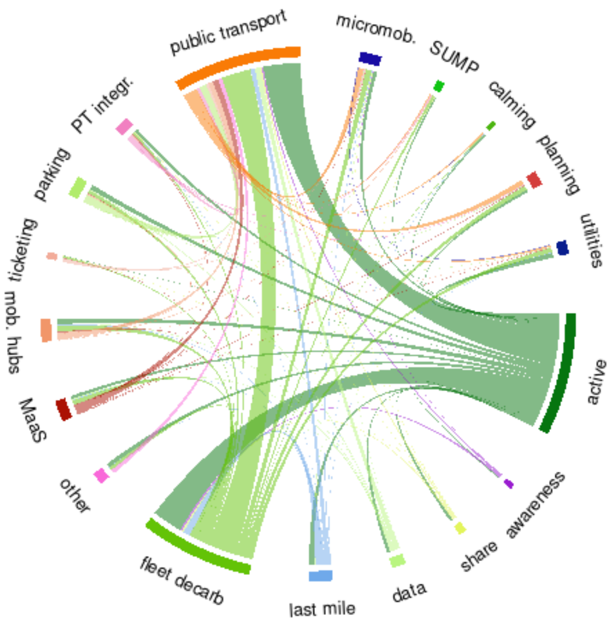


Source: Own work

Figure 30 summarizes the frequency of each macro-category of intervention. The three main ones (public transport, active mobility and car fleet decarbonisation) are each present in at least about 50% of the reporting cities. Only 26 cities did not target any of those three categories, whereas 109 cities included at least 1 of the three, 163 included 2, and 26 included all three. A further 15 categories can be distinguished, each representative of a smaller number of cities (from 6 to 30), which potentially may have a strategic contribution to reaching climate neutrality for urban transport. It should be noted that cities were limited to a maximum of 3 interventions, which may imply that they may be considering upscaling also other interventions that could not be reported. Assuming that the selections of each city were ranked based on their potential scalability and/or impact on total GHG emissions, it is probable that for several of these categories there is a certain under-reporting. Nevertheless, the frequency statistics still give a fairly good picture of the priorities of the cities and of the scalable interventions that they expect to have an impact by 2030.

Figure 31 visualizes the connections between scalable measure categories for the cities that reported at least one intervention. It is obvious that the 3 most reported categories have a central role in most policy measure packages implemented by cities, but there is still a large number of combinations that involve less frequent approaches.

Figure 31. Network diagram of transport measure packages



Source: Own work

6.1 Public transport

Public transport is the most frequent category among scalable interventions, addressed by 185 cities. This is not surprising as public transport lies within the competence of local authorities and is vital for a city's functioning. Public transport has the potential of attracting demand from car passengers and also – in many cities where conventional buses are used - is itself a sector where emissions can be cut. Three main groups of cities can be identified: those exploring ways to improve the attractiveness of public transport services, those focusing on greening the public transport fleets and those combining the two approaches.

a. Extend/ improve public transport services

The most numerous group of cities, 81, identified the extension and/or improvement of public transport services as an intervention that can be scaled up by 2030 towards climate neutrality. This group is heterogeneous and includes different city sizes and a wide range of existing public transport levels of service.

Larger cities tend to explore solutions based on subways, light train or tram improvements, aiming at high capacity public transport systems that can substitute private cars. In some cases the public transport network is already highly developed and dense, but extending coverage or improving accessibility can still contribute to increasing the modal share. The concept of BRT (Bus Rapid Transit) is also frequently mentioned, with at least 10 cities identifying it as a scalable solution. Innovation on the service type is seen also in relation to on-demand services including demand responsive systems. Land modes are not the only option explored; at least two cities are planning lake public transport systems using zero-emission fast ferries. Since most of those interventions are still at pilot or small-scale implementation, few cities expressed concrete targets for scaling up. Depending on the city size and the scale of the transport system improvement, the investment needs may be of a considerable magnitude.

b. Greening of public transport fleets

The second major group of scalable interventions addressing public transport through the improvement of the environmental performance of the fleet includes 76 cities. While electrification is the main option considered

(42 cities), it is interesting that many cities leave the technological choice open or have opted for other alternative technologies. Four cities are exploring the wider adoption of (bio)gas for public transport, while there is also a case of exploring hydrogen as an emerging alternative. Nevertheless, it is more frequent for cities to explore more than one alternative. Nine cities are testing electrification combined with hydrogen initiatives, 5 cities electrification combined with (bio)gas, and 1 aims to combine the three. On the other hand, there are 14 cities that, while exploring how to green their public transport system, do not specify the technology to apply.

c. Improvement of public transport services combined with greening of fleets

A considerable number of cities, 26, opt for both approaches simultaneously, by extending services and improving the environmental footprint of the public transport system at the same time. There are again various combinations of improvements and alternative technologies. Sixteen (16) cities will extend services and aim for the electrification of the system, while 10 cities also consider hydrogen and/or (bio)gas.

6.2 Active mobility

Scalable interventions addressing active mobility are reported by 171 cities. Most aim to improve cycling and walking infrastructure, primarily by extending the length and coverage of the networks for bicycles and pedestrians. In several cases, infrastructure improvement includes measures on bicycle storage, user safety, accessibility, as well as showering and changing facilities. Educational and awareness raising activities to promote active mobility also have an important role.

The Covid-19 pandemic triggered an increase in active mobility in most European cities and initiatives that started during that period are often continued or scaled-up. The investments and targets for active mobility vary significantly, depending on the local urban area characteristics (topography, extension), the current share of active modes, and the expected investments in infrastructure.

The combination of extending active mobility and implementing car free zones is an instrument explored by several other cities of different sizes. In some cases, the promotion of active mobility is an element of a wider urban design reconsideration, such as the 15-minute city, superblocks, or traffic islands. New ways of motivating active mobility users are also emerging, for example gamification. Such systems consist of smart applications that provide incentives ("nudges") to cyclists or users of other sustainable modes. Points can be accumulated towards small, non-monetary prizes or to achieve "badges" or "levels". An individual can compare their performance against that of other users. As in many video-games or apps, such game-reminiscent incentives can have an impact on user engagement also for active transport and micro-mobility.

6.3 Car fleet decarbonisation

The decarbonisation of passenger cars is explored through scalable interventions in 158 cities, with a wide diversity as regards the approach chosen. Two main approaches can be distinguished, one ensuring that charging infrastructure for alternative technologies is available and one based on applying regulatory measures that limit the access to conventional vehicles.

Following the first approach, 100 cities are focusing on the provision of public charging stations for electric vehicles.

Additionally to the ones investing in recharging infrastructure, a considerable number of cities (41) is implementing low/zero emission zones. Cities with successful pilot applications are considering the expansion of the area with access restrictions in order to accelerate the shift to alternative technologies and/or the shift to public transport and active mobility. In certain cases, national legislation allowing the implementation of zero emission zones is still needed.

Apart from infrastructure and access controls, incentives also appear as scalable interventions.

6.4 Last mile logistics

Scalable interventions addressing last mile logistics, solutions to decarbonize freight transport and distribution within the city limits, are reported by 27 cities. The measures explored include testing the use of cargo- or e-cargo bikes, the development of logistics hubs/consolidation centres, or the avoidance of freight traffic in the urban area.

The use of cargo bikes is still at experimental/pilot stage as cities aim to find solutions that meet the industry's needs while exploring possible regulatory issues.

The creation of logistics hubs/consolidation centres that will allow the trans-shipment to carbon-free last mile distribution is also a popular option, explored by 14 cities. In addition, several cities explore access restrictions, constituting zero emission zones for distribution.

6.5 Other categories of scalable interventions

Several of the reported scalable interventions can be grouped into smaller categories.

Mobility hubs provide a focal point in the transport network that seamlessly integrates different modes of transport and multimodal supportive infrastructure, and turns spaces into places. They are designed and spatially organised so as to facilitate access to transport modes and easy transfer between modes, from rail, to buses, shared cars, shared bikes, and/or shared electric scooters, ride-hailing/shared taxis.

While not one of the main categories of scalable interventions, mobility hubs are implemented or planned in 30 cities with different profiles. They usually consist of physical spaces where different (shared) mobility services meet so they can be easily combined by travellers.

Shared micro-mobility solutions are often seen as a way to reduce car dependency. Such solutions appear in the scalable interventions presented by 28 cities, in most cases accompanying measures in other categories.

Mobility as a Service (Maas) applications are being explored by 26 cities. While there is some degree of overlap with measures in other categories, such as active mobility, the measures in this group specifically address the technological part of MaaS and often develop city-managed apps that allow renting or sharing of vehicles and micro-mobility solutions.

Parking policy approaches are presented by 26 cities. Half of the interventions (13) correspond to applications of park&ride, with the main goal of stimulating the use of public transport and the avoidance of car traffic in city centres. In other cities, measures involving parking pricing schemes and/or parking duration limitations are used to discourage car use. Smart parking applications – aimed at optimizing the use of the available parking space and avoid unnecessary car use - are also present.

The exploitation of new sources of data and the increased digitalisation of urban traffic management systems are addressed by 20 cities. Specific applications include centralized control systems for traffic lights in order to reduce wait times and traffic emissions, real time data and information platforms, large scale Internet of Things (IoT) platforms, Digital Twins, and real time transport models.

Interventions to improve public transport integration are reported by 20 cities, while 10 cities explore multi-modal ticketing. Such interventions aim at increasing inter-modality, with public transport having a stronger role in the transport chain. The approaches used can be further grouped as regulatory or technological. Urban planning as a means for the reduction of transport demand is explored by 20 cities, an additional 17 cities are developing Sustainable Urban Mobility Plans (SUMP) and 6 cities are using traffic calming approaches.

Car sharing is promoted in 10 cities. Another 20 cities have started adapting their municipal fleets, while 7 cities are engaging in awareness raising to – for example - promote the use of cycling or sustainable transport behaviour. Finally, a few cities also address air transport, either in terms of urban air mobility or in terms of providing green aviation fuel for commercial use.

6.6 Challenges for urban transport policy

While the technology and the cities' political willingness to achieve carbon neutrality in transport appear to be already in place, the data from the expressions of interest suggest that there are still important barriers and concerns. The main obstacle is the high investment cost for the transformation of the urban transport system. Even though progress has already been made, the conversion of the full urban transport system to climate neutral options will still require important financial resources. The potential impact on user mobility is also a concern. Urban transport policy needs to ensure that all segments of the population will have access to transport services, public or private, at a cost that should not be considerably higher than currently.

The analysis of the scalable interventions suggested by the cities implies that a combination of technological, demand management (including modal shift), planning, regulatory or digitalisation interventions is needed for the transition to climate neutrality. The candidate cities have been exploring options across different types of interventions, but there are only rare examples of cities having already advanced sufficiently in a holistic approach. Notably:

- On the **technological aspects**, it appears that for the majority of the cities it is clear that conventional cars, buses and trucks should be eventually substituted by carbon-neutral alternatives. Electric cars seem to be the most promising alternative for private passenger transport, but other alternatives are also often considered as substitutes for public and freight transport, especially (bio)gas and hydrogen. The challenge for cities is to gradually put in place the infrastructure that would be needed - especially in terms of charging stations - and to convert public transport vehicles. Both tasks require significant investment, a main barrier by itself. Additionally, the uncertainty as regards the future uptake of emerging technological options (i.e. electricity, hydrogen, etc.) makes planning and budgeting even more complex.
- While technology has a seemingly central role, the decarbonisation of urban transport for the majority of the candidate cities has a strong element of **demand management**. A shift from passenger cars to public transport, walking, cycling and emerging concepts such as micro-mobility and Mobility as a Service (MaaS) can lead to drastic reductions in emissions and also ensure that accessible mobility options are available for users who cannot or do not want to adopt the shift to emerging car technologies. Options to reduce the need for trip generation are also frequently mentioned, especially through substituting the need for travel with the digitalisation of services, encouragement of remote work or online shopping.
- **Urban planning** can also be a decisive factor for the decarbonisation of urban transport. Interventions that influence how daily activities in a city are spatially organised have a strong impact on mobility choices. Returning public space to the use of pedestrians, implementing new concepts such as the 15 minute city or superblocks, creating mobility hubs that facilitate inter-modality, are all becoming part of the cities' toolboxes for achieving carbon neutrality.
- **Regulations** can have a direct impact on urban transport emissions, either in terms of the type of vehicles that are allowed to circulate, or in terms of which parts of the city they can access. Low Emission Zones or Car Free areas can be used for the avoidance of traffic based on fossil fuels, or for all car traffic in general, thus minimizing emissions from transport within their area of application. Nevertheless, such initiatives need to be accompanied by alternatives given to the users who would no longer be in the position to use their vehicles.
- **Digitalization** is often complementary to the other strategies followed. The growing new sources of mobility and user activity data, the improved monitoring systems and models, and the ubiquitous presence of smartphones are seen by many cities as an opportunity to optimize their transport and traffic management systems, identify solutions in real time and interact directly with the users. Such applications can increase the efficiency of the transport system – especially the public one - and remove a significant part of transport activity and emissions.

The experiences of the candidate cities indicate that there is a need to combine various types of measures in order to make progress towards climate neutrality in urban transport. Apart from the resource and overall planning constraints involved, an additional challenge is that different approaches may be required for each measure, often involving additional stakeholders with varying priorities. For example, establishing a Low Emissions Zone should be preferably accompanied by the wide availability of recharging stations (in order for users willing to shift to electric vehicles to have access to infrastructure), the expansion of public transport services (to allow the shift from the replaced car use) and the introduction of green last mile solutions. Different stakeholders from both the public and private domain would need to be coordinated: electricity providers, public transport operators, monitoring/policing services, retailers and distributors.

Cities often do not have the control of the transport providers within their area. Public transport providers - even when they are fully public organisations - may be managed or coordinated at a different administrative level, e.g. regional or metropolitan. Taxis and providers of Mobility as a Service/micro-mobility solutions are in principle private enterprises. Data which can be useful for city management is often collected by private companies for commercial purposes. As a result, cities may be limited in terms of the leverage they have to implement solutions that require the commitment of other stakeholders that need to be involved. In addition, a city may not dispose of the legislative power to apply a specific measure. For example, national level legislation is necessary for the establishment of Low Emission Zones in Denmark and Latvia. The rules concerning the operation of ride hailing or of electric scooters are still in a grey zone between national and local regulations in several EU Member States. Both aspects, stakeholder control and legislative power, are further accentuated when transport issues have to be addressed as a package involving other sectors, for example renewable energy. Additional external stakeholders would be involved in the case of distribution of alternative fuels, while the city's options would need to be aligned to the corresponding national or EU legislation.

Cities also lack control over the technological trends and the market uptake of the emerging options. It is probably impossible for a city to identify with certainty which technologies will be mature and affordable for them to be widely adopted by users in the time horizon the cities invest for (next 20-30 years). Even though urban transport as a market segment is a crucial factor for the technological development of the whole (land) transport system, cities – on an individual level - do not have the power to select the 'winning technology' that can lead to climate neutrality.

Perhaps as a result of the above limitations, the majority of cities is currently exploring options starting small, within the domains they control. Cities with a public transport system owned or managed by the local authority have bigger room for testing electric, (bio)gas or hydrogen buses, for extending tram and metro networks, or for improving the quality of service of their public transport system in general. Several cities use their municipal fleets, which include waste disposal vehicles, municipal police cars or maintenance trucks as a test bed for alternative fuels. Their plan is probably to demonstrate the applicability of the new concepts and develop the basic infrastructure for fuel/electricity distribution, before embarking into a wider implementation. Another purpose could be setting and showcasing examples for citizens and other stakeholders, based on which a larger ecosystem can be developed without the direct responsibility of the city.

Even when the direct contribution of the city to the uptake of new transport technologies is limited by other market powers, there are still potential benefits from raising user awareness and increasing citizen involvement. The goal of many cities is to stimulate more sustainable choices for all citizen activities, not only for mobility. In that sense, sustainable urban transport can be seen as part of a wider approach that can influence the whole lifestyle and promote changes in behaviour. The choice of an electric vehicle, the use of public transport, walking and cycling can all also influence user choices on e.g. recycling or residential heating. A few cities also gave examples of how involving citizens in the prioritization of measures and the design of mobility solutions can help in identifying interventions that enjoy a higher level of citizen approval.

Local conditions and preferences play a significant role in the selection and success of measures for urban transport. The city size and density affect the intensity of mobility problems, but can also be a factor for increasing the options available. Larger cities may have a higher transport intensity, but also benefit from economies of scale that allow the development of extensive public transport networks, or larger budgets for investment in infrastructure. More compact cities need fewer cars, but may not be able to count on residents having private electricity charging points. The existing situation and the progress made so far can create certain path dependencies or limit the options for a radical change in the transport system. Climate and topography can also affect user preferences and limit the available options, for example for walking and cycling. Several cities also expressed their concerns as regards the affordability and accessibility of their transport systems. Especially in the case of the shift to electric cars, the resulting purchase and usage cost for the citizen is seen as a potential barrier.

Even though it had extremely negative impacts for the society, the Covid-19 pandemic may have had a positive side effect in terms of sustainable mobility. The spike in active mobility during the pandemic and the measures adopted in many cities to accommodate it have strengthened the perception of walking, cycling and other micro-mobility solutions as modes that the cities should actually promote. The increased frequency of remote work has partially alleviated the pressure on the transport system and flexible workplace schemes are increasingly seen as an element of transport policy and overall urban planning.

Finally, it is worth noting that most measures towards climate neutrality for urban transport have significant co-benefits from the transport/urban planning point of view (e.g. reduced pollution and congestion) or for society as a whole (e.g. health benefits from walking and cycling). Such benefits are easier for users to perceive directly, rather than the longer term benefits from the climate change perspective, and can potentially contribute to increasing user acceptability and justifying public investment.

7 Case studies

We use a combination of data sources that allow quite detailed insights as regards the changes in mobility patterns triggered by the Covid-19 pandemic and their repercussions on the evolution – observed and expected - on urban road congestion levels:

- TomTom congestion indicators on a daily level for 178 cities in the EU, from 2019 to 2022
- Apple: Data show relative volume of directions requests per country/region or city compared to a baseline volume on January 13th, 2020. Three indicators are provided on driving, public transport and walking activity for 40 of the above cities, from January 2020 to April 2022.
- Google mobility indicators for workplace, retail and other activities for the same 40 cities, from January 2020 to October 2022
- An extensive Travel Survey carried out in 20 EU cities during the 2nd quarter of 2021, which explores the reasons for and the degree to which the 10 000 respondents changed lifestyles and mobility patterns as a consequence of the pandemic (Panayotis Christidis et al., 2022)

Depending on the specific data source, each indicator has its own explicatory value and representativeness. The evolution of each indicator varies considerably depending on the local conditions in each city, but the large number of cities covered and the long period for which observations are available do allow a number of patterns to be identified. The approach followed here uses exploratory, statistical and modelling techniques to identify the main correlations and derive the underlying trends for congestion levels, car use, public transport use, remote work and retailing. A subset of 40 European cities (Table 10) were separately analyzed aiming to draw conclusions about the new mobility trends in the post-pandemic European urban context. In this analysis, four indicators have been considered: (1) the average daily congestion in each city provided by TomTom; (2) the driving index provided by Apple; (3) the workplaces index provided by Google and (4) the retail and recreation index provided by Google. Among these 40 cities, the 18 cities that are also encompassed in the geographical coverage of the EU travel survey are underlined.

Table 10. List of European cities included in the case study.

Austria	• Graz • Vienna	Italy	• Bologna • Catania • Milan • Rome
Belgium	• Brussels • Charleroi		
Czechia	• Brno • Prague	Netherlands	• Groningen • Eindhoven
Denmark	• Copenhagen	Poland	• Krakow • Poznan
Estonia	• Tallinn		
Finland	• Helsinki	Portugal	• Lisbon • Porto
France	• Grenoble • Lille • Paris	Romania	• Bucharest
Germany	• Berlin • Bremen • Cologne • Dresden • Munich	Spain	• Madrid • Alicante • Barcelona • Malaga • Seville
Greece	• Athens	Sweden	• Malmo • Stockholm • Gotheburg
Hungary	• Budapest		
Ireland	• Cork • Dublin		

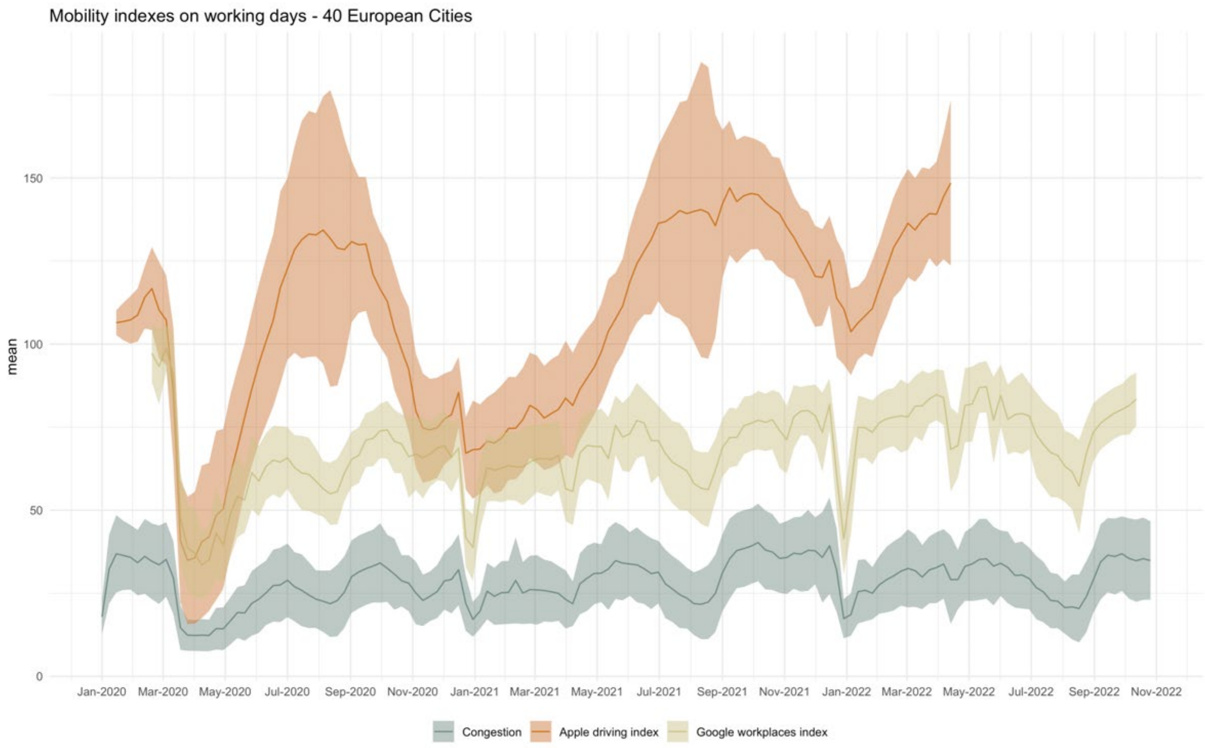
7.1 Mobility during working days

Figure 32 shows the evolution of the weekly average for the congestion parameter, the workplace and the driving index, considering only working days (Monday to Friday). These indexes have been simultaneously analyzed to understand the changes that might have occurred regarding the relationships between congestion, car use and commuting trips after the start of COVID-19 pandemic.

It can be observed that the evolution of affluence to workplaces and the congestion are to a large extent coupled. This joint behavior shows that the reduction of the number of trips to workplaces, probably through the implementation of teleworking, is a good strategy to reduce congestion, as it eliminates the need of travelling during peak hours for a large number of workers. After the first set of restrictions, affluence to workplaces and congestion seem to remain fairly stable until the present moment, leaving out the effect of the Christmas and summer holidays, with respect to the baseline.

On the other hand, the behavior of the driving index seems to follow a different trend. During the first lockdowns, between March and May 2020, it drops as much as the workplace indexes. However, as soon as the restrictions started to be lifted the driving index suffered a drastic increase, that was considerably higher than the increase observed for congestion and workplace affluence, suggesting that a large share of the trips during this post-lockdown period were done by car. In general, a higher level of flexibility regarding in-person working regimes is associated with an increased car use. This means that the reduction in congestion that was mentioned before is achieved at the cost of an increase share in car use, given that the possibility of deciding whether to travel to the workplace or when to travel to and from the workplaces increases the competitiveness of the car with respect to public transport. It is also noteworthy the large variability across the cities during the summer months probably due to the differences between tourist sending and attracting cities. When the second wave of restrictions (around April 2021) started to be lifted, the evolution of the driving index shows that the share of car use achieves levels well above the baseline and maintains this trend until the end of the series, with the only exception of the reduction associated with the Christmas holidays of 2021.

Figure 32. Evolution of the weekly average of mobility indexes for working days in 40 European cities



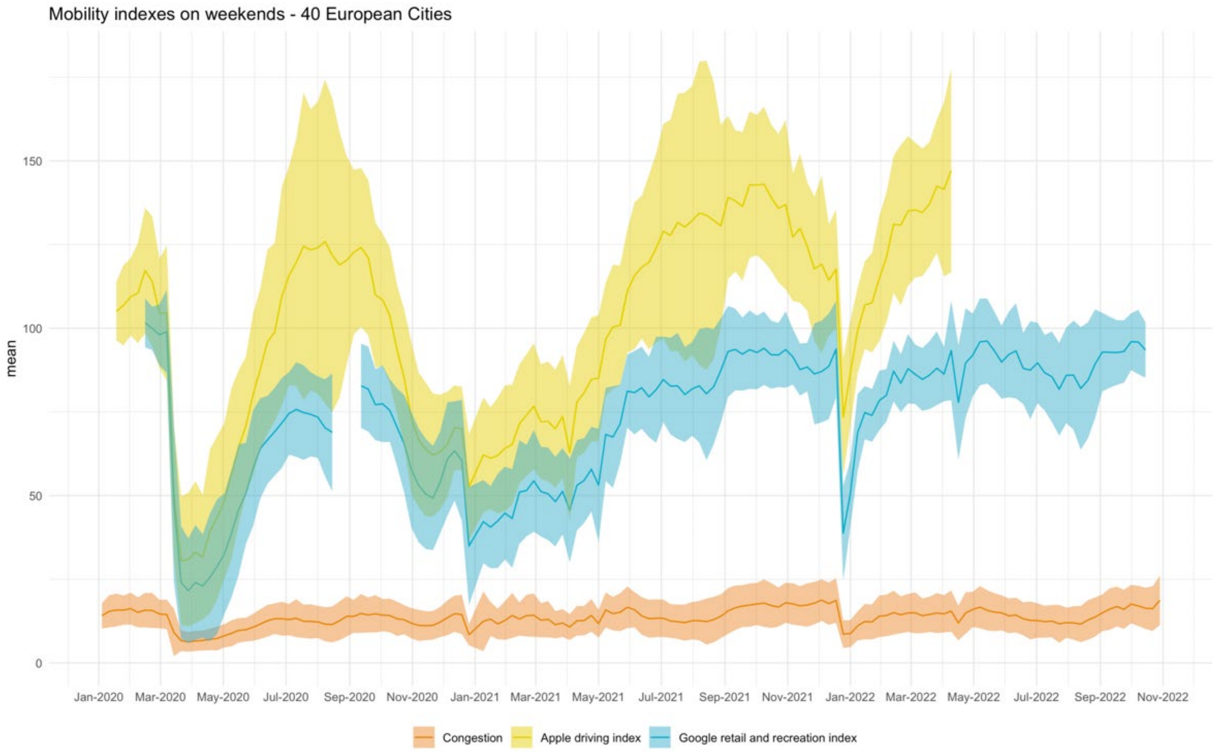
Source: Own work using TomTom, Apple and Google data

7.2 Mobility during weekends

Figure 33 shows the evolution of the weekend average for the congestion parameter, the retail and recreation and the driving index. In this case, the congestion remains low and independent from the other two indexes, as expected for weekend days.

After the initial drop for all the three indexes during the first lockdowns, the relationship between the driving and the retail indexes displays a very similar behavior to the one that was observed in Figure 32. The use of car increases disproportionately in weekends with respect to the retail index, which is reasonable given that there are many other purposes than can motivate mobility during weekends. During the second wave of restrictions (approximately between October 2020 and May 2021), the driving and recreation indexes evolve following a somehow similar pattern, showing that during the hardest periods of restrictions most of the car mobility during weekends was for leisure purposes. As the restrictions were lifted this coupled behavior of the two indexes seems to weaken and car use increases significantly more than the Google recreation index.

Figure 33. Evolution of the weekend average of mobility indexes for weekend days in 40 European cities



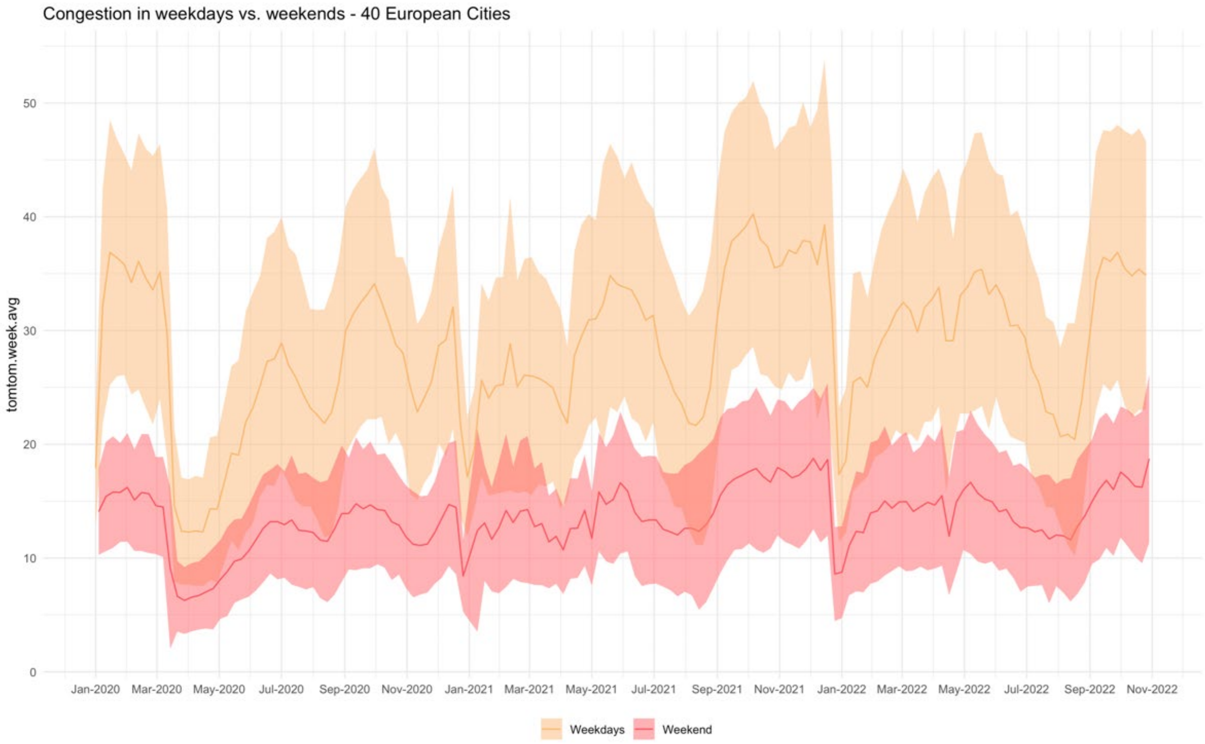
Source: Own work using TomTom, Apple and Google data

7.3 The evolution of congestion on working days vs. weekends

Figure 34 shows the evolution of the weekly average congestion for working days and weekends. The trends are very similar for both types of days, with the trend changes for weekend days being somewhat smoother than in working days.

Both for working and weekend days, weekly average congestion since the advent of the COVID-19 remains below pre-COVID levels, except for the last term of 2021, when the average congestion level peaks. At this point, the vaccination rates in Europe were already high and daily life seemed to be going back to normal after the summer, which probably created a rebound effect that led to an increase in congestion during these months. At the present moment, the data shows that congestion levels for both working and weekend days are very similar to those before the onset of the pandemic for the 40 European cities considered in this case study.

Figure 34. Evolution of the average congestion for working and weekend days in 40 European cities.



Source: Own work using TomTom, Apple and Google data

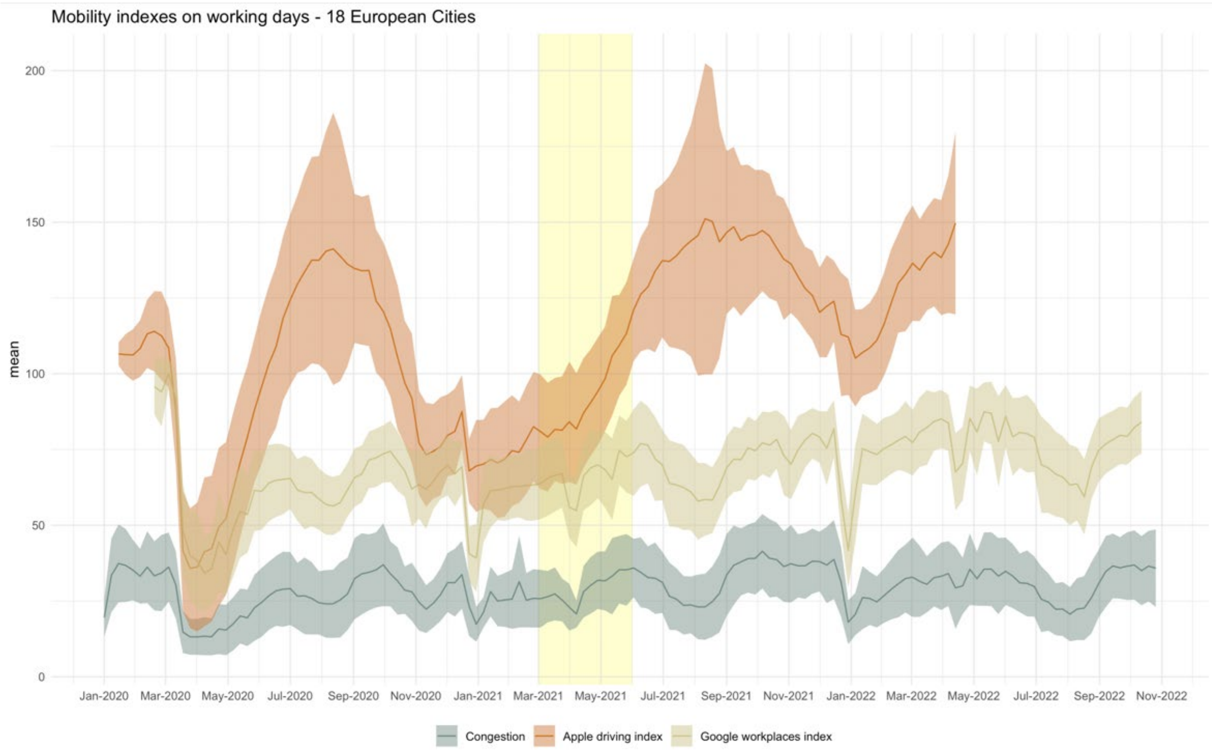
7.4 Focus on 18 cities in EU travel survey

Finally, the weekly average of the mobility indicators for working days for the 18 cities included in the EU travel survey (see underlined cities in Table 10) have been analyzed in order to compare the evolution of the aggregated trends with those observed at the individual level. The evolution of the indicators is displayed in Figure 35.

During the period in which the survey was carried out, the second wave of mobility and sanitary restrictions had just been lifted and mobility was slowly recovering. This is reflected in the behavior of the indicators, since an upward trend for all the three indicators considered can be observed. As in the previous case studies, the positive trend is stronger for the driving index than for the affluence to workplaces index. In fact, both driving and congestion rates reach pre-pandemic levels around May 2021. As for the workplace index, although it is slowly increasing at the time of the survey, its recovery is more contained.

The analysis of these indicators supports the main conclusions that were drawn from the survey's study in the 18 cities. The widespread adoption of teleworking induced by the pandemic has led to a decline in workplace presence with respect to pre-COVID levels with the consequent reduction in the number of commuting trips. However, by the time the survey was carried out, affluence to workplaces was experiencing a slow recover, as mobility and sanitary restrictions were being lifted. Unfortunately, the reduction in workplace presence has not been linked to a reduction in car use nor congestion, which are at baseline level or even higher than before the pandemic. Taking into account the results obtained from the survey this increase is most likely due to a modal shift from public transport and other shared modes to the private car, as well as the adoption of the private car for purposes different than reaching the place of work.

Figure 35. Evolution of the weekly average of mobility indexes for working days in the 18 European cities included in the EU Travel Survey.



Source: Own work using TomTom, Apple and Google data

8 Conclusions

The Covid-19 pandemic triggered significant changes in lifestyles and mobility patterns which are still evident at the end of 2022 and may still raise challenges for transport policy in the short to medium term. While changes in lifestyles - mainly as regards work patterns - have decreased total urban transport activity, the gradual return to pre-pandemic levels suggests that traffic and congestion levels may soon exceed their 2019 levels. Apart from the question of total transport activity, the trends identified in this report can influence modal choice and trip distances, with possible negative repercussions in terms of transport costs, congestion and emissions. Three main challenges are identified:

- Increased dependence on cars for daily urban mobility: the low perceived risk of contagion and the increasing car ownership levels contribute to maintaining high levels of private car trip demand and to attracting potential users of other, more sustainable modes and business models. The pandemic accelerated car-purchasing decisions, increasing total car ownership and decreasing the average age of car users.

- Risks for public transport due to the fall in demand: the – perhaps temporary - risk aversion towards shared modes of transport may cause financial problems for a large number of operators. It can be challenging to maintain the same level of service, which is necessary in order for operators not to lose additional market share.

- Impact on innovation: the fall in demand, the shift from shared to private alternatives and the overall uncertainty in terms of the evolution of economic activity may challenge the future of emerging technologies and business models such as micro-mobility or Mobility-as-a-Service (MaaS), which could potentially deliver more sustainable options for urban mobility.

On the positive side, the pandemic also led to a shift to active mobility, especially in urban areas. The increased willingness of residents to cycle or walk, combined with many cities improving their cycling or pedestrian infrastructure, can maintain or increase the share of active mobility in short trips in the longer term. The shift to active mobility, however, also affects other modes, especially public transport.

In terms of the measures taken at city level, there are numerous examples of cities combining the introduction of new technologies, such as the provision of recharging infrastructure, with the promotion of public transport and active mobility to reduce car dependency. Urban planning solutions, such as extending the pedestrian areas, or applying emerging concepts like the 15 minute city or mega-blocks, can influence mobility patterns and contribute to the reduction of transport activities and emissions.

Interventions in urban transport can be more successful if coordinated with a wider range of stakeholders and providers (e.g. transport operators, energy distributors). It is also important to take the potential limitations of a city's legislative power into account and actively involve institutions at the required administrative level (e.g. metropolitan or regional authority). New governance structures may be necessary in order to manage the path to decarbonisation.

Given the diversity of city profiles and needs, there is not a single solution that is applicable to all urban transport systems (i.e. no 'one size fits all'). Starting with small scale solutions that are suitable to the local conditions can be a first step before scaling up to more ambitious or challenging options. The indirect benefits of decarbonizing urban transport, especially as regards congestion, air quality and health should be included in the evaluation of the interventions that target climate neutrality.

New sources of data for transport (e.g. Internet of Things, sensors, mobile phones, social network data) can provide useful information for activity and mobility patterns that can be used for the optimization of urban transport management.

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List of abbreviations and definitions

AUC	Area Under the Curve
BRT	Bus Rapid Transit
EU	European Union
EV	Electric Vehicle
FUA	Functional Urban Area
GHG	Greenhouse Gas
IoT	Internet of Things
JRC	Joint Research Centre
MaaS	Mobility as a Service
MS	Member State
PT	Public Transport

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