10 Public urban transport in the face of the Covid-19 pandemic

Current trends, technological opportunities, and social challenges

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Introduction

The Covid-19 pandemic significantly reshaped mobility demand, altering travel behaviors at individual and community levels. As the virus spread in 2019 and 2020, ridership across all transport modes declined, with public transport experiencing the steepest drop (Tirachini & Cats, 2020). Fear of contamination and restrictive policies led to a shift toward private cars and active mobility (Beck & Hensher, 2020). Moreover, elevated public transport costs due to hygiene measures and reduced demand strained agency finances (Bucsky, 2020). It raised doubts about advancing policies aimed at reducing car dependency and promoting public transport (Abdullah et al., 2020).

At the same time, safety concerns prompted the rapid adoption of remote work and education, transforming traditional work dynamics and complicating mobility demand forecasting (Christidis et al., 2022). Furthermore, the pandemic broadened the Overton window for flexible public transport services and the expansion of cycling and pedestrian infrastructure (Marsden et al., 2020). This presented a unique opportunity to convert these interventions into lasting policies (ITF, 2023).

To explore the consequences of these opposing trends, the following section examines the current demand for car and mass transit travel in the V4 countries. The next part of the chapter delves into technological trends that could steer this recovery process toward a more sustainable direction. The final section discusses potential social challenges that may hinder the adoption of these innovations or, if widely implemented, exacerbate social inequalities in access to transport and other services.

The analysis presented here considers the international context with close attention to the V4 countries. It also utilizes data collected in two Polish agglomerations, Poznań and Tricity [Pol. *Trójmiasto*], during the project 'Travel behaviour in Polish cities: causality, behavioural changes, and climate impacts' (funded by the Polish National Centre for Science, grant agreement No. 2020/37/B/HS4/03931).

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Post-Covid-19 recovery of car and public transport travels in cities

The impact of Covid-19 pandemic on urban mobility in the V4 countries

In Czechia, mobility reductions during the pandemic were profound, particularly in urban centers like Brno and Prague. For instance, mobility in Brno dropped by 60–70% within seven days after the initial outbreak. Similarly, the Prague metro network experienced an 80% reduction in passengers during the same timeframe. Data from March 2021 indicated a 63% year-on-year decline in urban bus and tram usage. Public transport usage in Prague fell globally by 64.8% compared to pre-pandemic levels, reflecting a consistent reduction across all modes of transport (Fridrisek & Janos, 2022).

In Hungary, the pandemic's impact on mobility was similarly severe but manifested differently. For instance, mobility in Budapest dropped between 51% and 64% in March 2020, reflecting substantial shifts in travel behavior (Bucsky, 2020). Also, public transport in Budapest showed a performance decline ranging from 33% to 40% (Christidis et al., 2023), while ticket sales decreased by an extraordinary 90%. Bicycle traffic, however, increased by 13%, signaling a shift toward alternative travel modes. Notably, while public transport ridership dropped by 80%, bike ridership only declined by 23%, and bike-sharing services experienced a marginal 2% decrease (Bucsky, 2020).

Slovakia also experienced significant reductions in mobility during the pandemic. From March to June 2020, urban public transport saw an average decline of 40% in bus services and 56% across the entire public transport sector. Cities like Žilina recorded a 36% decrease in urban transport ridership in 2020 compared to 2019. Revenue from public transport in Žilina decreased by 30%, exacerbated by reduced ridership and the costs of implementing safety measures. Recovery has been uneven. After a brief resurgence in summer 2020, when ridership in cities like Žilina rose by 53%, subsequent pandemic waves caused additional, albeit smaller, declines (Majerčák et al., 2023).

In Poland, the Covid-19 pandemic led to a significant decrease in both private cars and public transport ridership. Both the number of passengers and ticket revenues dropped by several dozen percent. For instance, in March 2020, the number of passengers using public transport in Warsaw fell by 80%, while in April, ticket sales dropped by 92% (Bryniarska & Kuza, 2021). A case study focusing on 17 Polish regional cities observed that the reduction in public transport ridership varied over time and was closely linked to the dynamics of the pandemic in each city (Zajfert, 2024).

Post-Covid-19 recovery of urban transport in the international context

Despite differences in methods analyzing the Covid-19's impact on urban mobility, some trends are consistent. After more than a year of the pandemic, mass vaccination campaigns and the end of the third wave of infections (from

June 2021 onward) reduced the psychological impact of COVID-19 on residents' commuting behaviors (Zajfert, 2024). Consequently, there was an uptick in public transport usage, accompanied by a gradual recovery in private car utilization.

By 2022, global vehicle-miles traveled and traditional peak commuting times had rebounded, with traffic congestion nearing 2019 levels (Christidis et al., 2023). Despite ongoing disruptions such as rising oil prices and inflation, travel behavior largely normalized. According to calculations by Christidis et al. (2023) based on the TomTom Traffic Index, congestion surpassed pre-pandemic levels in some European cities, though these cases remain exceptions rather than the norm (Figure 10.1). Additionally, the prevailing traffic

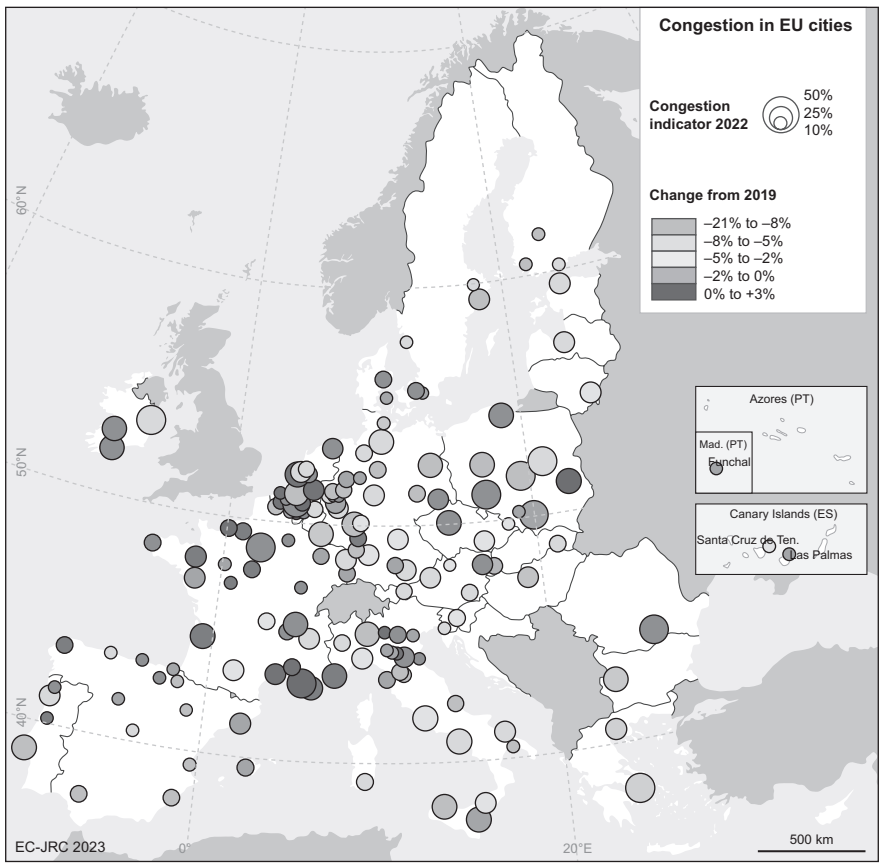

Figure 10.1 Urban road congestion levels in the EU based on the TomTom data, change 2019–2022.

Source: Christidis et al., 2023. The congestion indicator compares travel times during non-congested periods (free flow) with travel times in peak hours. The difference is expressed as a percentage increase in travel time. More: TomTom, 2024.

and demand structure highlights the continued dominance of private cars, with other transport modes playing a supporting role.

Despite car domination, there has also been a noticeable recovery in demand for public transport services across the world, although the return to pre-pandemic usage patterns is uneven and slower compared to congestion measures (Plotch, 2022). In general, in 2022, the demand remained approximately 20% lower than in the same period before the pandemic in V4 countries, achieving even 80–90% of pre-pandemic levels in some regions. Similar trends are observed, for instance, in the UK and in several Spanish cities (Christidis et al., 2023).

Furthermore, certain cities in the US, Europe, and Poland, including Miami, Amsterdam, Gdańsk, and Wrocław, have experienced a complete resurgence in public transport demand, with some cities reaching or surpassing pre-pandemic levels. This phenomenon can be attributed, in part, to the cities' tourist attractions, as evidenced by the case of Gdańsk (Zajfert, 2024). However, in some cases, the growth is not just a result of more passengers. It is also driven by higher sales revenues from fare hikes implemented during the pandemic to ensure the financial stability of transport systems (Figure 10.2).

This overall summary needs to be considered with several reservations. Firstly, the sales structure has undergone a shift, with one-time tickets becoming increasingly popular, indicating an increase in occasional passengers and a decrease in loyal users (Rowlands & Loh, 2023). Furthermore, the influx of migrants following the Russian-Ukrainian war in countries such as Poland has led to an increase in city populations, thereby positively affecting demand for public transport services despite the disruptions caused by the pandemic.

It is also important to note that the lower demand for public transportation is more related to fewer passenger trips than a change in transportation preferences (Rowlands & Loh, 2023). This particularly concerns regions

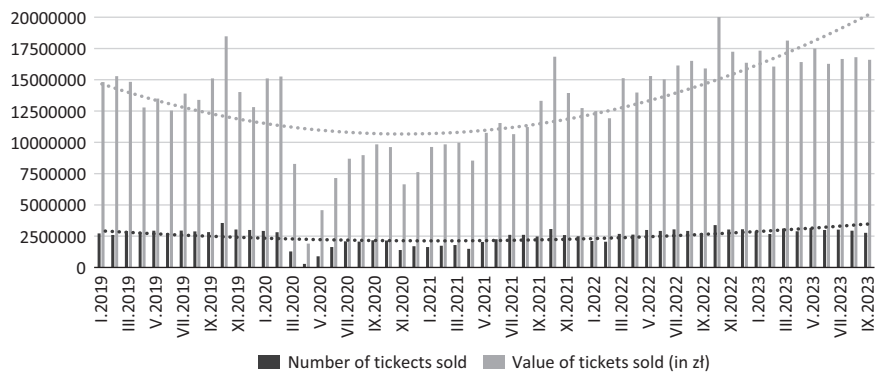

Figure 10.2 Demand for public transport tickets in Wrocław.

Source: own elaboration based on OpenData Wrocław

where office jobs, typically held by the middle class, continue to be worked remotely, while lower-paid sectors are unable to do so (Long et al., 2023). Thus, public transport demand may remain subdued as remote work persists. In the event of a full resumption of office work, two scenarios are conceivable: either a recovery in public transport demand or a permanent shift to private cars or active mobility.

Window for socio-technological opportunities

While travel behaviors are gradually returning to pre-pandemic norms, it is important to consider the potential long-term shifts in work organization, active mobility, and flexible transportation demands. These changes, initially driven by pandemic restrictions, could become ingrained habits if supported by policies and infrastructure promoting sustainable choices and adaptable systems for work and education (Lindberg et al., 2023).

Efforts to build on these shifts are essential. Pre-pandemic transport demand was seen as inefficient, highlighting the need to reduce reliance on cars. A return to pre-pandemic transport patterns should be avoided, particularly given the uncertain effects of pandemic hybrid work models, which could cause rebound effects (Rowlands & Loh, 2023). While remote work reduces daily commuting, teleworkers often switch from public transport to private cars for other trips, making environmental goals harder to achieve (Baldassa et al., 2023).

Additionally, pandemic-induced changes in commuting patterns, such as more atypical or leisure-oriented travel, have made transport needs more dynamic. Moreover, the reduced availability of public transport during the pandemic has also deepened accessibility challenges for those without private cars (Carney et al., 2022).

Bearing that in mind, experts argue that post-pandemic public transport must adapt to evolving needs through multimodal systems that offer viable car alternatives and address risks of social exclusion, particularly in underserved areas (Turbay & Firmino, 2023). Advancing flexible multimodality requires investments in digitalization and urban mobility solutions like Mobility as a Service (MaaS). MaaS integrates public and private transport services into a unified platform, enabling real-time planning, ticketing, and payments, while promoting shared mobility over private vehicle ownership (Schikofsky et al., 2020). Closely linked to MaaS, Demand Responsive Transport (DRT) offers flexible, on-demand services tailored to real-time travel patterns, addressing first-mile/last-mile connectivity and ensuring accessibility, especially in peripheral areas. During the pandemic, DRT proved effective in meeting fluctuating demands and ensuring safety through pre-booked services and contact tracing (Nelson et al., 2023).

Active mobility solutions, such as bike-sharing systems, complement these approaches by offering sustainable, low-infection-risk transport options. The pandemic spurred investments in bike infrastructure and pedestrian zones,

with many cities transitioning temporary measures into permanent networks to support active travel (Teixeira et al., 2022).

The shift in focus from mobility-centric policies to accessibility-oriented approaches was another trend during Covid-19. This paradigmatic change emphasizes the importance of spatial proximity and opens new opportunities for policies accelerating the development of mixed-use communities that minimize travel requirements (Moreno et al., 2021).

The proliferation of telework is a further significant trend that has become a pivotal strategy during the pandemic. Although possible rebound effects, the phenomenon of working from home has been identified as having significant post-Covid-19 opportunities, such as the reduction of emissions and the alleviation of traffic congestion (Thombre, 2021). Moreover, telework, facilitated by digital connectivity, has emerged as a critical option for individuals with disabilities, offering greater flexibility and inclusion (Dadashzadeh et al., 2022).

Social challenges in utilizing the new technological trends

Recent trends and emerging opportunities underscore the significance of adopting a holistic approach that integrates both physical and virtual access to foster more resilient, inclusive, and sustainable communities (Marsden et al., 2020). While these trends offer greater flexibility and have the potential to reduce congestion, emissions, and transport disadvantages, they also depend on specific skills and reliable broadband connectivity. This introduces potential equity concerns linked to the abilities of end-users.

Researchers indicate that the digitalized solutions tend to be more frequently utilized by young, employed, highly educated people, and usership is dominated by white men without children (Xin et al., 2018). Moreover, the adoption of digitalized transport or access services may pose a barrier for elderly individuals, primarily due to financial constraints and the lack of technological familiarity (Caiati et al., 2020).

Similar findings arise from a survey conducted between November 2022 and April 2023 in two Polish agglomerations: Poznań and Tricity.[1] The study assessed the level and distribution of six digital skills that are considered crucial for remote work, digital access, and, to some extent, the use of micromobility.[2] The analysis also investigated the relationship between the level of digital literacy and other relevant socioeconomic characteristics of the respondents.[3]

A separate investigation of six variables regarding digital skills indicated an overall high level of digital proficiency in the surveyed population (see Figure 10.3). However, despite the evidence suggesting that the respondents demonstrated a satisfactory level of digital proficiency, the distribution of these competencies was found to be disproportionate across various social categories. The findings revealed that younger ($\rho = -.579$, $p < .01$, $N = 1{,}203$) and better-educated ($\rho = .289$, $p < .01$, $N = 1{,}203$) respondents exhibited

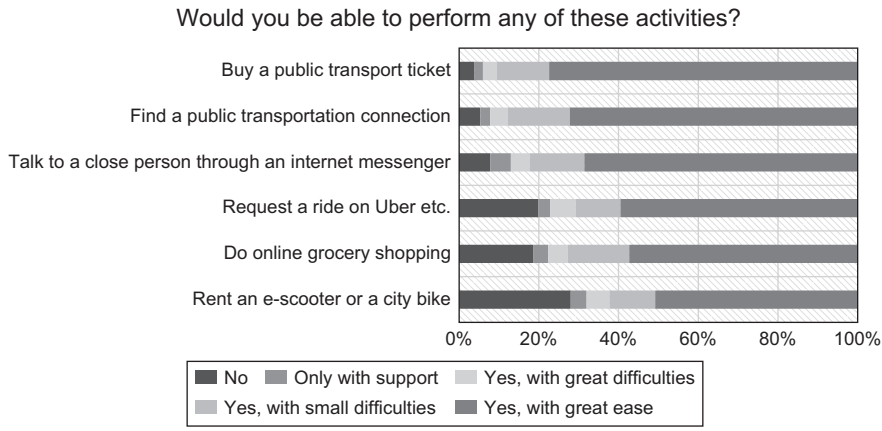

Figure 10.3 Distribution of digital skills in the sample (N = 1,203).
Source: own elaboration.

higher proficiency in these digital activities. A parallel association emerges between subjectively assessed respondents' economic situation and their digital skills: individuals reporting better financial situations also reported higher levels of digital literacy ($\rho = .272$, $p < .01$, $N = 1{,}203$). In addition, a positive correlation was demonstrated between the higher level of the competency index and the possession of a driver's licence ($r_{pb} = .441$, $p < .01$, $N = 1{,}203$).

Further inquiry, employing the competency index (the mean value of responses to questions about the six digital skills), also revealed that the differences in digital literacy significantly affect the ability of respondents to avoid exclusion from various social activities. Low-skilled respondents relatively frequently had to forgo basic activities such as shopping, meeting family or friends, engaging in leisure activities, and attending healthcare appointments (correlation between the competency index and the index of exclusion from activities due to difficulties with transport was $\rho = -.124$, $p < .01$, $N = 1{,}203$).

This effect was particularly important among people with limited access to a private car in their household. While no significant correlation was found between the competency index and the index of exclusion from activities among individuals with good access to a private car ($\rho = -.034$, $p > .05$, $N = 687$), the analysis demonstrated that low-skilled respondents without such access experienced more difficulties with reaching services than their better-skilled counterparts ($\rho = -.166$, $p < .01$, $N = 384$).

The challenges regarding low-skilled respondents were further exacerbated by differences in the perceived flexibility to choose between various modes of transport, which could help mitigate difficulties in accessing different destinations. This flexibility was significantly less prevalent among respondents with lower levels of digital literacy ($\rho = .301$, $p < .01$, $N = 1{,}203$).

Additionally, limited digital skills may impede the widespread adoption of remote work, potentially reducing exclusion from professional activities among non-car users. Among the 17.5% of respondents who reported the ability to work remotely – a figure consistent with findings from other studies (Garrote Sanchez et al., 2020) – those with higher digital competencies were significantly more likely to recognize their potential for working from home ($\rho = .149$, $p < .01$, $N = 945$[4]).

The significance of these competencies is affirmed by a linear regression model, which controlled for the effects of age, various professional activities, educational background, and economic status (Table 10.1). Although with limited power, the model showed that higher digital skills and a favorable economic situation correlate with a positive propensity to work remotely. The significant role of digital skills persists even when the model includes variables related to specific professions performed by respondents.

The implementation of digital innovations in transport and work may not only perpetuate existing inequalities but also face challenges regarding low social acceptance and entrenched mobility habits. These habits are often automatic, repetitive, and deeply embedded in individuals' routines (Chang et al., 2018). As a result, car owners may not exhibit a strong willingness to replace car travels with alternative modes of access (van't Veer et al., 2023).

Some similar results are also drawn from our study, showing that car owners who are most skilled in using digital technologies are relatively resistant to changing their transport habits. For example, they perceive limited opportunities to reduce car use, at least compared to less skilled car owners (the correlation between the competency index and the index of habituation in mobility choices was $\rho = -.252$, $p < .01$, $N = 819$[5]).

Table 10.1 Linear regression coefficients predicting the perceived ability to work remotely (model limited to respondents who declared professional activity, N = 945)

	Coef.	*95% CI*	*VIF*
Intercept	–*	–	–
Specialists and humanistic intelligence	–0.019	(–0.188–0.150)	1.997
Administrative or office worker	–0.023	(–0.168–0.122)	1.911
Manager	0.010	(–0.430–0.449)	1.093
Trade worker	–0.091*	(–0.232–0.050)	1.986
Education	–0.032	(–0.136–0.072)	1.754
Economic condition	0.102**	(0.004–0.200)	1.171
The level of competency index	0.225***	(0.186–0.264)	1.256
*p < .05; **p < .01; ***p < .001; $R^2 = 0.06$			

Source: own elaboration

Furthermore, the findings indicate that well-skilled car owners comparatively rarely consider the options offered by different modes of transportation and display a relatively high level of automaticity in driving a car or making travel choices, tending to consistently travel in the same manner. This often results in unreflective use of the car (the correlation between the competency index and the index measuring the ability to reduce the use of car was $\rho = .300$, $p < .01$, $N = 819$[2]), corresponding with trends observed in other studies.

Conclusions

This chapter explores urban mobility in the pre-post-Covid-19 period and examines available technological and organizational innovations endorsing 'digital access without mobility' based on the implementation of technological innovations in the mobility sector. These trends gained traction during the pandemic restrictions and created opportunities for substantial changes in post-pandemic transportation policies.

The analysis of the situation in the cities of the V4 countries indicates that public transport in these cities was similarly affected by the pandemic. This resulted in a significant – reaching up to several dozen percent – decline in ridership during the initial phase of Covid-19 in Poland, Czechia, Slovakia, and Hungary. Similar trends were observed in other European cities.

However, the findings presented here suggest that the pandemic may have had limited potential to alter the structure of transport demand. Despite considerable disruptions in mobility habits during the pandemic, the current use of private cars and public transportation is gradually returning to pre-pandemic patterns, with public transport usage in cities of the V4 countries and other states remaining at around 80% of its pre-pandemic levels.

The role of new technological trends in shaping the post-Covid-19 mobility patterns may also be limited. Although individuals with advanced skills perceive more favorable (though still limited) conditions for working remotely compared to their low-skilled counterparts, the patterns of behaviors associated with cars remain deeply rooted and habituated among individuals in the former category. The routine nature of transport behaviors also indicates that, despite the introduction of technological, organizational, and digital innovations in mobility, car-oriented behaviors may not shift without additional restrictions on cars.

Moreover, the study results suggest that while innovative technologies in transportation are expected to address evolving passenger needs and compensate for limitations in traditional public transport offerings, they pose the risk of reproducing social inequalities in access to goods and services. In particular, elderly and less educated individuals with limited economic resources may face barriers to accessing emerging mobility solutions within the digital-access and mobility-as-a-service models. Addressing these challenges is crucial to ensuring equitable access to the benefits of digital advancements in transportation.

Table 10.2 Distribution of basic socioeconomic characteristics of respondents

Variable	*Category*	*N*	*% of N in column*
Age	18–24	112	9.3
	25–34	184	15.4
	35–44	495	41.2
	45–64	144	12
	65+	267	22.2
Education	Primary	126	10.5
	Secondary or vocational	641	53.2
	Higher	437	36.3
Economic condition of the household	Bad	122	10.1
	Moderate	851	70.7
	Good	230	19.1
Driving licence	No	419	34,8
	Yes	784	65.2
Specialists and humanistic intelligence	No	1024	85
	Yes	181	15
Administrative or office worker	No	943	78.3
	Yes	262	21.7
Manager	No	1193	99
	Yes	12	1
Manual worker	No	892	74
	Yes	313	26
Trade worker	No	1028	85.3
	Yes	177	14.7
Flexibility in choosing mode of transport	Low	218	18.1
	Moderate	282	23.4
	High	703	58.4
Ability to work remotely	Low	829	68.9
	Moderate	163	13.5
	High	211	17.5

Source: own elaboration.

Table 10.3 Distribution of indexes utilized in the analysis

		Habituation of mobility behaviours[6]	*Exclusion from activities due to difficulties with transport*[7]	*Level of digital skills*[8]	*Ability to reduce car use*[9]
N		819	1203	1203	819
M		4.07	1.42	4.9	1.95
SD		0.87	0.67	1.35	0.75
Skewness		–0.72	1.78	–1.2	0.48
Kurtosis		–0.41	2.28	0.28	–0.43
Min		1.67	1	1	1
Max		5	4	5	4.25
Quartiles	Lower	3.33	1	3.29	1.25
	Upper	5	1.5	5	2.5

Source: own elaboration.

Table 10.4 Correlation matrix of variables utilized in the analysis

	The level of digital skills (N= 1,203)	*Habituation of mobility behaviors (N = 819)*	*Ability to reduce car use (N=819)*	*Exclusion from activities due to difficulties with transport (N = 1,203)*	*Driving licence (N = 1,203)*	*Age (N = 1,203)*	*Education (N = 1,203)*	*Economic condition (N = 1,203)*	*Flexibility in choosing mode of transport (N = 1,203)*
Habituation of mobility behaviors (N = 819)	.300**	–							
Ability to reduce car use (N = 819)	–.252**	–.401**	–						
Exclusion from activities due to difficulties with transport (N = 1,203)	–.124**	–.121**	.169**	–					
Driving licence (N = 1203)	.441**	.521**	–.483**	0.008					
Age (N = 1,203)	–.579**	0.021	0.029	0.043	–.169**	–			
Education (N = 1,203)	.289**	.170**	–.114**	–.064*	.389**	–.101**	–		
Economic condition (N = 1,203)	.272**	.116**	–0.068	–.096**	.329**	–.185**	.257**	–	
Flexibility in choosing mode of transport (N = 1,203)	.301**	.256**	–.183**	–.194**	.312**	–.060*	.195**	.210**	–
Ability to work remotely (N = 945)	.149**	–.086**	–0.063	.162**	–.135**	0,046	.144**	0.014	–0.009

*p<.05; **p<.01

Source: own elaboration.

Notes

1 The survey was administered by professional pollsters who visited households using a random route procedure with starting points distributed proportionally to residential distribution in the census area, and filled out in a Computer-Assisted Personal Interview (CAPI) setting using tablet computers. The socio-demographic characteristics of the sample were controlled to obtain a representative structure in terms of age, gender, education level, and residential location (i.e., the proportion between the core municipalities and the rest of the region). The resulting sample size included 3,847 interviews. The presented analysis uses 1,203 interviews with questions regarding skills and access to services.
2 Participants rated each skill on a scale of 1 to 5, where 1 indicated a complete lack of proficiency and 5 denoted the ability to perform the activity with great ease.
3 These characteristics were measured as single variables and complex indices. For detailed information about each variable, including the competency index, please refer to Appendices 1 and 2.
4 Correlations are only based on individuals who have declared professional activity.
5 Correlations are only based on individuals who have declared that they have at least partial access to a car within their household.
6 The mean value of responses to questions about always using the same means of transport, deciding to drive without thinking, choosing the car automatically (scale from 1 to 5, where 1 means strongly disagree, while 5 means strongly agree). Cronbach's Alpha = .77. N limited to individuals who have declared that they have at least partial access to a car within their household.
7 The mean value of responses to questions about the necessity to resign from shopping, meeting family or friends, medical appointments, and visiting recreational venues due to the lack of transport (scale from 1 to 4, where 1 means never, while 4 means many times). Cronbach's Alpha = .86.
8 The structure of this index was explained in the main text. Cronbach's Alpha = .88
9 The mean value of responses to questions about the ability to live without car, reduce the frequency of car travels, approach important destinations without car, travel by bike on a daily basis and travel by public transport on a daily basis (scale from 1 to 5, where 1 means very difficult/definitely not, while 5 means very easy/definitely yes). Cronbach's Alpha = .82. N limited to individuals who have declared that they have at least partial access to a car within their household.

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