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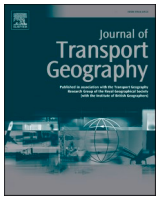

How emerging time-use patterns explain travel behaviour: A systematic review☆

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ABSTRACT

Many studies have investigated how digital engagement, new ways of working, and automated vehicles (AVs), are reshaping travel behaviour. However, their findings are frequently divergent or inconclusive. This work proposes that three emerging time-use patterns (TUPs) – multitasking, flexibility and fragmentation of activities – can help to explain the divergent results. To assess this notion, we systematically investigate the mediating role of TUPs in the relationship between digital engagement/telework/AVs and four key travel outcomes (trip frequency, travel distance, mode choice, and value of travel time). Using empirical data from 2019 to 2024, we find that TUPs can be seen as a mediator in shaping travel outcomes. For instance, when digital activities or telework increase activity fragmentation, they are associated with increased trip frequency. When digital activities or telework have been shown to increase flexibility, that has resulted in lower trip frequency. We notice that a potential reason for divergent results is that different configurations of digital engagement, telework, and AVs correspond to distinct TUPs, leading to opposite travel effects. We recommend that future studies integrate TUPs into assessments of travel behaviour change to better interpret causal relationships and address inconclusive findings.

1. Introduction

Significant changes in everyday life have emerged, driven by technological advancements, evolving policy environments, and cultural shifts. Among the many possible areas of change, this study focuses on three digital and mobility transitions (DMTs): digital engagement, new ways of working, and automated vehicle (AV) use. Digital engagement, involving online meetings, learning and shopping, is largely facilitated by Information and Communication Technology (ICT). The adoption of new ways of working, such as remote work and flexible working schemes, was accelerated by COVID-19 restrictions and cultural shifts towards greater work-life balance. AVs are prompted by advancements in driving technology and the increasing demand for safer, more efficient transportation solutions. Understanding how these DMTs[1] influence travel behaviour is essential for predicting transportation demand, informing infrastructure planning, and achieving sustainability goals transformed by these DMTs.

Despite prolific research on these three DMTs in the travel behaviour literature, many impacts remain uncertain. For example, e-shopping allows us to make purchases without travelling, but it also encourages additional trips to physical stores (Zhai et al., 2019). Telework might reduce car use for commuting; however, it can create opportunities for car use for other activities. AVs could trigger more trips with public transport by offering last-mile services (Mo et al., 2021); however, they may shift individuals towards private mobility modes.

This work explores whether changes in time-use patterns (TUPs) resulting from digital engagement, new ways of working and AVs could explain such uncertainty. That is, we examine whether emerging TUPs may act as mediators between DMTs and travel behaviour outcomes. We define TUPs as individuals' underlying time allocation characteristics for activity and travel time. Specifically, we address three emerging TUPs: **multitasking** (engaging in multiple activities simultaneously) (Circella et al., 2012; Kenyon and Lyons, 2007), **flexibility** (conducting an activity across different locations and times) (Rose, 2015), and **fragmentation** (dividing an activity into smaller time segments) (Couclelis, 2004). On the one hand, TUPs can reflect how people are

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[1] In this paper, the term "digital and mobility transitions" is used as an umbrella concept to describe the fundamental behavioural changes represented by digital engagement, new ways of working, and AVs. Other interchangeable terms could be societal transitions, etc.

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affected by DMTs. For instance, messaging apps and social media platforms enable us to do multiple activities simultaneously while frequently interrupting activities to reply to messages, leading to fragmented work/leisure time; Remote work allows employees to adjust their work schedules/places to better fit personal commitments; The autonomy provided by AVs allows users to engage in a wide variety of onboard activities. On the other hand, TUPs are inherently connected to travel-related decisions. For example, people who prefer multitasking during travel are prone to choose public transport (Arranz-Lopez and Soria-Lara, 2022) or AVs (Harb et al., 2022). Travellers with flexibility can adjust their departure times to avoid morning/evening congestion (Rahman et al., 2022). Workers with fragmented activities across different locations will likely travel more (van Lier et al., 2014).

We propose the causal link among DMTs, TUPs, and travel behaviour (see Fig. 1). Relying on this link, the role of TUPs can be explained by analysing the diverging findings mentioned above. For instance, people might travel less due to increased spatial flexibility offered by digital engagement, e.g., meeting online instead of travelling to physical locations (Mouratidis and Papagiannakis, 2021). However, they are associated with more and longer trips due to the more enjoyable trips with ICT-enabled multitasking, such as playing web games and video chatting with family and friends during travel (Varghese and Jana, 2018). To explore this proposal, we first synthesise the theoretical expectations for how DMTs influence TUPs and how TUPs influence travel behaviour based on studies addressing **Arrow 2a** and/or **Arrow 2b**. Then, we explore whether and how TUPs can explain the diverse findings of the empirical studies relevant to **Arrow 1** by reviewing empirical studies that have also measured some TUP indicators and comparing those with the theoretical expectations derived before. This approach acknowledges the critical role of TUPs in this exploratory chain, thereby enhancing the interpretational power of current empirical findings.

Our work complements several literature reviews that have studied pathways in the conceptual model. Synthesising the direct effects of DMTs on travel patterns (**Arrow 1**), Mokhtarian (2002) provides pioneering insights into the impacts of telecommunications on travel. Le et al. (2022) systematically examine the influence of online shopping on travel behaviour. Regarding new working ways and travel, Zhu and Wang (2024) provide the latest review. AVs' influence on travel has recently gained significant attention, with comprehensive reviews by Soteropoulos et al. (2019) and Rahman and Thill (2023). For the influence of DMTs on TUPs (**Arrow 2a**), Pawlak (2020) offered a systematic review of how mobile services increase multitasking. In addition, there are some conceptual studies on the impacts of TUPs on travel behaviour (Arrow 2b), but no empirical studies have been reviewed. Furthermore, no previous reviews examine the connections between **Arrow 2a** and **Arrow 2b** and compare the conclusions with empirical evidence (**Arrow 1**). Our review contributes to bridging this gap by investigating how TUPs can clarify the varied empirical findings about the impacts of DMTs on travel.

The rest of this paper is structured as follows. Section 2 outlines the methodology and reviews the state of the art of TUPs and travel behaviour. Section 3 synthesises theoretical thinking on the role of TUPs in the causal link. Section 4 summarises the empirical evidence from the three DMTs. The findings are discussed in Section 5, and key points are concluded in Section 6.

2. Methodology

2.1. Searching and analysing method

To examine the relationship among DMTs, TUPs, and travel behaviour, the literature search considers the influence of three major DMTs on travel behaviour, i.e., digital engagement, new ways of working, and AVs. Note that various emerging working patterns have been studied, including telework and its variants such as telecommuting, flexible work schemes, work from home, and hybrid work (Mokhtarian et al., 2005). For clarity and consistency, we use the unifying term "new ways of working" to encompass these variants.[2] Regarding AVs, while there are many forms of AVs, our analysis focuses on the transport impacts of privately owned AVs. Three emerging TUPs are addressed: multitasking, flexibility,[3] and fragmentation. Four travel outcomes are considered[4]: trip frequency, travel distance, mode choice, and value of travel time (VOTT).[5]

Relevant literature was searched in three sequential steps (see Fig. 2). First, the initial list was compiled by searching scientific databases and search engines like Web of Science Core Collection and Scopus. This process encompassed papers published in English-language journals, excluding other forms of research such as working papers, conference papers, policy papers, and postgraduate theses. The search was guided by specific keywords aligned with the selected DMT, the three TUPs we focused on and travel outcomes, as outlined in Table 1. Two columns were used in each search to represent the corresponding arrow. For **Arrow 1**, we consider empirical evidence from 2019 to 2024 to ensure that the analysis reflects the recent empirical findings. Correspondingly, we applied three additional keywords, "survey", "questionnaire", and "interview", to obtain the dataset addressing **Arrow 1**. For **Arrow 2a** and **Arrow 2b**, we include relevant studies[6] from all years to develop theoretical thinking on the role of TUPs in the causal link between DMTs and behaviour comprehensively. Second, we exclude studies irrelevant to the four types of travel outcomes we addressed here by screening titles and abstracts. Third, backward/forward snowballing methods were employed to replenish the original database.

After these three steps, we collected three datasets containing the studies labelled **Arrow 1**, **Arrow 2a** and **Arrow 2b**. Each dataset partially overlapps with another as shown in Fig. 2. For example, some studies addressing the direct relationship between digital engagement on travel behaviour (**Arrow 1**) might also explore the relationship between digital engagement and activity fragmentation (**Arrow 2a**). Thus, we screened the studies again and divided them into seven categories using specific criteria. After categorising, we extract studies pertinent to **Arrow 2a** or **Arrow 2b**, excluding the empirical studies relevant to **Arrow 1** (i.e., using the non-overlapping **Area 1**). These studies allow us to develop theoretical expectations for how DMTs lead to various TUPs and how TUPs influence travel behaviour in **Section 3**. In **Section 4**, three case studies are conducted to explore how the three TUPs can explain the diverse empirical results. For this, we use the overlap between **Arrow 1 and the joint area of Arrow 2a and Arrow 2b (i.e., Area 2** in Fig. 2). Two criteria must be satisfied for a study to be grouped into **Area 2**: (a) the studies either measure TUPs in their datasets, reference TUPs in their surveys, questionnaires, or interviews, or explicitly include TUPs as assumptions in their model frameworks; and (b) the authors provide interpretations that explain the connection

[2] The definition of telework, as outlined by Mokhtarian et al. (2005), is broader and includes any work done remotely, not limited to working from home. In this context, we use "telework" interchangeably with "new ways of working".

[3] Spatial and temporal flexibility are critical aspects of activities (see Section 3). Thus, we classify spatial flexibility as a time-use pattern to discuss its influence on travel. We categorise a study under spatial flexibility if temporal flexibility is shaped by it, while studies where temporal flexibility is examined independently (e.g., flexible work hours without location changes) fall under temporal flexibility.

[4] We selected travel outcomes based on the following criteria: (1) they should capture key aspects of travel patterns and preferences; (2) they should be easy to compare quantitatively.

[5] VOTT reflects how much someone is willing to pay to reduce travel time (Small, 1992).

[6] Due to limited conceptual studies in this field, we also include some empirical studies and draw on the conceptual parts of these studies to synthesise theoretical expectations.

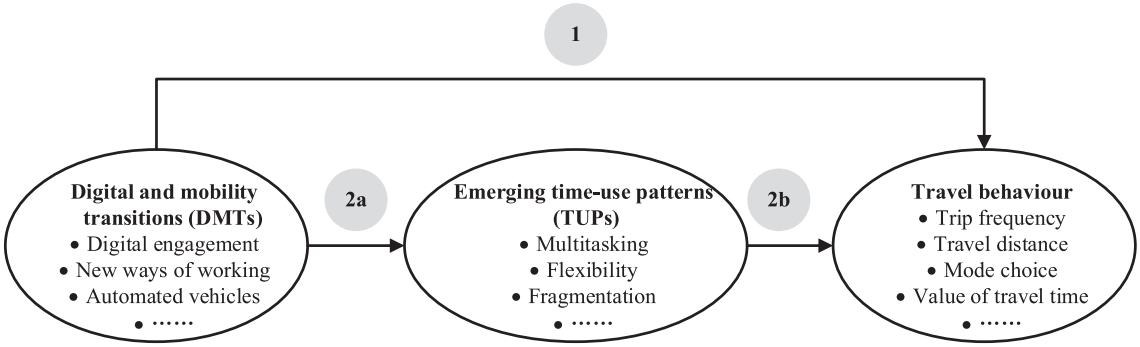

Fig. 1. Relationship among DMTs, TUPs, and travel behaviour.

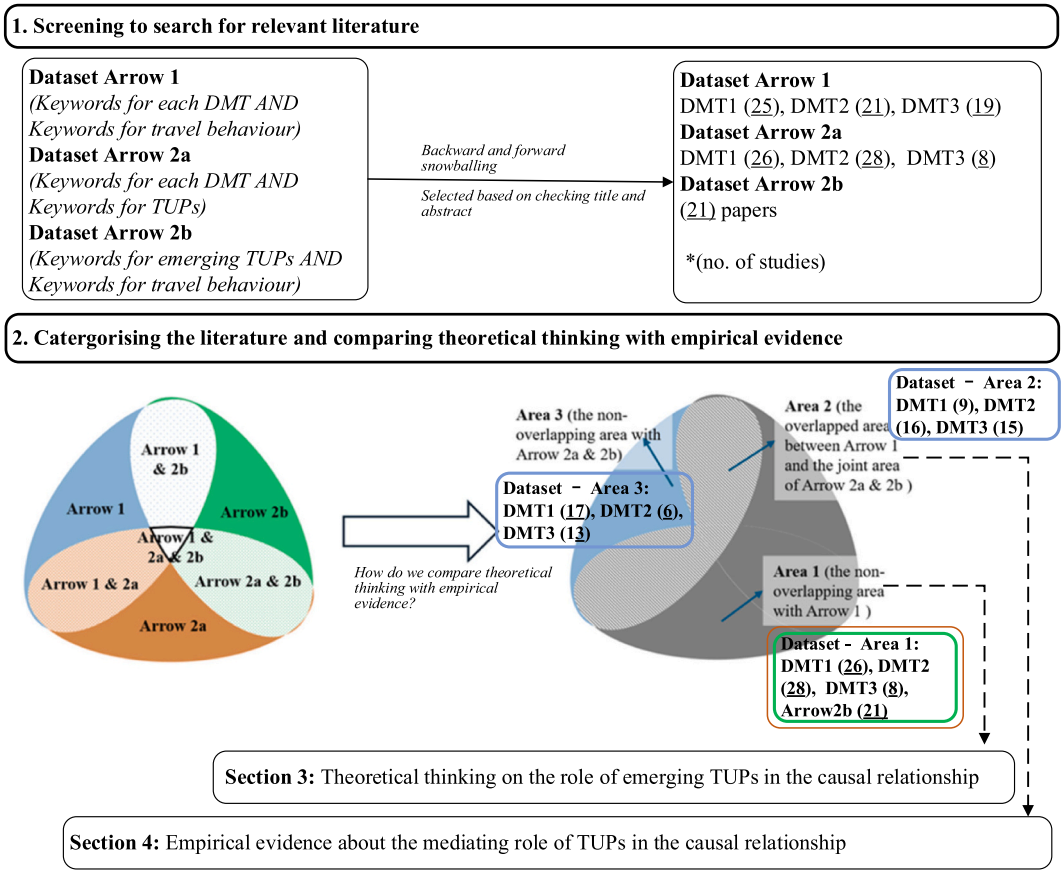

Fig. 2. Analysis procedure.

between TUPs and travel. This systematic approach ensures the methodological rigour and comprehensiveness of this literature review.

2.2. Bibliographic overview of the state of the art of emerging time-use patterns

This section provides a snapshot of current research in the three TUPs, as illustrated in Fig. 3. A key insight is the uneven field coverage, highlighting multiple gaps in the literature. Notably, most studies focus on activity flexibility (48 studies), compared to multitasking (38 studies) and activity fragmentation (20 studies). Specifically, more attention is paid to connections between new ways of working and flexibility, AVs and multitasking and digital engagement and multitasking. This uneven distribution may reflect a DMT's (in) direct effect on a specific TUP, e.g., telework directly enhances flexibility, thus enabling individuals to combine work and household responsibilities. Similarly, AVs directly increase the possibilities for multitasking in vehicles, helping individuals save time and accommodate more flexible scheduling.

When examining the influence of the three TUPs on travel behaviour, multitasking has received the most significant attention, with 14 studies compared to 9 for fragmentation and flexibility. This focus likely stems from multitasking's association with increased efficiency and productivity, which can alleviate the time pressures of modern people (Yuan and Zhong, 2024). Studies have linked multitasking to trip frequency, VOTT and mode choice, but lack discussion about its impact on travel distance. This gap might result from the assumption that VOTT proxies travel distance, leading researchers to overlook the direct effects of multitasking on travel distance. Similarly, flexibility is more often studied as affecting trip frequency and mode choice, with limited exploration of its effects on travel distance and VOTT. Fragmentation, on

Table 1
Keywords used to search for relevant studies.

Keywords for the three digital and mobility transitions (DMTs)	Keywords for the three emerging time-use patterns[1]	Keywords for travel behaviour
DMT1: Digital engagement "ICT" OR "Information and communication technologies" OR "Virtual mobility" OR "Virtual collaboration" OR "*E*-shopping" OR "E-commerce" OR "Online shopping" OR "Teleshopping" OR "Teleconference" OR "Digital communication" OR "Telecommunication" OR "Digital activities" OR "Social media" OR "Online services" ***DMT2: New ways of working*** "Flexible work" OR "Telework" OR "Remote work" OR "Work from home" OR "WFH" OR "Hybrid work" OR "Telecommute" OR "Telecommuting" ***DMT3: Automated vehicles*** "Driverless car" OR "Driverless vehicle" OR "Self-driving car/ vehicle" OR "Automated car/ vehicle" OR "Autonomous/ automated driving"	"Activity pattern" OR "Time pattern" OR "Time-use" OR "Multitasking" OR "Onboard activities" OR "Flexibility" OR "Fragmentation"	"Number of trips" OR "Trip frequency" OR "Travel frequency" OR "Trip-making" OR "Mode choice" OR "Modal split" OR "Value-of-travel-time" OR "VOTT" OR "Vehicle Miles Travelled" OR "VMT" OR "Vehicle Kilometers Travelled" OR "VKT" OR "Travel distance" OR "Passenger Miles Travelled" OR "PMT" (OR "Survey") (OR "Questionnaire") (OR "Interview")

Note: Additional keywords are added to collect empirical studies relevant to **Arrow 1**: "Survey", "Questionnaire", and "Interview".
[1] The keywords for time-use patterns are strictly defined to include only papers explicitly using the unified time-use patterns. Papers using vague or indirect terminology related to these patterns are excluded.

the other hand, is mainly linked to trip frequency, while its relationship with travel distance, VOTT, and mode choice is largely overlooked. This suggests a narrow and incomplete understanding of its impact on travel behaviour.

Another insight is that more studies recognise the three TUPs' role in the context of telework (73 %, 16 out of 22) and AVs (54 %, 15 out of 28), compared to digital engagement (38 %, 9 out of 24). This reflects the conceptual closeness of digital engagement, new ways of working and AVs with the three TUPs. Telework is by definition related to spatial flexibility, allowing individuals to choose where they work. AVs are inherently linked to multitasking during travel as they enable hands-free driving. In contrast, digital engagement is often quantified by the frequency of engaging digitally, such as e-shopping frequency (Xi et al., 2020), which partially captures the time-use intensity of the activity but does not directly relate to the three TUPs.

3. Theoretical thinking on the role of emerging time-use patterns in the causal relationship

This section outlines the relationship between the three DMTs and the three TUPs (**Arrow 2a** in the Methodology above) while synthesising evidence on how these TUPs impact travel behaviour (**Arrow 2b**). The assessment is based on current studies and our theoretical reasoning, particularly when previous studies have overlooked relevant research topics (see the bibliographic overview above).

3.1. How do digital and mobility transitions lead to time-use patterns?

3.1.1. Digital engagement and time-use patterns

Digital engagement in daily life impacts how people manage their time. ICT-induced multitasking (especially the use of social media) has received much attention in the literature. Frequent engagement with social media and other digital platforms is a key contributor to student multitasking in educational settings (Deng et al., 2022; Lau, 2017). This tendency extends beyond academic environments, pervading daily activities where individuals simultaneously use digital devices for entertainment (Lin et al., 2021), social interactions (Yoon et al., 2021), and work. This often results in decreased task efficiency and increased cognitive load (Reinecke et al., 2017). Furthermore, digital engagement, particularly through portable devices, facilitates multitasking during travel, (potentially) transforming previously idle time into productive activities like checking emails or joining virtual meetings (Kenyon and Lyons, 2007; Krueger et al., 2019; Pawlak, 2020). Additionally, digital engagement significantly enhances spatial and temporal flexibility (Heldt et al., 2021; Schwanen and Kwan, 2008; Shen et al., 2020). The ability to remotely access work and personal tasks allows individuals to perform activities at any time and location, altering traditional activity patterns. Such flexibility allows displacing, overlaying, or modifying traditional activities with digital means, e.g., digital social networks enable the maintenance of extensive social ties without geographic proximity. Furthermore, ICT use can help mitigate the negative impact of limited infrastructure accessibility on individuals' space-time flexibility (Shao et al., 2023). Finally, constant connectivity via smartphones and email alerts leads to invasive notifications that fragment the day (Andrade and Matias, 2022; Selwyn, 2016). Namely, digital engagement

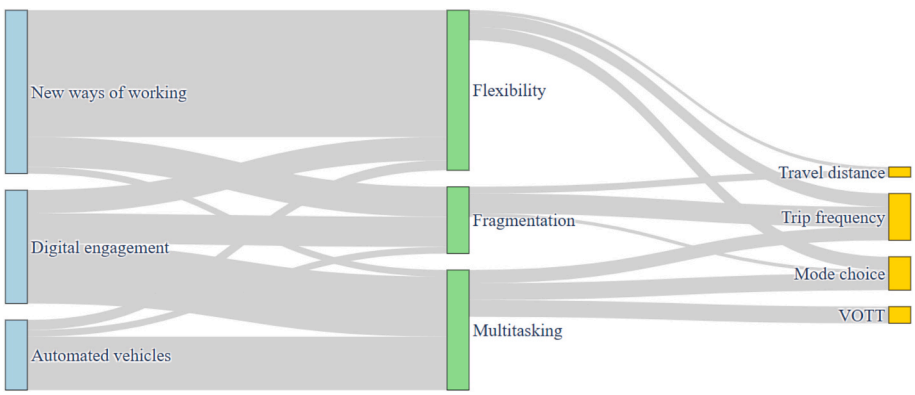

Fig. 3. Bibliographic overview of the number of studies addressing the relationship among the three DMTs, the three TUPs, and travel behaviour.

allows tasks to be split into subtasks completed at different times and locations (Alexander et al., 2010; Ben-Elia et al., 2014; Lenz and Nobis, 2007). In e-commerce, shopping is fragmented into online research, in-store trials, and online purchases, distributed across time and space (Couclelis, 2004; Mokhtarian, 2004).

3.1.2. New ways of working and time-use patterns

New ways of working provide employees with temporal flexibility, enabling them to adjust their work hours according to their obligations and hobbies (Shockley and Allen, 2007). Additionally, they offer spatial flexibility, allowing employees to choose different workplaces, thereby reducing commuting demands (Krajcik et al., 2023; Kroesen, 2022). However, they have caused fragmentation and multitasking, making it challenging to separate work from personal life. For instance, integrating home and neighbourhood environments often leads teleworkers to interruptions for errands during work hours (Powell and Craig, 2015). Similarly, overlap between home and work spaces encourages multitasking, such as engaging in household chores or childcare while working. The constant availability of digital tools has further blurred the boundaries between work and personal time, leading to continuous spillover of work into personal life (Wheatley et al., 2023).

3.1.3. Privately owned automated vehicles and time-use patterns

Fully automated vehicles (AVs) are expected to significantly enhance the ability to multitask during travel by freeing passengers from driving responsibilities. This shift transforms travel time from a passive to an active period where various activities can be accomplished. For example, activities like remote meetings, meals, and entertainment are more likely to occur during travel with AVs than public transit due to the favourable environment and the removed transfer time (Hamadneh and Esztergár-Kiss, 2022). However, concerns like motion sickness when using travel time might make respondents hesitate to multitask in AVs (Meyer and Beiker, 2016). Additionally, fully automated vehicles can create room for multitasking during non-travel activities, e.g., picking up groceries or parcels while searching for parking lots (Kim et al., 2020). Due to the opportunities granted by such multitasking, AV users can enjoy more spatial flexibility. For example, they may sleep in AVs instead of going back home or let their AVs park outside the city centre instead of in places near their destinations. They arrange their schedule more flexibly thanks to the freed time by multitasking in/outside AVs (Kim et al., 2020). Likewise, with AV-enabled multitasking, users can fragment one activity across (non-)travel durations. For instance, they may divide their work into individual tasks in AVs and physical meetings at the office.

3.2. How do time-use patterns influence travel behaviour?

3.2.1. How multitasking influences travel behaviour

In general, multitasking is classified into two types, i.e., multitasking during travel (Ettema et al., 2012) and non-travel activities (Kenyon and Lyons, 2007). The former can make travel more comfortable and happier, leading to lower VOTT (Ettema and Verschuren, 2007; Jara-Diaz, 2024), longer travel distances (Mokhtarian, 2018) and more preference for transport modes enabling multitasking (e.g., public transit (Hartwig et al., 2024) and AVs (Hamadneh and Esztergár-Kiss, 2022)). Additionally, the time savings with onboard activities might make room for people to modify daily activity schedules (Pudāne et al., 2019) and add or reduce trips (Chidambaram and Scheiner, 2024; Mokhtarian, 2018; Pudāne et al., 2018). In the aggregate, trips may likely remain unchanged or slightly increase due to multitasking during travel (Kim et al., 2020).

While multitasking during travel offsets the disutility of travel time, multitasking in non-travel activities primarily helps alleviate time pressures from responsibilities such as work and study (Malokin et al., 2019). Consequently, we speculate that people may become less inclined to pay for time savings (i.e., have lower VOTT). Moreover, the more people multitask, the more efficiently they can use their time, freeing time to travel more to participate in additional activities. As a result, they may prefer to use private vehicles or on-demand mobility modes to manage more complex activity arrangements, potentially offsetting some of the initial VOTT reduction (Guevara, 2017).

3.2.2. How flexibility influences travel behaviour

Spatial and temporal flexibility are critical aspects of activities that enhance understanding of travel behaviour (see Doherty (2006) for a detailed explanation). Spatial flexibility allows individuals to reduce travel (Ng, 2017). For instance, a person who works remotely can eliminate daily commute. Temporal flexibility may increase travel by giving people more control over their schedules and accommodating more trips (Wang et al., 2022). Additionally, employees with greater flexibility are more likely to choose active transport modes than when they have fixed schedules, as fewer time constraints make slower modes more feasible and appealing (Wohner, 2023). Moreover, without rigid spatial or temporal constraints, individuals can base their travel decisions on personal preference. Flexibility can also make public transit a more viable and appealing option (Lu et al., 2023; Shao et al., 2022). For example, users who can switch their nighttime travel to daytime are more likely to use public transit, which operates less frequently or does not run at night. The flexibility of online shopping at home decreases the need to drive to large, suburban shopping malls that are less accessible by bus. In contrast, strong spatio-temporal fixity, such as fixed work schedules or childcare duties, tends to increase reliance on private cars, as rigid daily routines demand fast, reliable, and flexible transport options (Chidambaram and Scheiner, 2024). Moreover, a major disadvantage of public transport that deters its use is the congestion and longer travel time during morning and evening rush hours. Temporal flexibility can change travellers' departure times, helping them avoid negative feelings during travel and reduce VOTT (Thorhauge et al., 2016), thereby encouraging public transport use.

3.2.3. How fragmentation influences travel behaviour

Activity fragmentation is commonly understood as dividing a particular activity into smaller segments, each capable of independent execution at different times and/or locations (Couclelis, 1998). Studies on activity fragmentation are often bundled with increasing digital engagements. A typical case is that with mobile phones and the internet, people can split their work between the office and other locations (e.g. home and train) and work outside the regular working hours (e.g. early morning, evening, and weekends). The increasing dispersion of activities across different locations naturally triggers more trips (Ben-Elia et al., 2014; Couclelis, 2004) and more travelled miles (Su et al., 2021). Furthermore, frequent fragmentation can create stress and time pressure as individuals attempt to juggle multiple fragmented activities (Osin and Boniwell, 2024). Hence, people may be willing to pay more for time-saving measures (i.e., have higher VOTT) and move away from the slower active modes. The more fragmented people's activities become, the more they tend to prefer door-to-door services over multimodal transport options. This shift is reflected in more car travel (Lenz and Nobis, 2007).

3.3. Summary: How digital and mobility transitions may influence travel behaviour through emerging time-use patterns

Based on the synthesis, the identified DMTs are expected to increase multitasking, flexibility and activity fragmentation behaviour. Each of these three TUPs uniquely influences travel behaviour, as summarised in Table 2. Specifically, our theoretical thinking suggests that since each of these DMTs amplifies the three TUPs, conflicting effects on travel outcomes may arise. In the next section, we will present empirical evidence to compare with theoretical expectations.

Table 2
Theoretical thinking on the role of emerging time-use patterns in the causal relationship.

Three digital and mobility transitions	Three emerging time-use patterns (TUPs)		Travel outcomes			
			Trip frequency	VOTT	Travel distance	Mode choice
• Digital engagement • New ways of working • Privately-owned automated vehicles	Multitasking ↑	during travel	↑	↓	↑*	A higher share of modes that allow multitasking during travel (public transport or AVs)
		during non-travel	↑*	↓*	↑*	More car use (or AVs) /on-demand services*
	Flexibility↑	Spatial	↓	↓*	↓	More public transport/active modes
		Temporal	↑		↑	
	Fragmentation↑	/	↑	↑*	↑	Less active mode and more car/on-demand services

Note: "*" indicates that the influence of a TUP's influence on a travel outcome is inferred from our theoretical reasoning due to limited relevant studies.

4. Empirical evidence about the mediating role of time-use patterns in the causal relationship

After reviewing the collected studies, we found diverse results related to the impacts of digital engagement on trip frequency (see Fig. 4) and new ways of working on trip frequency and mode choice (see Fig. 5). In contrast, empirical results related to AVs converge regarding the four travel outcomes (see Fig. 6). This section discusses how the three TUPs are related to such diverse or convergent results. It is important to note that our discussion is limited to travel outcomes for which more than 3 relevant studies were available, ensuring a robust basis for comparison. Detailed information about the relevant studies on digital engagement, new ways of working and AVs is in **Appendix A**, **B** and **C**.

4.1. The impacts of digital engagement on travel behaviour

We find that the exploration of digital engagement's impact on travel mainly focuses on trip frequency (as summarised in **Appendix A**), consistent with the findings of a literature review (Le et al., 2022). Diverse empirical results are related to whether digital engagement increases or decreases trip frequency, corresponding to the substitution or complementarity effects proposed by Mokhtarian (1991). These diverse findings are relevant to fragmentation and spatial flexibility triggered by digital engagement. We report how these two TUPs explain the diverging results of trip frequency as follows.

Current studies indicate that activity fragmentation activated by hybrid engagement[7] in shopping, socialising, and consuming intangible services is associated with more frequent trips. Etminani-Ghasrodashti and Hamidi (2020), Pernot (2021), and Shi et al. (2021a, 2021b, 2021c) observed that shopping is increasingly divided into multiple distinct phases, which likely results in increased trips. Their study found that, instead of a single trip to purchase an item, individuals now often search for and evaluate products online, pick up larger items at designated collection points, and make additional visits to physical stores to finalise purchases. This multi-step process contributes to an overall increase in shopping-related trips. Similarly, Lizana et al. (2022) observed that while virtual interactions help maintain relationships, they do not eliminate face-to-face meetings, which are necessary to reinforce social bonds. Their observations show that this combination of virtual and physical socialisation increases social-related trips. Although the authors did not explicitly link this to activity fragmentation, their findings reveal a two-phase socialising process with online contact before physical meetings. Further evidence of this fragmentation was found in Shi et al. (2021a, 2021b, 2021c), who showed that using online platforms to discover intangible services (e.g., hairdressing, dining, or entertainment) leads to more trips. The authors compared individuals gathering information online before travelling to use services with those who skip this step. They found people relying on the internet for service discovery make more trips. Although their findings were not explicitly described as activity fragmentation, they align closely with our theoretical thinking.

Contrary results emerge when digital-dominant engagement[8] enhances spatial flexibility. Shah et al. (2021) and Shi et al. (2019) showed that individuals who leverage ICT-enabled spatial flexibility tend to reduce their trip frequency. They explained that online shopping allows consumers to choose across three spatial locations: in-store shopping, online shopping with home delivery, and online shopping with pick-up points. Notably, Shah et al. (2021) observed that time-pressured shoppers are more inclined to substitute in-store visits with online shopping.

4.2. The impacts of new ways of working on travel behaviour

Many studies show that the trip frequency decreases with the adoption of telework, though some suggest the opposite. The impact of telework on mode choice remains uncertain (Mogaji, 2022). These varied findings are linked to flexibility and fragmentation activated by different configurations of telework, i.e., full-day or part-day telework (discussed in **Section 5.1**). See **Appendix B** for detailed information on the relevant studies.

Current empirical studies show that full-day telework, which offers greater spatial flexibility, is associated with reduced trips and car use. For instance, Asmussen et al. (2024), Ceccato et al. (2022), Goshima et al. (2023), Kogus et al. (2022), and Motte-Baumvol et al. (2024) found that telework negatively correlates with travel frequency. They measured telework-activated flexibility through the number of days employees work from home weekly. However, they did not explicitly point out the underlying time-use characteristics. Their results revealed that individuals who telework more often tend to make fewer trips. Empirical evidence from Abe et al. (2023), Chalabi and Dia (2024), Elldér (2020), and Kalter et al. (2021) shows that telework-enhanced flexibility is linked to less driving. Their findings indicate that car commuters working from home for an entire day are more likely to replace driving with walking or cycling, particularly in densely populated areas (Abe et al., 2023). However, Victoriano-Habit and El-Geneidy (2024) observed that full-day teleworkers living in suburban areas with lower accessibility are less inclined to choose active transport modes, even with increased spatial flexibility. In addition, Ceccato et al. (2022), Javadinasr et al. (2022), and Zheng et al. (2023) reported that many full-day teleworkers use cars more, likely due to travel restrictions, health concerns in public transit, and increased car purchases during COVID-19.

Contrasting findings emerge when activity fragmentation is enhanced by part-day telework. Survey data from Balbontin et al. (2024), Budnitz et al. (2020), Elldér (2020), and Su et al. (2021) reveal

[7] Hybrid engagement means individuals regularly participate in both digital and physical activities, using digital engagement to complement their physical engagement.

[8] Digital-dominant engagement refers to individuals primarily interacting through digital platforms to replace physical ones.

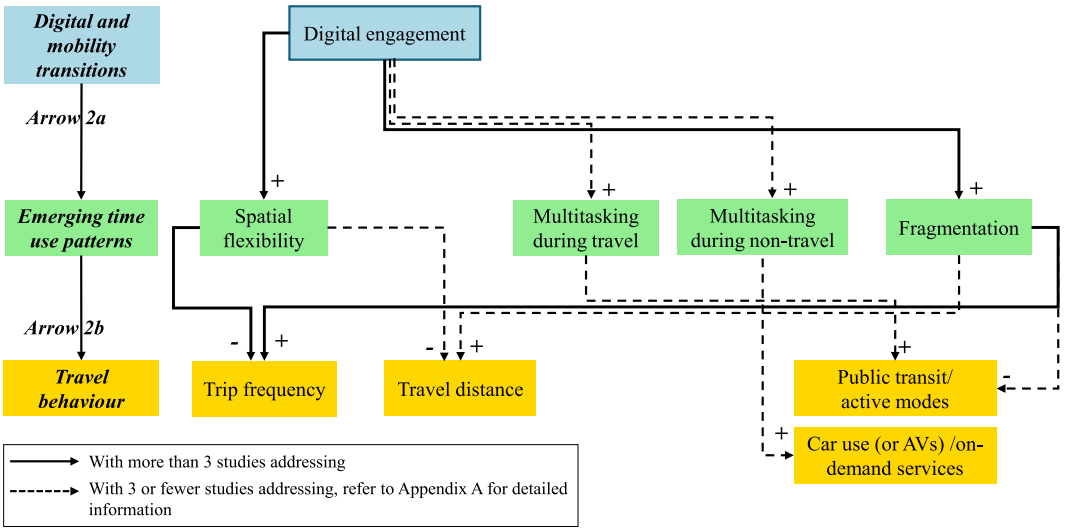

Fig. 4. Empirical results about the role of the three TUPs in the causal relationship between digital engagement and travel behaviour.

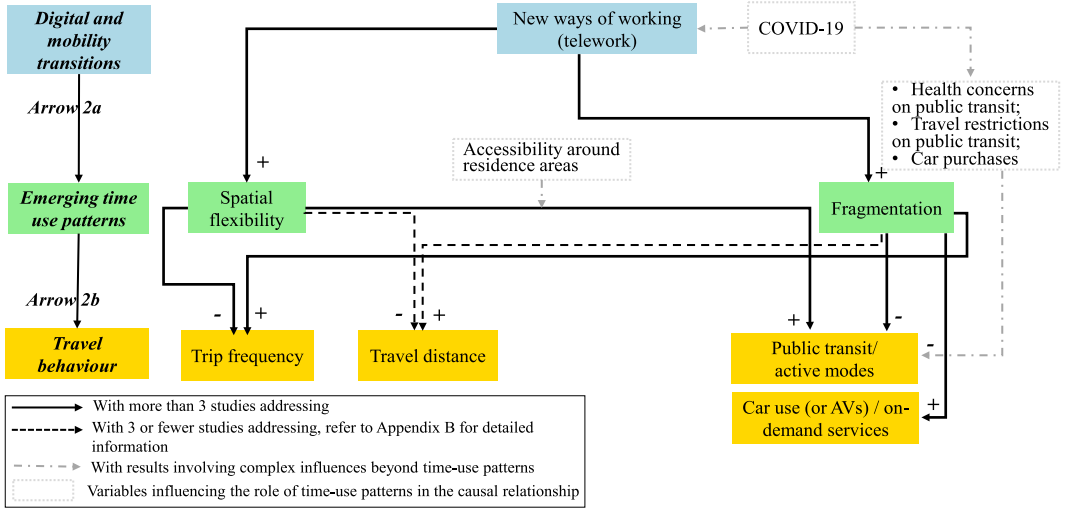

Fig. 5. Empirical results about the role of the three TUPs in the causal relationship between new ways of working and travel behaviour.

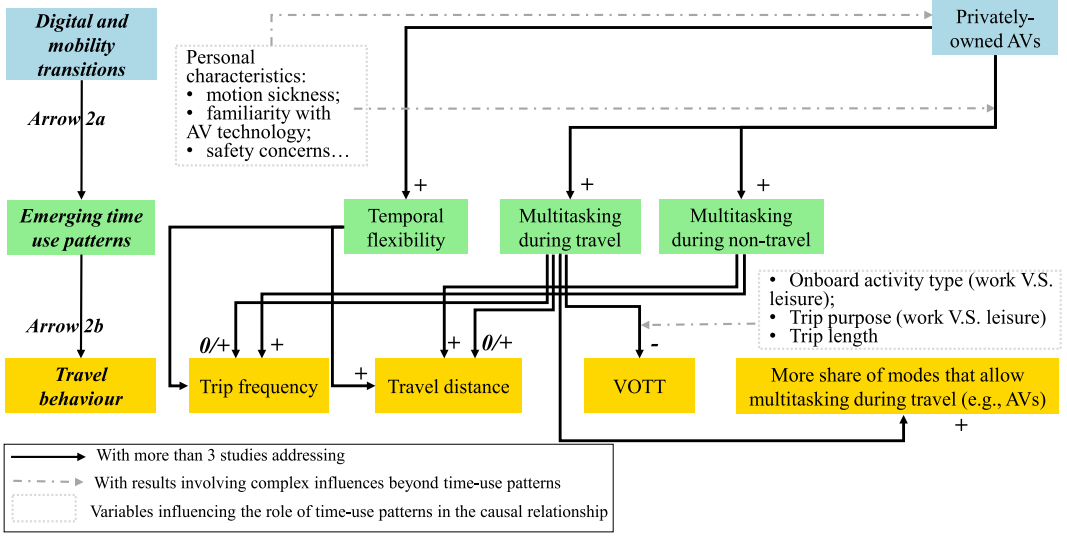

Fig. 6. Empirical results of the role of the three TUPs in the causal relationship between privately-owned AVs and travel behaviour.

that fragmented work activities often result in more trips. They indirectly assess fragmentation by identifying people who telework for only part of the day. For example, Elldér (2020) found that part-day teleworkers, who split their workday between home and external locations, travel more than those who do not telework. Moreover, part-day teleworkers are less likely to use active transport modes than full-day teleworkers.

4.3. The impacts of privately owned automated vehicles on travel behaviour

Multitasking during (non-)travel and temporal flexibility are often shown to be relevant to AVs. Despite these various TUPs, empirical studies consistently demonstrate AVs' impact on the four travel outcomes. This is relevant to the theoretical basis that multitasking and temporal flexibility exert a unified rather than opposing effect on travel behaviour. See **Appendix C** for detailed information on the relevant studies.

Increasing multitasking and temporal flexibility in fully automated vehicles have been linked to increased trip frequency and travel distance, although some studies indicate no impact in the daily travel context. The findings of Dannemiller et al. (2023) revealed that onboard activities were closely linked to more local and long-distance trips, among which leisure activities are the most popular, such as sleeping and enjoying the scenery. Similarly, Pudāne et al. (2019) conducted a focus group with Dutch commuters, where some (though not all) anticipated that they would travel more, especially considering long-distance and holiday travel. Some participants considered the ability to assign tasks to AVs, such as dispatching an empty AV to pick up groceries or guests. Jia et al. (2022) explored this further, suggesting that AV users could outsource tasks like parking relocation to their vehicles, contributing to additional vehicle travel distance. This reflects a broader concept of multitasking during non-travel activities. Intriguingly, Lehtonen et al. (2022) found mixed results that more leisure activities in AVs are relevant to more travel; however, working in AVs is not. Additionally, Kim et al. (2020) examined various potential behaviour changes with AVs, finding that roughly half of the respondents expected more or longer trips, either daily or over long distances. In their sample, 13 % of respondents anticipated greater flexibility in daily schedules and more leisure/long-distance travel. Debbaghi et al. (2024) observed that while about half of the respondents indicated changes to their activity schedules (i.e., adding onboard activities or changing stationary activities), fewer than 5 % indicated any change in trip frequency (i.e., eliminating or adding trips). Rahman et al. (2020) found that temporal flexibility, particularly the ability to adjust travel schedules, is highly valued by the elderly, who may rely on AVs due to their limited driving ability.

Furthermore, the greater multitasking activated by fully automated vehicles has also been shown to reduce passengers' VOTT. A survey by Andrei et al. (2022) found that passengers in AVs are more likely to engage in non-work activities during journeys. The authors suggest that the ability to multitask may contribute to the reduced VOTT. Similarly, Kolarova et al. (2019) introduced AVs in their online survey as a mobility mode allowing travellers to use travel time for activities like watching movies and surfing the internet. The results revealed a 41 % reduction in VOTT for commuting in AVs compared to conventional cars, while VOTT for leisure or shopping trips remained largely unchanged. Aligning with the previous studies, Kolarova and Cherchi (2021) observed that most respondents preferred passive activities (like relaxing) to productive tasks (e.g., working) when travelling in AVs. They suggest that these enhanced travel experiences contribute to lower VOTT. In contrast to fully automated vehicles, Choi et al. (2023) reported that VOTT in partially automated vehicles for local trips was not necessarily lower than in public transit, based on a 2019 survey of Korean commuters. They explained that travellers require enough trip duration to fully use the in-vehicle time. Also, accident risks, unfamiliarity with AVs, and immature technology of AVs could prevent travellers from better using the travel time.

Regarding mode choice, empirical results consistently show that fully/partially automated vehicles are more attractive than public transit (disregarding the purchase costs) due to the diverse onboard activities they offer. Similar findings are reported in the surveys of Hamadneh and Esztergár-Kiss (2022), Hardman (2021) and Malokin et al. (2019) AVS are seen as more competitive than public transit, considering the reduced stress enabled by extensive in-vehicle activities.

5. Discussion

5.1. Time-use patterns: A potential mediator in the causal relationship

Our first observation is that TUPs can explain how digital and mobility transitions (DMTs) influence travel behaviour. Empirical evidence shows that digital engagement and new ways of working impact travel differently because they are associated with the three TUPs, which have partially counteracting effects on travel. As illustrated in **Figs. 5** and **6**, new ways of working and AVs increase activity fragmentation, leading to more trips and reduced use of active transport modes. Meanwhile, they enhance spatial flexibility, thus decreasing the number of trips and car use. This result aligns with our theoretical thinking in Table 2. The net outcome of these partially counteracting effects on travel depends on the dominant TUPs triggered by DMTs. The case of AVs reinforces our theoretical perspective. Concretely, AVs are shown to increase multitasking during (non-)travel and temporal flexibility. Despite the variety of TUPs, empirical results about AVs' impact on travel behaviour are largely convergent (as shown in Fig. 6), because the TUPs linked to AVs have a uniform effect on travel (see theoretical basis in Table 2).

An important question is which TUPs each DMT may activate. Even as **Section 3** concludes that each DMT may activate each of the three TUPs, empirical evidence typically identifies only a subset of them. We propose that an important determinant is the considered configuration of DMTs. In telework, full-day telework often leads to flexibility, where individuals can manage their work without commuting (e.g., Asmussen et al., 2024; Balbontin et al., 2024). Part-day telework often leads to fragmentation, with workers splitting their focus between life and office tasks (e.g., Budnitz et al., 2020; Elldér, 2020). This notion is similar to the point proposed by Mokhtarian (1991) and Mokhtarian et al. (2005): there is no consensus on telework, as its definitions can vary depending on context. Fully automated vehicles facilitate multitasking during travel by reducing or eliminating the need for human control. Furthermore, they enable multitasking during non-travel by allowing users to delegate tasks to the vehicle while engaging elsewhere. In contrast, partially AVs lack this capability. Unlike telework and AVs, the configuration of digital engagement does not appear to explain the dominant TUP.

5.2. Beyond time-use patterns: Diverging results from confounding and moderating variables

According to current empirical evidence, divergent results may also arise due to confounding variables that weaken the mediating effect of TUPs in the causal relationship (see **Figs. 4, 5** and **6**). First, several studies (Ceccato et al., 2022; Javadinasr et al., 2022; Victoriano-Habit and El-Geneidy, 2024; Zheng et al., 2023) suggest that teleworkers, despite their increased spatial flexibility, tend to increase car use and reduce reliance on public transit. This may be attributed to the influence of a confounding variable, "COVID-19", which affects telework and travel through factors such as health concerns about public transit, travel restrictions and increased car purchases during the pandemic. Additionally, the minimal changes in trip-making behaviour observed by Abe et al. (2023) among part-day teleworkers may be explained by confounding effects related to the timing of data collection. Their data

were gathered in 2018 when telework had not yet significantly influenced how individuals organise their daily activities.

In addition, certain factors acting as moderators can alter the strength or direction of the relationship between TUPs and travel. For example, Victoriano-Habit and El-Geneidy (2024) indicate that neighbourhoods with low local accessibility diminish the positive effects of spatial flexibility on promoting active transportation modes, while high-accessibility areas amplify this effect; Trip characteristics such as purpose, onboard activity types, and trip length have been shown to moderate the relationship between multitasking and VOTT. For instance, Kolarova et al. (2019) found no significant change in VOTT for leisure trips using AVs, suggesting that trip purposes moderate the mediating effect of multitasking on travel; Likewise, Correia et al. (2019) reported that reported that VOTT in an AV with work interior should be lower than in a conventional vehicle, while VOTT in an AV with leisure interior could stay the same; Lehtonen et al. (2022) concluded that while more leisure activities in AVs lead to more travel, working in AVs does not; Choi et al. (2023) revealed that VOTT tends to increase for shorter trips because in-vehicle time is insufficient for longer-duration activities, such as business tasks.

5.3. Limitations and future research directions

This paper proposes that the mediating role of TUPs in the causal link is applicable across various contexts, including digital engagement, new ways of working, and AVs, as examined here. However, several limitations should be addressed to enhance the generalisability of the framework. First, the focus on only three DMTs may constrain its broader applicability. Other DMTs, such as the use of electric vehicles (Adsule and Manoj, 2025), may also significantly influence time use and travel behaviour and merit further exploration. Second, while we focus on three TUPs to maintain conceptual clarity, we acknowledge that other TUPs, such as procrastination (Pestana et al., 2020), may also be relevant. Future research could expand the framework by incorporating additional DMTs and TUPs to enhance its comprehensiveness and applicability across diverse contexts. Third, we acknowledge that overlaps may occur between the three TUPs discussed (Kenyon and Wing, 2010). Rather than imposing strict boundaries between them, we adopt the terminology used in the literature we reviewed. For instance, if a study emphasises the spatial flexibility of shopping (e.g., shifting from physical to online shopping), we classify it under flexibility (e.g., Shi et al., 2019). Conversely, if shopping is explored as one of several activities performed during travel, we categorise it under multitasking during travel. More research on refining the distinctions between different TUPs and developing more consistent classification criteria would be valuable for enhancing the analytical robustness and comparability of empirical studies in this field.

Furthermore, we outline several future research directions based on the development of our theoretical thinking and its exemplification through empirical evidence. First, current studies have largely overlooked the influence of TUPs on travel (**Arrow 2b**). Future research should conceptually and empirically explore the relationship between multitasking during non-travel activities and travel, temporal-spatial flexibility and VOTT, activity fragmentation and VOTT, as outlined in Table 2.

Second, as illustrated in Figs. 5 and 6, more empirical studies are needed to examine the influence of DMTs on TUPs (**Arrow 2a**). Future work could investigate (1) whether telework promotes multitasking and activity fragmentation and (2) whether AVs foster greater activity fragmentation and flexibility. Presumably, these questions have not been studied because the influence could be seen as secondary to another TUP. Namely, telework directly enables people to work at home, allowing them to combine household responsibilities through multitasking and fragmentation. Similarly, AVs allow drivers to engage in more in-vehicle activities, leading to more flexible and fragmented schedules. It is essential to understand when and how these secondary effects will be significant, to capture the evolving influences of DMTs on time use.

Third, we recommend future studies integrate direct measurements of TUPs into assessments of how DMTs affect travel behaviour to better interpret causal relationships and address inconclusive findings. Our reviewed empirical studies seldom measured the three TUPs directly, and we have reinterpreted related measurements as TUPs to validate our theoretical thinking. For instance, we have seen the number of full telework days as a representation of time flexibility and the splitting of shopping activity into phases as a representation of fragmentation. Even as the current analysis aligns with our theoretical expectations, a more direct measurement of these three or other TUPs in future work is essential to further support our framework.

6. Conclusions

How do digital engagement, new ways of working and automated vehicles impact travel behaviour? Inspired by uncertainties around digital and mobility transitions (DMTs) such as these influence travel, our study proposes a new conceptual framework connecting DMTs, time use patterns (TUPs), and travel behaviour. We suggest that the net outcome of these partially counteracting effects on travel depends on the dominant TUPs activated by DMTs. To investigate this new conceptual framework, we focus on three emerging TUPs (i.e., multitasking, flexibility and fragmentation) and four travel outcomes (i.e., trip frequency, travel distance, mode choice and value of travel time). To analyse these relationships, we first synthesise theoretical thinking on how DMTs influence TUPs and how TUPs influence travel behaviour. Next, drawing on empirical data from 2019 to 2024 on digital engagement, new ways of working, and AVs, we compared these empirical results with our theoretical thinking.

Our results show that TUPs may serve as a mediator in the causal relationship between DMTs and travel behaviour. The impacts of digital engagement and new ways of working on travel behaviour vary, as these DMTs influence activity fragmentation and spatial flexibility—two TUPs that can have opposing effects on travel. In contrast, empirical findings on the impact of AVs on travel behaviour are more consistent, emerging from the increase in multitasking due to AVs. Based on these observations, the impact of a proposed DMT may be analysed in terms of its expected impacts on time use. For instance, we expect that the new hybrid work arrangement will lead to more fragmentation of activities. Our work has shown that, given that reasoning, we can reliably anticipate the direction of the travel behaviour outcomes of such DMT.

To further refine this conceptual framework, we recommend additional theoretical and empirical studies to examine how DMTs (e.g., digital engagement, new ways of working, and AVs), influence the three TUPs or other TUPs. Particularly, more research is needed on AVs' impact on temporal flexibility and activity fragmentation, as current findings remain inconclusive. Additionally, greater attention should be given to the influence of TUPs on travel, particularly regarding the impacts of multitasking during non-travel activities on travel. Finally, future empirical research should integrate direct measurement of TUPs into analyses of how DMTs affect travel. This is especially important in digital engagement, which has not been conceptually closely linked to TUPs in transport research but remains highly relevant. By understanding the mediating role of TUPs, we will be better equipped to predict the direction of travel behaviour outcomes associated with DMTs.

CRediT authorship contribution statement

Qiuju Xue: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis, Data curation, Conceptualization. **Baiba Pudāne:** Writing – review & editing, Visualization, Supervision, Methodology, Data curation, Conceptualization. **Maarten Kroesen:** Writing – review & editing, Visualization, Supervision,

Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Diverging results about the influences of digital engagement on travel behaviour

Author (year)	Arrows addressed	Configurations of digital engagement[1]	The three TUPs	Explanation for other moderating/ confounding effects[2]	Tavel outcomes			
					Trip frequency	Travel distance	VOTT	Mode choice
Etminani-Ghasrodashti and Hamidi (2020)	A1 & A2b	ADSL/mobile phone/ cell phone	Fragmentation		Increase			
Hong and McArthur (2024)	A1 & A2b	Internet use at home	Multitasking during travel					More public transit
			Multitasking during non-travel					More car use
Jaller and Pahwa (2020)	A1 & A2b	N.A.	Spatial flexibility			Decrease		
			Fragmentation			Increase		
Lizana et al. (2022)	A1 & A2a & A2b	Landline/mobile phone/ computer/ tablet	Fragmentation		Increase			
Pernot (2021)	A1 & A2b	N.A.	Fragmentation		Increase			
Shah et al. (2021)	A1 & A2b	N.A.	Spatial flexibility		Decrease			
			Fragmentation		Increase			
Shi et al. (2019)	A1 & A2b	N.A.	Spatial flexibility		Decrease			
Shi et al. (2021a, 2021b, 2021c)	A1 & A2b	N.A.	Fragmentation		Increase			Less active modes
Shi et al. (2021a, 2021b, 2021c)	A1 & A2b	Mobile phone/ computer	Fragmentation		Increase	Increase		

Note: "N.A." means that the configuration of DMTs was not clearly explained in the study.

[1] With configurations of digital engagement, we mean which digital devices are considered.

[2] We explain other confounding and moderating variables that might weaken the strength of the mediating effects of TUPS on the relationship between DMTs and travel.

Appendix B. Diverging results about the influences of new ways of working on travel behaviour

Author (year)	Arrows addressed	Configuration of new ways of working	The three TUPs	Explanation for other moderating/ confounding effects	Tavel outcomes			
					Trip frequency	Travel distance	VOTT	Mode choice
Abe et al. (2023)	A1 & A2b	Full-day telework	Spatial flexibility	Data was collected in 2018 when the implementation of telework was in an early stage.	Decrease			More active modes
		Part-day telework	Fragmentation		×			×
Asmussen et al. (2024)	A1 & A2b	Full-day telework	Spatial flexibility			Decrease		
Budnitz et al. (2020)	A1 & A2b	Full-day telework	Spatial Flexibility		Decrease			
		Part-day telework	Fragmentation		Increase			
Balbontin et al. (2024)	A1 & A2b	Full-day telework	Spatial flexibility		Decrease			
		Part-day telework	Fragmentation		Increase			
Ceccato et al. (2022)	A1 & A2b	Full-day telework	Spatial flexibility	Health concerns of public transit during COVID-19 influence travel outcomes.	Decrease			**More car use**
Chalabi and Dia (2024)	A1 & A2a & A2b	Full-day telework	Spatial flexibility		Decrease			More active modes
			Temporal flexibility					
Elldér (2020)	A1 & A2b	Full-day telework	Spatial flexibility		Decrease			More active modes
		Part-day telework	Fragmentation		Increase			Less active modes
Goshima et al. (2023)	A1 & A2b	Full-day telework	Spatial flexibility		Decrease			
Javadinasr et al. (2022)	A1 & A2a & A2b	Full-day telework	Spatial flexibility	Health concerns about public transport during COVID-19 influence travel outcomes.	Decrease			**Less public transit**

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(*continued*)

Author (year)	Arrows addressed	Configuration of new ways of working	The three TUPs	Explanation for other moderating/ confounding effects	Tavel outcomes			
					Trip frequency	Travel distance	VOTT	Mode choice
Kalter et al. (2021)	A1 & A2b	Full-day telework	Spatial flexibility			Decrease		Less car use
Kogus et al. (2022)	A1 & A2a & A2b	Full-day telework	Spatial Flexibility		Decrease			
Motte-Baumvol et al. (2024)	A1 & A2b	Full-day telework	Spatial Flexibility		Decrease			
Obeid et al. (2024)	A1 & A2b	Full-day telework	Spatial flexibility		Decrease			
		Part-day telework	Fragmentation		Increase			
Su et al. (2021)	A1 & A2a & A2b	Full-day telework	Spatial flexibility		Decrease	Decrease		
		Part-day telework	Fragmentation		Increase	Decrease		
Victoriano-Habit and El-Geneidy (2024)	A1 & A2b	Full-day telework	Spatial flexibility	Local accessibility around residence areas influences travel outcomes.				**Less or more active modes**
Zheng et al. (2023)	A1 & A2a	Full-day telework	Spatial flexibility	Travel restrictions and health concerns of public transit and car purchases during COVID-19 influence travel outcomes.				**More car use**

*The bolded results show other moderating/confounding effects beyond the mediating effects of TUPs, which are discussed in **Section 5**.

Appendix C. Diverging results about the influences of privately-owned automated vehicles on travel behaviour

Author (year)	Arrows addressed	Configuration of automated vehicles	The three TUPs	Explanation for other moderating/ confounding effects	Travel outcomes			
					Trip frequency	Travel distance	VOTT	Mode choice
Andrei et al. (2022)	A1 A2a A2b	Fully automated vehicles[1]	Multitasking during travel				Decrease	
Choi et al. (2023)	A1 A2b	Partially automated vehicles	Multitasking during travel	Potential risks of accidents, unfamiliarity with AVs, immature technology of AVs and trip length influence travel outcomes.			?	
Correia et al., 2019	A1 A2b	Fully automated vehicles	Multitasking during travel	Onboard activity type: work Onboard activity type: leisure			Decrease ×	
Dannemiller et al. (2023)	A1 A2a A2b	Fully automated vehicles	Multitasking during travel		Increase	Increase		
Debbaghi et al. (2024)	A1 A2a	Fully automated vehicles	Multitasking during travel Temporal flexibility Fragmentation	Low commitment of the survey influences the adoption of the three TUPs.	×			
Hamadneh and Esztergár-Kiss (2022)	A1 A2a	N.A.	Multitasking during travel					Higher share of Avs
Hardman (2021)	A1 A2a A2b	Partially automated vehicles	Multitasking during travel			Increase		Higher share of Avs
Pudāne et al. (2019)	A1 A2a A2b	Fully automated vehicles	Multitasking during non-travel Multitasking during travel		Increase or no change	Increase or no change		
Jia et al. (2022)	A1 A2a	Fully automated vehicles	Multitasking during non-travel[2]			Increase		
Kolarova et al. (2019)	A1 A2a	Fully automated vehicles	Multitasking during travel	Trip purposes: work Trip purposes: leisure or shopping			Decrease ×	
Kolarova and Cherchi (2021)	A1 A2a	Fully automated vehicles	Multitasking during travel				Decrease	
Kim et al. (2020)	A1 A2a	Fully automated vehicles	Multitasking during travel Temporal flexibility		Increase	Increase		
Lehtonen et al. (2022)	A1 A2a A2b	Partially automated vehicles	Multitasking during travel	Onboard activity type: work Onboard activity type: leisure	× Increase	× Increase		
Malokin et al. (2019)	A1 A2b	N.A.	Multitasking during travel					Higher share of AVs
Rahman et al. (2020)	A1 A2a	Fully automated vehicles	Temporal flexibility		Increase			

[1] We identify the fully automated vehicles as SAE level 5, which has no steering wheels, pedals, or other controls for human drivers because they are designed to operate without human intervention. The automation level under 5 is regarded as partially automated.

[2] Some may argue that AVs also have spatial flexibility for parking locations, however which is the secondary effect enabled after multitasking during non-travel.

Data availability

Data will be made available on request.

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