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Multimodality and sustainable transport: a critical perspective

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Abstract

Sustainable transport research and policy making currently identify multimodality as an important way to reduce carbon emissions and other negative transport externalities. This emphasis is consistent with the 'behaviour change agenda' for sustainable mobility, which places responsibility for changing behaviour on 'citizen-consumers', while policy makers help them make 'better' modal choices, rather than introducing regulatory or pricing measures. In this paper, we present findings based on the British National Travel Survey, which lead us to qualify the emphasis currently placed on multimodality. We first focus on the relationship between multimodality and CO_2 emissions, at the individual and trip level. While multimodal trips produce less CO_2 than unimodal trips over comparable distances, they are typically longer and therefore have higher average emissions. At the individual level, there is an association between greater multimodality and lower emissions, although of weak magnitude. Second, we investigate trends in multimodality between 1995 and 2015. Contrary to expectations, we find that individual-level multimodality has decreased over time, notably among younger adults, and this during a period of declining car travel distances per capita. We conclude that there is merit in encouraging greater multimodality, but this can hardly be the only or primary goal of sustainable transport policies. More policy attention needs to be directed to the pivotal role of high levels of travel activity, and the reduction of these.

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1 Introduction

In current sustainable transport policy and research, the term ‘multimodality’ is on everyone’s lips. For example, the European Commission proclaimed 2018 the ‘year of multimodality’, with an aim to “reducing CO_2 emissions, congestion and air pollution to improve the quality of life of European citizens and to reach the goals set by the Paris Agreement” (European Commission, 2018). In Germany, increasing multimodality is one of the key goals of the 2018 Berlin Mobility Act, which aims to make the city “safer, more mobile and more climate-friendly” (Senatsverwaltung für Umwelt, Verkehr & Klimaschutz, undated), and is often mentioned in the urban mobility plans of cities all over the country. Scientific attention has also increased over time: a Scopus search for journal articles on multimodality and sustainability in passenger transport[2] shows a surge of research interest in the last decade (out of 345 articles retrieved, 91% were published since 2009).

Our key argument in this chapter is that the current debate on multimodality and sustainable transport would benefit from adopting a more critical perspective[3]. Notably, our impression is that the current debate too often relies on three largely unproven assumptions:

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[2] Search conducted on article titles, abstracts and keywords on 2nd October 2019, search string: “multimod* AND transport* AND sustainab* AND NOT freight”.

[3] While the concept of sustainability is notoriously ill defined, it is generally seen to include three dimensions: economic, social and environmental. In this chapter, we refer specifically to the

- Multimodal travel patterns are less polluting than unimodal travel patterns;
- Multimodality is increasing in developed countries;
- This increase in multimodality is particularly pronounced among young adults.

The first assumption is based on a 1:1 substitution perspective, i.e. it envisages a scenario where current car-dependent travel patterns are replaced by a more balanced mix of modes, while other travel pattern characteristics (trip frequency, destinations, travel distance, etc.) remain unchanged (e.g. Gebhardt et al. 2017). While such a scenario is clearly desirable, the literature offers little evidence to support or refute the claim that, in practice, multimodal travel patterns are less polluting than unimodal ones (for a detailed literature review see Heinen and Mattioli, 2019b). Moreover, changes in travel behaviour are often no simple full shift from one mode to another (Heinen et al., 2017). We note a similar lack of robust evidence to support the assumption that levels of multimodality have increased in recent years, and that younger generations are leading the way in this development (for a detailed literature review see Heinen and Mattioli, 2019a).

This chapter builds on and brings together findings from two recent empirical studies (Heinen and Mattioli 2019a, 2019b), where we have tested these three assumptions based on the National Travel Survey (NTS) data for England. Before moving on to presenting the dataset and the empirical findings, in the next section we provide a more precise definition of what 'multimodality' means, to allow a discussion on this topic based on clear understanding of various definitions.

2 What do we mean by multimodality? A conceptual clarification

There now exists a substantial body of literature on multimodality (see e.g. Heinen and Chatterjee, 2015; Kuhnimhof et al., 2006; 2012; Nobis, 2007). The term 'multimodal' is used variously "to describe properties of the transport system, of specific services, or of travel" (Kuhnimhof et al., 2006, p.40), as well as associated personal attitudes (see e.g. Diana and Mokhtarian, 2009). Most commonly though, 'multimodality' is used to refer to *travel behaviour*, i.e. the use of multiple transport modes. This is the understanding adopted in this chapter.
Even in the travel behaviour domain, the term is used in various ways. We believe that this is the source of much confusion in the current academic and policy debate, and with this chapter aim to provide the basis for a more rigorous discussion.

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environmental dimension of sustainability, which is generally emphasised in accounts of sustainable mobility (e.g. Banister, 2008).

We argue, in particular, that the concept can be used to refer to three different levels of analysis, which are often confused, or not clearly distinguished in the literature (Table 1). First, at the *aggregate* level, multimodality is the attribute of a population group (e.g. older people, or the residents of a city or country). In this understanding, multimodality is essentially equivalent to a balanced modal split. Second, multimodality can also be used as an *individual* attribute, referring to the travel patterns of a particular person, and to the extent to which he/she has used different transport modes over a given time frame. Third, at the *trip* level, the term refers to the use of multiple transport modes for the different stages of a single trip – also sometimes referred to as *intermodality*.

Type of multimodality / level of analysis	**Definition**	**Also referred to as:**	**Empirical studies (examples)**
Aggregate-level multimodality	Attribute of a population group where the aggregate number of trips is rather evenly split between different modes	(Balanced) modal split	Kuhnimhof et al. (2012)
Individual-level multimodality	Attribute of a person who uses a variety of modes in their travel behaviour (as observed over a given time frame)	Multimodality	Heinen and Chatterjee (2015): Kuhnimhof et al. (2006); Nobis (2007)
Trip-level multimodality	Attribute of a trip that consists of more than one stage, i.e. it involves the use of multiple modes	Intermodality	Gebhardt et al. (2017)

Tab. 1: Proposed conceptualisation of different levels of analysis for multimodal travel behaviour. Based on Heinen and Mattioli (2019a; 2019b).

Crucially, the three levels require separate analysis, as they are only loosely related to each other. This can be illustrated with an example. Consider the fictional case of a city where one third of the population, over the course of a year, always uses the car, one third always uses buses, and one third always walks, and all residents undertake the same number of trips. Such a city would have a high level of *aggregate* multimodality (i.e. a balanced modal split), even though each of the *individuals* living there is entirely unimodal. Similar considerations apply to the relationship between individual and trip-level multimodality as, for example, an individual can be highly multimodal even if none of his/her trips combines different modes. Conversely, high levels of multimodality on a trip level will contribute to high levels of multimodality on an individual level, and high levels of multimodality at the individual level will contribute to a more balanced modal split (on an aggregate level), even though the relationship is not deterministic (as it depends, for example, on how trips rates vary among the population).

In current debates on multimodality, the distinctions between the different levels are not always explicit, which can lead to conceptual confusion when, for example, a trend towards a more balanced modal split is interpreted as an increase in multimodality at the individual or trip level (or vice-versa). In contrast, we believe that it is crucial to be clear about what level of multimodality is under consideration at any one time.

In the remainder of this chapter, we will not focus on aggregate multimodality, as this is a much researched area already, instead we focus on individual- and trip-level multimodality. We start by discussing our data, indicators and methods (Section 3). We then present the results of our empirical study on the relationship between multimodality and CO_2 emissions (Section 4 – Heinen and Mattioli 2019b). This is the most important assumption underlying the common equivalence between multimodality and sustainable transport. In this first empirical study, we consider both individual- and trip-level multimodality. In Section 5 we discuss the findings on trends in individual-level multimodality between 1995 and 2015 (Heinen and Mattioli 2019a): here we empirically test the assumption that multimodality is on the rise.

3 Data and methods

Our analysis is based on the British National Travel Survey (NTS) (DfT, 2015; 2017), and for reasons of data availability focuses on England only. The NTS has two characteristics, which make it uniquely suited to the analysis presented here:

- all individuals in the surveyed households complete a seven-day travel diary as well as report the characteristics of their vehicles. This allows a good assessment of multimodality and CO_2 emissions, i.e. one that can be considered as representative of longer-term patterns of behaviour, especially since travel patterns are to some extent organised in weekly cycles (Buehler and Hamre, 2015; Kuhnimhof et al., 2006; Nobis, 2007). When the travel diary covers only one or two days, as is often the case in travel surveys, the analysis of individual-level multimodality is much less reliable.
- it is a long-term continuous cross-sectional survey, i.e. it has been conducted every year, with consistent survey design, since the mid-1990s. This allows us to investigate trends in multimodality.

The NTS sample size for England consists of ca. 7,000 households per year in 2002-2015 (ca. 3,000 in 1995-2001). Our analysis in this chapter uses two different samples. The study of the relationship between multimodality and CO_2 emissions (Section 4) is based on a 2015 sample of 11,887 individuals. The study of trends in multimodality (Section 5) is based on a sample of ca. 11-12,000 individuals per year for waves 2002-2015, and roughly 5,000 individuals per year for waves 1995-2001 (for more details see Heinen and Mattioli, 2019a). In both studies, our sample consists of adults (16 or older) who completed the travel diary and conducted at least one trip during the diary week.

In the research literature, individual-level multimodality is often measured using categorical indicators. Our preference is for continuous indicators, as these allow a more accurate assessment of levels of multimodality, enable correlation analysis, and take full advantage of the NTS seven-day travel diary (Heinen and Chatterjee, 2015). In sections 4.1 and 5, we measure individual-level multimodality using OM_PI, a continuous index of variability based on Shannon's Entropy proposed by Diana and Pirra (2016). OM_PI ranges between 0.0, corresponding to minimum multimodality (all trip stages in the travel diary week were conducted with the same mode) and 1.0, corresponding to maximum multimodality (stages are evenly distributed among all modes considered). For the full formula and a discussion of index properties see Heinen and Mattioli (2019a) and Diana and Pirra (2016). For the analysis of trip-level multimodality (Section 4.2), we use a categorical indicator of multimodality, distinguishing trips where a single mode has been used (i.e. the trip consists of a single stage), from those where multiple modes where chained together (i.e. multi-stage trips). A continuous indicator would be inappropriate here, as it would have a limited range, would have little variation and would be extremely skewed.

A key methodological choice when measuring multimodality is the number of different modes considered. In accordance with previous work based on the NTS (Heinen & Chatterjee, 2015) we adopt two transport mode classifications, one including three modes (car transport, active travel, and public transport (including taxi)) and another with eight modes (walking, cycling, car driver, car passenger, bus, rail, taxi, and other). Most of our analysis in this chapter present multimodality indicators based on both classifications, except for the analysis of trip-level multimodality (Section 4.2), where we use indicators based on three modes only. The broad results are robust to adopting an eight-mode classification (see Heinen and Mattioli, 2019b).

CO_2 emissions for trips and individuals were calculated based on information available in the NTS on trip stage distance, transport mode, and the $kgCO_2/km$ emission factors of household vehicles (imputed when necessary), which vary depending on vehicle make, model, engine size, etc. We used the CO_2 emission factors recommended by the UK government (DECC, 2015) for public transport modes, and some categories of privately-owned vehicles. Stages by active travel modes were assigned zero emissions[4].

For cars and other private vehicles, we used vehicle-km emission factors, which have to be allocated to passengers. For the calculations presented in this chapter, we allocated all vehicle emissions to the driver (and none to other passengers). This leads to an underestimation of the emissions of frequent car passengers, but avoids a 'leakage' of the emissions of car passengers below 16 years of age (who are excluded from our analysis). Results based on an alternative allocation method (emissions equally shared among all passengers) show slightly different CO_2 averages, but the broad findings are consistent with those reported here (see Heinen and Mattioli, 2019b).

4 Multimodality and CO_2 emissions

To test the widespread assumption that multimodal travel patterns result in lower emissions, we investigate the relationship between multimodality and CO_2 emissions. We start by focusing on individual-level multimodality, then consider the trip level.

4.1 Individual-level multimodality and CO_2 emissions

When considering three modes, roughly 55% of the 2015 NTS sample is multimodal, a share that increases to 68% when considering eight modes. This means that a substantial minority of respondents – between 32% and 45% depending on the number of modes considered – are unimodal, i.e. they use only one single mode during the travel diary week.

The Spearman's rank correlation coefficient between the continuous indicator of multimodality OM_PI and CO_2 emissions is -0.04 (when considering three modes) and +0.02 (when considering eight modes). While both estimates are statistically significant at the $p<0.05$ level, the magnitude of the association is very low, and the direction varies depending on the number of modes considered. This suggests that the relationship between multimodality and carbon emissions is weak to non-existent in the population.

When the analysis is stratified by weekly travel distance (Table 2), the results show moderate levels of correlation in the expected direction – i.e. individuals with higher levels of multimodality tend to have lower CO_2 emissions. The important exception is individuals in the lowest quintile of travelled distance (those

[4] For reasons that are set out in detail in Heinen and Mattioli (2019b), we excluded trips including air travel stages, and the individuals who had conducted such trips, from the analysis of the multimodality-CO_2 relationship.

travelling less than 35 miles per week). Among them, the sign of the relationship is reversed, with multimodality being associated with more CO_2 emissions. A possible interpretation is that, among respondents with small activity spaces, active travel and public transport use prevail, so that car use tends to be associated with both greater multimodality and higher emissions.

Distance quintiles (miles per week)	**Mean CO_2 emissions ($kgCO_2$) for distance quintile group**	**Spearman's correlation coefficients between multimodality (OM_PI) and CO_2 emissions, for respondents in the distance quintile group**	
		3 modes	**8 modes**
1st (0-35)	2.1	0.15	0.24
2nd (35-72)	7.3	-0.22	-0.22
3rd (72-126)	15.8	-0.30	-0.37
4th (126-223)	28.9	-0.28	-0.39
5th (223+)	65.2	-0.23	-0.33

Tab. 2: Spearman's correlation coefficients between multimodality (OM_PI) and CO_2 emissions, and mean CO_2 emissions, stratified by distance travelled in the diary week. All correlation coefficients have $p<0.05$ significance.

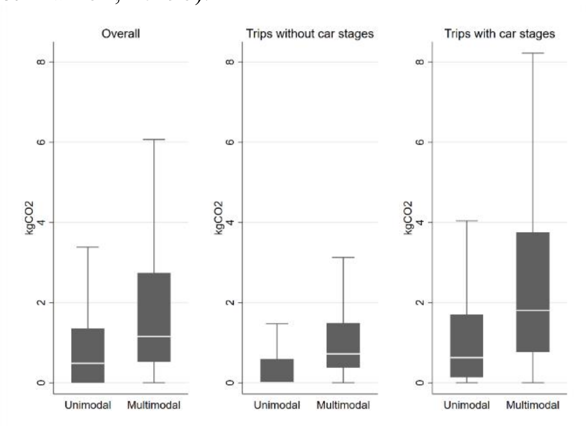
Further multivariate analysis (not reported here for the sake of brevity – see Heinen and Mattioli 2019b), broadly confirms these results: while there is a small negative association between multimodality and CO_2 emissions at the individual level, this becomes substantial when controlled for weekly travel distance. Excluding individuals who did not use the car at all during the travel week from the analysis results in slightly stronger associations but does not change the overall picture.

In sum, these findings can be interpreted as follows: among people who travel comparable distances, greater multimodality does result in lower carbon emissions. This reflect the common assumption. However, multimodal individuals also tend to travel longer overall distances with associated higher emissions, which weakens the association between multimodality and CO_2 emissions found on a population level. In other words, the fact that multimodal people tend to travel further seems to dampen the positive environmental effect of multimodality.

4.2 Trip-level multimodality and CO_2 emissions

Our analysis of trip-level multimodality shows rather similar results. Trips combining more than one transport mode are rare (3% when considering three modes) and are characterised by higher average levels of CO_2 emissions[5] (Abb.1). This finding holds whether the car is included in the modal mix or not. In other words: multimodal trips combining the car with other modes have higher average emissions than trips where the car is the only mode; and multimodal trips with non-car modes tend to have higher emissions than unimodal trips with non-car modes. Incidentally, the graph also shows that: unimodal trips by car are on average more polluting than unimodal trips by other modes; unimodal trips by car and multimodal trips without car have rather similar CO_2 emission distributions; multimodal trips including car stages tend to be the most polluting of all.

When the analysis is stratified into quartiles of travel distance (Abb.2), the relationship is reversed (except for the lowest quartile, where the median of the CO_2 emission distribution is at similar levels for multimodal and unimodal trips). This suggests that multimodality tends to result in lower emissions for trips of comparable distance. However, multimodal trips tend to be over longer distances, which explains why the opposite association is observed in the aggregate. These broad findings are confirmed by statistical tests of means differences and multivariate regression analysis (not reported here for the sake of brevity – see Heinen & Mattioli, 2019b).



[5] Our analysis included short walks (i.e. of less than one mile) as well as longer walking trips, and weighted both appropriately, so in our definition multimodal trips include e.g. those consisting of a walk to the bus stop followed by a trip by bus.

Abb. 1: Box plots of the distribution of CO_2 emissions for unimodal and multimodal trips (OM_PI indicator based on three modes), stratified by car use. Note: the upper whiskers of the box plots represent the upper adjacent value, corresponding to the largest observation that is less than or equal to the upper inner fence (i.e. the third quartile plus 1.5 the value of the interquartile range).

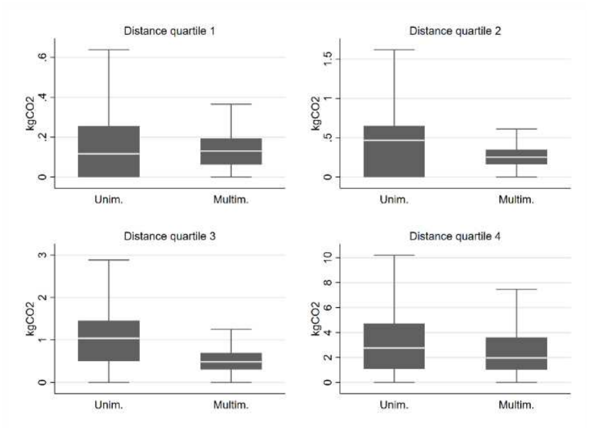


Abb. 2: Box plots of the distribution of CO_2 emissions for unimodal and multimodal trips (OM_PI indicator based on three modes), stratified by distance. Note: the upper whiskers of the box plots represent the upper adjacent value, corresponding to the largest observation that is less than or equal to the upper inner fence (i.e. the third quartile plus 1.5 the value of the interquartile range).

5 Trends in multimodality

The second part of our empirical analysis looks at historical trends in individual-level multimodality. The goal is to test the common assumption that multimodality is increasing, and this particularly among younger adults – as is sometimes implied in debates e.g. on 'peak car'. The graphs in this section show mean values of individual-level multimodality for 21 annual data points (1995-2015).

The results show that, looking beyond annual fluctuations, the multimodality of individuals was on average lower in 2015 than two decades earlier – regardless of whether three or eight transport modes were considered (Abb.3). An even more pronounced decline is observed among younger adults (16-30 years old), particularly since the year 2000 (Abb.4). While absolute levels of multimodality are higher for this age group than for middle and older adults, differences between age groups seem to be losing importance over time.

It is also interesting to note that the only age group where multimodality has increased over time (at least when considering eight transport modes) is older people (aged 65 and over). This goes against the common wisdom but may be explained as follows: while car ownership and use were traditionally lower among people of retirement age, they have caught up with the rest of the population since the 1990s. Second, the disposable income of those aged 65 and over have increased in the last decade, and as a result this group travels more frequently and to a wider variety of locations. Third, the current generation of older individuals is perhaps in better health, which allows them to use a greater variety of modes. As a result, older people today use on average a greater variety of modes than they did in the 1990s – although this is not associated with 'greener' travel behaviour.

The findings presented here are broadly confirmed by more in-depth analysis, including sensitivity tests with alternative multimodality indicators, and multivariate analysis (not reported here for the sake of brevity – see Heinen and Mattioli, 2019a).

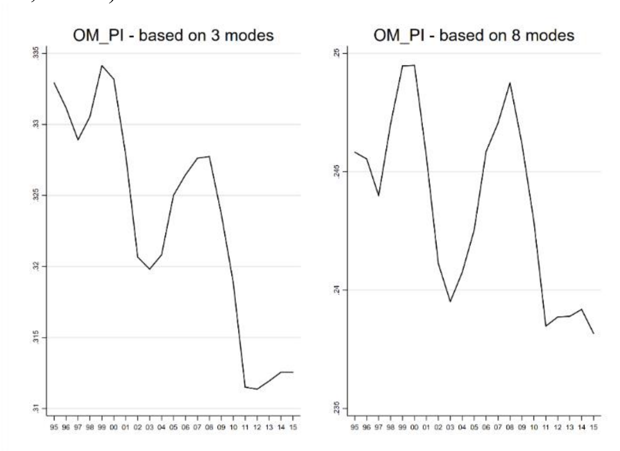


Abb. 3: Trends in multimodality 1995-2015 (OM_PI indicator based on three and eight modes). For ease of representation, the time series are smoothed, i.e. each point represents the centred moving average of three consecutive years.

While multimodality has decreased in England since the 1990s, this has not been accompanied by an increase in car use (Abb 5). In 2015, car trip rates and travel distances per capita were roughly 10% lower than they were in 1995, reflecting a broader trend towards the saturation or decline of car use ("peak car") in developed countries (Bastian et al. 2016). The modal share of the car is roughly 5% higher in 2015 than in 1995 (when calculated on the basis of the number of stages), but has declined since 2002 and, when calculated in terms of travel distance, has decreased by roughly 5%.

Overall, our analysis suggests that, contrary to expectations, English residents (and particularly younger adults) have become less multimodal since the 1990s. Interestingly, this development was not accompanied by an increase in levels of car use, as this has decreased according to most indicators.

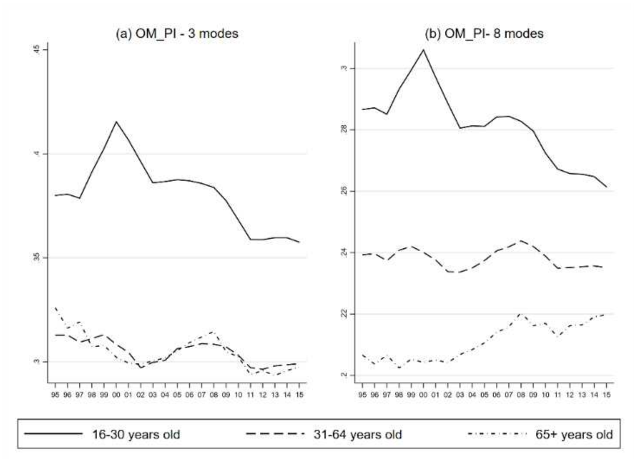


Abb. 4: Trends in multimodality 1995-2015 (OM_PI indicator based on three and eight modes), stratified by age. For ease of representation, the time series are smoothed, i.e. each point represents the centred moving average of three consecutive years.

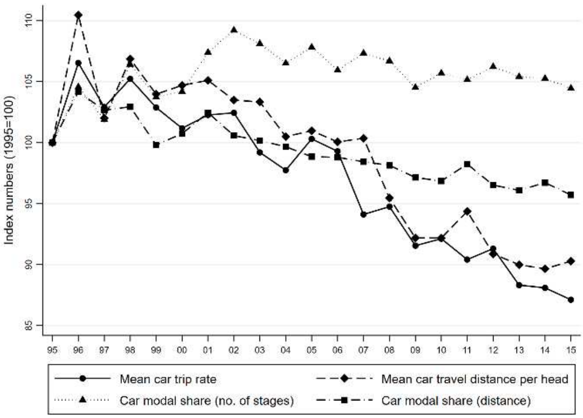


Abb. 5: Trends in car use 1995-2015 (index numbers – 1995=100)

6 Discussion

A reduction in car use and a shift to more sustainable modes of transport would have many societal benefits. Multimodality, whether at a trip- or individual-level, has the potential to contribute to this aim. This chapter aimed to provide an evidence-based discussion of the merits of and trends in multimodality. Three assumptions specifically had not yet received sufficient scrutiny.

First, it is often assumed that multimodal travel patterns are less polluting than unimodal car travel patterns. Our findings only partially supported this assumption. Among individuals who travel over similar distances, those who are more multimodal emit on average less CO_2 compared to those who are less multimodal. Similar findings are present on the trip level: trips over a similar distance that are multimodal are less polluting than unimodal trips. However, multimodal trips and individuals are associated with longer travel distances. As such, multimodality is only associated with very small CO_2 reductions among individuals, and with CO_2 increases on a trip level. Overall, this suggests that travel distance is a more important factor than multimodality for climate change emissions.

Second, multimodality is often assumed to be on the rise in developed countries – notably in recent debates around peak car, new 'smart' mobility services and the Mobility as a Service (MaaS) concept. Our analysis showed that this assumption is incorrect for England, where average levels of individual-level multimodality are actually decreasing, and largely unrelated to aggregate levels of car use. Third, this assumed increase in multimodality is often expected to be particularly pronounced among young adults. Our findings actually showed the opposite. If there is any trend visible, it is that younger people nowadays are less multimodal than in the past. Taken together, our findings on travel behaviour trends suggest that reductions in per capita car use levels (such as those that have taken place in England since the 1990s) do not necessarily require an increase in individual- or trip-level multimodality.

While our analysis is based on data from England, it is likely that similar results would be found in comparable countries as, to date, the findings of multimodality research have been largely aligned between OECD countries. For example, the correlates of multimodality are fairly similar between the UK, Germany and the US (Heinen and Chatterjee, 2015) – even though trends in car use per capita have diverged (Bastian et al., 2016). While our results have not been corroborated in other countries, similarity in other findings may imply that their validity is not limited to England. Reichert and Holz-Rau (2018), for example found a positive association between individual-level multimodality and climate impact among the residents of large German cities.

More broadly, the aim of this chapter is to advocate for the adoption of a more critical *perspective* on multimodality, something which goes beyond specific countries or case studies. Even assuming for the sake of argument that our findings were unique to England, the general point would still hold that individual-level multimodality is not *necessarily* increasing over time, and is not necessarily associated with substantially lower CO_2 emissions. We argue therefore that, in the absence of robust evidence, such assumptions should be avoided in future research (irrespective of the location).

7 Conclusion

If the three assumptions tested in this paper do not hold (or do not hold entirely), then why does multimodality draw so much attention from sustainable transport researchers and policy-makers? A possible explanation is that multimodality provides a convenient narrative for those wanting to avoid more controversial discussions on how to achieve sustainable transport. The very notion of multimodality frames the problem as one of providing travellers with better access to non-car modes, while also emphasizing how these can be combined with car use (rather than entirely substituting for it). The emphasis is on sustainable policy ‘carrots’, rather than potentially more controversial ‘sticks’ aimed at reducing car use, such as regulatory or pricing measures.

This is consistent with broader ‘behaviour change’ and ‘citizen-consumer’ approaches to sustainable consumption (Barr et al., 2011; Barr & Prillwitz, 2014; Shove, 2010). In this perspective, the policy makers’ role is “helping people to make better choices" through the expansion of consumer choice sets, while (environmentally-motivated) 'citizens-consumers' are ultimately responsible to change their behaviour. This approach has been criticised for being ineffective, as well as for shifting attention away from structural and political determinants of unsustainable consumption (Akenji, 2014; Shove, 2010).

Our findings are consistent with this criticism, as they suggest that encouraging greater multimodality will not be sufficient on its own to achieve significant emission reductions at the required scale and speed. While we should continue researching and stimulating multimodality, this needs to be complemented by additional policy and research efforts on 'taboo' topics such as curbing travel activity and distance. Distance in particular seems crucial. Over the past centuries, efforts have been made to increase our travel speed and connectivity, and as a result we travel further distance. Our findings show that distance is directly linked to emissions and cannot be (completely) compensated by other behavioural adjustments.

Part of the problem with the current debate on multimodality is that it tends to adopt a 1:1 substitution perspective, envisaging that current car-dominated travel patterns will be substituted by a combination of modal alternatives, while other factors remain constant. There are plenty of historical examples to show that such assumption is naïve: the introduction of faster modes of transport has not reduced travel time, as travel and settlement patterns have adapted to greater speed. Similarly, greater use of information and communication technology has not resulted in lower levels of travel (as sometimes hoped).

Efforts to promote greater multimodality might have the same fate, if better provision of modal alternatives is used to travel more or further, rather than to substitute for car travel. For example, provision of park and ride facilities at the edge of cities might incentivize household relocation to periurban areas, resulting in more multimodal trips over longer distances, with uncertain impacts in terms of CO_2 emissions. While our analysis does not demonstrate that these developments are actually happening, it does provide evidence of a (cross-sectional) association between multimodality and longer travel distances. At the least, this suggests that the benefits of greater multimodality can be undone by greater levels of travel activity, although further (longitudinal) research is required on this point.

Overall, our contention is that we need a more critical approach to the study and promotion of multimodality, i.e. one that considers the limits and possible unintended consequences of such a policy approach. Similar arguments have been put forward for other sustainable transport 'buzzwords' such as vehicle automation (Wadud et al., 2016), 'smart mobility' (Docherty et al., 2018), and 'Mobility as a Service' (Pangbourne et al., 2020) – many of which are inherently linked to multimodality.

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