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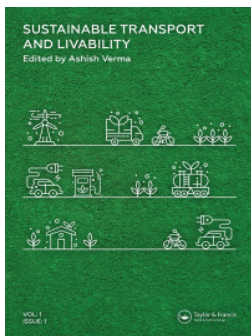
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Rethinking accessibility in a post pandemic, net zero world

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ABSTRACT

Most measures of accessibility depend on the specific context for which they are used. This paper explores the way measuring accessibility needs to change to meet the needs of equity both across communities and across generations. The accessibility of a place needs to reflect the accessibility faced by all individuals at that place. Including equity in investment appraisal raises the problem that implicit lower values of time for certain groups can lower the value of investments making improvements to transport in poorer areas more difficult to justify. The Covid-19 pandemic led to reductions in peak-hour traffic and the decentralisation of residential location as working from home increased. The move towards net-zero affects mode choice and changes infrastructure needs. In the longer term, however, this will require a recalibration of mobility needs and housing needs as the cost of movement rises to meet these new challenges. The paper explores the need to redefine both the economic mass to which access is sought and the deterrence effect of space recognising that this will need to reflect the different circumstances of individuals and households. Accessibility is ultimately a reflection of the general equilibrium of labour, housing and transport markets.

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1. Introduction

The concept of accessibility lies at the core of understanding how transport provision affects mobility. Whereas the focus in much earlier research was on mobility, increasingly the focus has shifted towards a concern with accessibility (e.g. Handy, 2020). Changes in accessibility form the basis of appraising the benefits of changes in transport provision through investment. How to measure accessibility has a long history and most measures relate to a specific context

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rather than being a context-free measure like time, distance or speed. Most measures have certain elements in common, however. They depend on the ease of reaching a relevant set of opportunities from a given location, often rendered in some form of a gravity equation where the opportunities (or economic mass) are deflated by the distance to those opportunities. Distance may be measured in the form of linear distance or time or generalised cost. But accessibility thus depends on the relevant range of opportunities for the activity in questions; it may differ for work, shopping and leisure activities and work opportunities will depend on an individual's qualifications, skills or training. Generalised cost will vary between different modes. The other dimension that has been introduced here is the way the accessibility of a place may not reflect the distribution of accessibilities for households or individuals at that place. This will depend on their work characteristics, their household responsibilities, and the availability of different modes of transport. Any final measure of accessibility will depend on how these various dimensions can be aggregated to get a single measure of accessibility. Maybe this lies behind the concern expressed by Handy (2020) that accessibility has not achieved the same status in transportation planning as it has in the literature on measurement?

As the recognition that the accessibility of a place may not reflect adequately the accessibility faced by specific individual living at that place has increased, equity considerations have grown (Lucas et al., 2016). Inequality can depend on income, age, physical or mental ability, or responsibilities within a household. This inequality is becoming recognised in investment appraisal but can be double-edged as the implicit lower values of time for certain groups as conventionally measured can lower the value of investments designed to improve accessibility. Hence improvements to transport serving poorer areas may be more difficult to justify on conventional measures. This includes areas with lower employment rates and higher proportions of disadvantaged individuals, and rural areas, where those without access to a car face difficulty in accessing essential services which are often themselves being reduced or concentrated in areas with larger local population.

Against this background there are two new factors which may change the requirements for a useful measure of accessibility. The Covid-19 pandemic saw a large reduction in the use of mass public transport, which in many areas has struggled to regain pre-Covid levels. Working from home for at least part of the week has seen big reductions in peak-hour traffic although this is countered to some extent by a tendency towards decentralisation of residential location and thus longer commuting journeys. Similarly, the trend towards more on-line shopping, including for weekly groceries, has also changed patterns for travel for that purpose. This implies the need to recalibrate the relevant economic mass to which access is sought.

The second factor is the pressure to move towards net-zero in terms of greenhouse gas emissions. This initially affects mode choice with an increasing emphasis on more efficient public transport modes. The move towards zero-emission vehicles such as electric cars and vans requires a completely new infrastructure for charging which has in many countries failed to keep pace with the demand. In the longer term, however, this will not be just about choice of mode but also about a recalibration of mobility needs and housing needs as the cost of movement rises to meet these new challenges. This brings the conflict between mobility and accessibility into sharp relief.

This paper explores these challenges, reviews possible solutions and assesses the implications for transport investment appraisal to meet the needs of equity both across communities and across generations.

2. Concepts of accessibility

The relevance of accessibility to an understanding of both the demand for transport, or more widely mobility, and the evaluation of changes in transport provision has a long history. There are elements in the work of Dupuit (1844) and the search for a robust means of measuring the price of overcoming separation through improved transport has continued. Many of the early statements are essentially vague and it was the need to make more precise definitions to assist the development of formal transport models and appraisal methods that led to a growth in the discussion of accessibility in a more formal way from the late 1950s. Following the work of Carrothers (1956), Hansen (1959) and Wilson (1971), I made an early contribution to the discussion (Vickerman, 1974) and have recently returned to thinking about the historical development of the role of pricing in transport (Vickerman, 2023, 2024). This coincides with a renewed interest in ensuring appraisal methods in transport are consistent with both economic theory and a growing concern for methods that incorporate the distributional concerns of the transport justice debate. Two recent Round Tables of the International Transport Forum have addressed these concerns (ITF, 2020, 2022).

Geurs (2019) has summarised a useful typology of accessibility measures as: infrastructure-based, location-based, utility-based, and person-based. The typology shows a gradual move from a purely transport planning concept of the effect of a change in generalised cost on traffic flow/demand and the implicit consumer surplus through a wider concern with the attractiveness of opportunities and the cost of reaching them to a more formal link with the utility of choice and a recognition that accessibility may vary considerably between different people/households at the same location. Martens (2017, 2019) has argued that this latter shift towards placing people as the central focus is a key to tackling the distributional and social justice questions implicit in planning transport improvements. Klar et al. (2023) show how different measures of accessibility can give very different outcomes in terms of the overall evaluation of projects.

Whilst it is easy to criticise simple measures of accessibility for their failure on the one hand to comply with economic theory and on the other with the social dimensions relating to households' or individuals' ability to access a range of potential opportunities, it is more difficult to define practical metrics that can be used to evaluate and appraise alternative improvement schemes that respect these concerns.

Person-based accessibility relates back to the space-time geography pioneered by Hägerstrand (1970) that plots both the time and space within which activities take place. These can be incorporated in the move away from trip-based modelling of transport towards activity-based models that explicitly focus on both the locations and time spent in activities for which transport is used (see Pinjari & Bhat, 2011, for a useful review of concepts and models).

Going further than this, linking mobility to a range of social constructs that affect mobility potential has been defined as motility (Kaufmann, 2002, 2011; Kaufmann et al., 2004). Motility offers an approach that combines the social determinants of utility with their impact on mobility and this relates directly to how a wider definition of accessibility can be evaluated. The key determinants of variations in mobility/motility are usually seen as income, gender, race and employment status, but it is also possible that household structure and within that caring responsibilities can have distinct impacts on outcomes (see Hu et al., 2023, for a critical review of the issue).

Zamorano and Galilea (2022) propose a set of household typologies to help in the analysis of what they term "care mobility". This covers a range of activities including caring for others, including children, shopping, and housework, some of which generate a specific type of mobility and others constrain mobility for other activities. This approach demonstrates that a simple classification by gender loses the richness of the diversity of household types, particularly when mobility generated by caring activities is concerned. Porath and Galilea (2022) examine the characteristics of female caregivers' mobility patterns. They point out that security issues and the time taken for journeys using a combination of walking and public transport often make journeys more difficult for women within the time available given their care responsibilities. This constraint on mobility means that women frequently are unable to make journeys to satisfy their own personal needs. This consideration of what is called care (im)mobility reinforces the view that transport disadvantage cannot be analysed by reference to simple geographical area averages or single personal characteristics such as gender or disability but is a more complex multi-dimensional problem that can only be adequately analysed by a much deeper understanding of the various crosscutting elements at a household level (Vickerman & Gee, 2024).

But if any of these considerations are to have an impact on how we evaluate attempts to improve accessibility for disadvantaged groups, there is still the need for an objective, operational measure. Shiftan et al. (2021) explored a range of socio-economic based accessibility indicators to assess the impact of a

proposed new metro and alternatives in Tel Aviv (see ITF, 2022). Using the results of estimated accessibility impacts on different socio-economic groups it was shown how it was possible to effect a form of levelling up with greater gains for lower socio-economic groups. However, it was suggested this analysis should be kept separate from an overall cost-benefit analysis where these differences would be less obvious. In a long-term study of the impact of accessibility improvements via public transport Vigié et al. (2023) showed that whilst the initial impact was fairly neutral in terms of access to job market opportunities, through time relocation of both households and employment led to larger gains for richer households.

The problem with accessibility measured by a physical measure is that it cannot easily be aggregated across individuals or used to determine the benefits from changes in transport provision. The usual way in which user-benefits from transport projects are incorporated into appraisal is through the value of travel time savings (VTTs). This aggregation of accessibility across individuals might therefore imply that we need a disaggregation of travel time savings and the use of different values for different groups. Relating values of travel time savings to income may result in valuing schemes which benefit richer people more than those that benefit poorer people. There is a large literature debating the merits and demerits of such a system (for an empirical assessment see Guzman et al., 2023). Börjesson and Eliasson (2019), in a review of this issue, identify that variations across travel times, trip lengths, travel modes and trip purposes may be more important in defining different marginal utilities of time savings.

3. Changes post covid-19 pandemic

There are three main impacts of the Covid-19 pandemic which cause us to reconsider conventional views of accessibility: changes in working practices, changes in attitudes to the use of public transport and a move to relocate to less densely populated or more rural locations. It is clearly too early to be certain as to whether or how long it will be either to return to a pre-pandemic norm or to stabilise at a new equilibrium, but some trends are discernible (see Vickerman, 2021, for an earlier view of potential longer-term impacts, but there is a growing literature from around the world on observed changes, see for example Hensher et al., 2023 for a study in Australia).

The practice of working from home that became prevalent during the lockdowns experienced in many countries has clearly continued into the post-pandemic era albeit in a less extreme form with many office workers only going to their previously normal place of work on two or three days a week. Whereas commuting journeys had previously clearly dominated measures of accessibility, in the new situation a rather wider range of activities and destinations could become relevant as more flexible working dominates. Evidence from public transport operators across the world (Transport Strategy Centre, 2023) confirms

that whilst, with the exception of the Americas, overall public transport ridership in cities has gradually grown back to between 80 and 100 per cent, and in some cases more than 100 per cent, of 2019 levels, weekday peaks remain consistently below pre-pandemic levels and weekend ridership has generally grown back faster. Similarly, in many countries longer distance, non-commuting, journeys have shown stronger growth.

The flattening of the peak may reflect two changes. One is a move to more flexible working in which the availability of on-board wi-fi enables working on the commuting journey. This may allow workers to arrive at the place of work later, or leave earlier, whilst continuing to work on the journey. The second is a possible desire to avoid crowded public transport vehicles as the perception of both aerial and tactile transmission of infection (see Anupriya et al., 2022, for some evidence on transmission effects) has led to an attempt to avoid the most crowded services (Hörcher et al., 2022). Bansal et al. (2022) provide some evidence of the way perceptions of crowding change ridership through time. During the height of the pandemic there was some evidence that private car traffic did show less reaction, although this was also affected by the response of public transport operators in reducing service levels to match demand or imposing social distancing on board vehicles.

Relocation of both residences and workplaces is until now a more speculative and, if real, longer-term process. If there is confirmation of a tendency towards a lessening of concentration in core city areas and a move towards less dense suburban or rural locations this could have significant impacts on overall levels of accessibility. Less dense concentrations of population or employment are more difficult to serve efficiently by public transport, particularly mass transit services such as metros or other rail services. This may reduce levels of accessibility as service levels reduce, a process reinforced by an increasing switch to private means of transport, whether private car or active transport such as cycling (including e-bikes) or walking. Such shifts discriminate particularly against certain groups, the less wealthy, the less physically able etc. These trends have become particularly pronounced in rural areas as the availability of public budgets to support what are perceived as uneconomic services has been reduced at the same time as economic pressures towards increasing concentration have reduced the supply of banks, post offices, health services etc in these locations. In the UK the number of registered bus routes has fallen by almost a half since 2010, most happening after 2019 and with the biggest fall of 17.5% between 2022 and 2023 (Traffic Commissioners for Great Britain, annual). The number of passenger journeys by bus fell by around 40% from 2010, with a steady decline until 2019 and then a significant fall during the pandemic with numbers only returning slowly. The number of buses fell by around 18% over this period (Department for Transport, 2023). Although Covid has accelerated the trend it was already well established before the pandemic. Such changes discriminate particularly against certain groups, the less wealthy,

the less physically able etc., at the same time as economic pressures towards increasing concentration have reduced the supply of banks, post offices, health services and similar services in the locations less easy to serve effectively. It is notable that the use of concessionary travel passes (mainly for older or disabled passengers) has fallen by 36 per cent post-pandemic (Chartered Institute of Logistics and Transport (CILT), 2023).

This gives us a set of contradictory pressures with the search for cost savings leading organisations to want to increase the concentration of services into larger operations at fewer locations, but those locations being deconcentrated spatially. This potentially reduces the traditional view of agglomeration with firms seeking externalities and is part of the process which Venables (2017) has referred to as “expanding cities and connecting cities”. Better inter-city communications enable firms to interact effectively with firms in other cities without being physically close, a process aided by the substitution of virtual communications (including working from home and virtual conferences) for in-person meetings. Whilst this may work for business-to-business connectivity it imposes costs on consumers wanting in-person contact with firms, and potentially on the firm’s labour force. The expanding city (in the Venables model) may be better connected with its competitors but less well connected internally. This deconcentration of the expanding city imposes differential costs on individuals and groups with different accessibilities.

This suggests that the relevant components of accessibility are changing for both work and non-work journeys that will have implications for the willingness to pay and the evaluation of individual trips and hence on appraisal. Changing journey lengths, changing perceptions of crowding and security and changing implicit values of time all have an effect and will have differing effects on different groups of people. But this may not involve a simple transfer of value from centre to periphery. Schouten and Kawano (2024) suggest from a study of real estate prices in Tokyo that properties with lower access to transit facilities showed stronger price growth than in previous periods, but this did not detract from continuing growth in better accessed locations.

4. The effects of net-zero

The commitment by most developed countries to achieving net-zero by dates between 2035 and 2050 as a response to global climate change also poses issues for future accessibility. The question is again largely one of distributional problems. There are two main issues here: the costs of upgrading the vehicle fleet to reduce emissions and the impact on mobility.

The move towards low or zero emission vehicles is already underway in both private and public transport with the electrification of rail modes, the introduction of hybrid buses and cars using both internal combustion and electric motors and the move towards fully electric vehicles or alternative fuels such as hydrogen

power. Given the additional cost of such vehicles due both to the adoption of new technologies and the cost of raw materials such as for batteries governments have tried to encourage switching through various incentives such as grants for purchase and discounts on annual taxation. Public budgets also suffer from the reduction in revenues from traditional fuel taxes. These incentives for the private buyer are gradually being withdrawn in many countries and the loss of fuel tax revenues is leading to greater pressure towards the introduction of general road pricing schemes. Similarly grants towards bus operators to help in the transition to electric fleets are important (Wang et al., 2024), but such grants may be likely to be more limited after the initial adoption. The problem constraining the switchover for private vehicles is also the failure of the necessary charging infrastructure to keep pace with the size of the fleet (Globisch et al., 2019). Here the usual accessibility issue arises as those living in housing with dedicated car parking on private drives can install charging equipment and charge overnight, those in denser residential areas without a dedicated parking space or garage will need to rely on public charging points which may be faster but more expensive and subject to congestion (Gan, 2023).

There is also a move towards the creation of low emission zones in congested urban areas. These restrict free entry to vehicles which meet specific criteria and impose additional charges on those which do not. The evidence on their effectiveness as a stand-alone policy is mixed (Ma et al., 2021; Prieto-Rodriguez et al., 2022), but as part of a coherent set of pollution reducing ensures they have their place. Since older and more polluting vehicles are often owned by those with lower incomes and such individuals are often also more likely to have jobs with hours of work or locations outside the normal hours for convenient public transport, this presents a further reduction of accessibility. Scrappage schemes that provide a financial incentive to replace older vehicles may help but still require a significant outlay by those seeking to take advantage of such schemes. The key problem here is the mismatch between mobility needs and the demands of pollution reducing schemes. This reflects a further way in which conflicts of interest arise that is not sufficiently met in policy decision making. The interests of different stakeholder groups may reflect their economic power rather than their needs.

The introduction of zero-emission buses requires a consistent approach between the different actors involved in both the planning and operation of local transport (Åslund & Pettersson-Löfstedt, 2023; Hensher, 2021) The cost of zero emission vehicles for public transport services may also restrict their use to denser routes where revenues are sufficient to make them economic. Maintaining lighter trafficked routes may require even larger subsidies that often results in routes being abandoned. These are more likely to be in already poorly served rural areas. Different policy objectives come into conflict with the unintended consequences of other policies the cost of which needs to be factored in.

The transition to a net-zero economy has profound implications for transport as the biggest polluting sector. These changes will affect both public and private transport and seem likely to have an impact on mobility and the accessibility costs faced by different groups in the population.

5. Dealing with accessibility concerns in appraisal

Appraisal typically focuses on the easily measurable impacts of transport improvement, dominated by time savings and reductions in accident costs as for example in the UK Transport Appraisal Guidance (Department for Transport, 2022). Time savings in particular pose distributional problems but as Shifftan et al. (2021) and others have shown it is possible to refine such accessibility measures to allow for the distributional impact. But this only goes part of the way to reflect the factors discussed above. The traditional appraisal approach is rooted in a partial equilibrium model that focuses only on the demand and supply in the transport sector and assumes that the rest of the world is under conditions of perfect competition so that any changes in the price/cost of transport are passed directly through into the cost of transport using sectors. If we move to the general equilibrium setting implicit in the introduction of wider economic impacts, it is not just a question of applying distributional weights but requires a deeper examination of the way accessibility changes impact on welfare more widely than just the direct transport users.

The question thus arises as to whether the changes in accessibility implied by the above discussion of the impacts of the Covid-19 pandemic and the push to net-zero lead to changes in the approach to accessibility in appraisal. If, as suggested, the changes implied lead to a widening of the variation in accessibility experienced by individuals and households then it seems imperative to question the validity of simple area-based measures of accessibility as the basis for the changes in welfare resulting from a transport improvement. Since time savings typically comprise the majority of welfare gains to the user in appraisal, allowance for the variation in the value of such savings between individuals for each journey purpose, or for a given individual between different journey purposes, and in both through time is a critical step.

The wider economic impacts literature has focussed primarily on the way transport improvements can impact on productivity through accessibility-induced changes in agglomeration (Graham, 2007; Graham et al., 2022; Venables, 2007), but this does not allow for the more dynamic effects operating through relocation and changes in urban form (Glaeser, 2022). Venables (2017) has explored the ways that such changes may operate within and between cities. The question here is whether the changes in workplace post-pandemic have changed the agglomeration impacts of improving accessibility. The implication here would be that effective density or economic mass may be less important. However, the empirical evidence is largely anecdotal and has been changing

quite rapidly as first there was seen to be a reduction, particularly in office work-space in city centres, but more recently this trend seems to have been stopped if not reversed with a move to a return to office working at least on a minimum number of days per week. Delbosc and Kent (2024) summarise research that has been carried out and look particularly at the extent to which employers have accepted the concept of working from home as a normal part of the employee contract and the impact that has had on commuting. Hensher et al. (2021) considered evidence from the earlier stages of the pandemic on the likely impact on the value of time for use in appraisal suggesting that it implies an increase in the value. Gong et al. (2024) have modelled the joint impact on residential location and commuting choice showing how decentralisation that might increase commuting costs can be mitigated by working from home or telecommuting. Caulfield and Charly (2022) have explored the potential of a middle way in which remote working hubs closer to a residential location can obviate the need to travel to a major centre but provide the range of facilities normally found in an office. This might imply a fragmentation of the economic mass with some loss of agglomeration benefits but avoiding a complete loss whilst increasing the welfare of workers by reducing commuting time and cost.

The dynamic effects operating through the growth of new firms and the relocation of existing firms is an important response to changing accessibility that may either reinforce the agglomeration effect on productivity or in some cases operate in a different direction. The unpredictability of such changes is consistent with the new economic geography models developed by Krugman (1991) and Fujita et al. (1999). Whilst these models show that improved transport can have either centralising or decentralising effects, they do not fully consider the second-round consequences of any resulting changes in accessibility for residents of gaining or losing cities. In part this is because of a rather basic representation of the transport sector in terms of iceberg costs (the transport of goods is shown as equivalent to a loss of value from the factory gate cost to the delivered price at the destination) rather than allowing for the generalised cost including the cost of time and other factors affecting the transport choice more familiar from passenger transport models.

Work on the impact of high-speed rail on firm location suggests that there is relocation relative to access to new stations (Carbo et al., 2019) although this may involve a more complicated assessment of balancing the attraction of local transport with access to the high-speed rail station (Chen & Vickerman, 2020). Recent developments of so-called quantitative spatial models that aim to fuse insights from urban economics with new economic geography (Redding & Rossi-Hansberg, 2017) offer a further new approach to this issue and have already been used to provide some insights into the impact of high-speed rail in Japan (Hayakawa et al., 2023), although the representation of the detail of the transport sector remains too basic to provide real insight into the welfare impacts necessary for a full appraisal.

6. Conclusions

The focus of this paper has been on the ways in which our understanding of accessibility has shifted from a largely geographical notion of the relative location of places that can be measured by distance or time to a more complex notion of individual or household access to activities by available means of transport. This evolution has been amplified by the impact of two major external forces, the Covid pandemic and the push towards net-zero in response to the climate crisis. These forces do not operate uniformly across the population, and they highlight many existing imbalances in the provision of transport, especially local public transport and particularly in less densely populated areas. This has serious consequences for the modelling of the effects of a change in transport provision and particularly its appraisal to reflect the changes in the welfare of both transport users and the wider community. A general equilibrium approach is needed that brings together all the elements that have a spatial dimension: labour markets, housing markets, investment decisions and above all transport. Frequently in such models the transport market is the one that is not modelled effectively, for example the reliance on the iceberg concept in new economic geography models, whereas in practice the way different modes of transport are delivered can make real perceived accessibility very different from ones based solely on distance and time costs. Developing quantitative spatial models to include a better representation of the transport sector is a useful way forward here (see Cusson et al., 2024, for an initial approach).

This has serious implications for future transport policy and raises the key question of how the governance of transport can reflect the interest of all users and potential users against a background of increasing public sector financial stringency (for a further discussion of this see Vickerman, 2021, 2024). This paper has shown that there is a considerable research agenda to update our understanding of accessibility and how it can be used in transport planning and policy. Redefining economic mass to reflect the diversification of activities and ensuring that the deterrence effect truly reflects real access to all modes is just one part of that as is a more accurate representation of the transport sector in forecasting models. Against a background of changing working practices and public sector financial constraints this will impose an ever-changing framework for analysis.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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