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Accessible accessibility research challenges

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Keywords: accessibility, future research, indicators, evaluation

Abstract

Accessibility is a key concept in the field of transport geography. There is a rich, though not very mature, body of literature on this topic which is largely application-driven. The focus in the literature is generally on methods and concept and/or on applications. Applications generally focus on *ex ante* or *ex post* evaluations of the implications for accessibility of (candidate) policy plans. An important question is which are the main challenges in the area of accessibility research? This paper aims to examine this question and provide a research agenda for the coming one or two decades or so. The focus is on putting relatively new topics on the agenda, rather than making suggestions for improvements of given accessibility indicators. The paper does not aim to provide a complete list, but rather proposes avenues for future research focusing on (1) indicators to express accessibility, and (2) evaluation. In the area of indicators the challenges include the impact of ICT on accessibility; the inclusion of the robustness of the transport system in indicators; comparing perceptions of accessibility and traditional accessibility indicators; the option value; and the indicators of accessibility for goods transport, air transport, and slow modes. In the area of evaluation the paper discusses the pros and cons of the logsum as an accessibility measure, ethical aspects, comparisons of accessibility indicators to evaluate a specific case, and the needs of the clients of accessibility research.

1. Introduction

In order for societies to function adequately a certain level of accessibility to destinations by different modes, for both goods and people, is required. Accessibility is therefore a key concept in transport policies across the world. The main aim of Ministries of Transport throughout the world is to improve accessibility. Additional aims relate to reducing the negative impacts on the environment and safety. Because of the huge importance of accessibility for policy makers and society, transport geography and other research areas have studied accessibility in many ways, ranging from defining it, translating definitions to indicators, discussing the pros and cons of indicators, methods to calculate indicators, and applying indicators in real world cases. For an overview of the literature on accessibility indicators see, for example, Handy and Niemeier (1997), Geurs and van Wee (2004), or Paez et al. (2012).

During the past two decades considerable progress in the academic literature on accessibility has been made. For example, advances in time-space geography have been made (e.g. Neutens et al., 2008 who

focus on joint activity participation; Lee and Kwan (2011) who studied visualization options; and Farber et al. (2013) who developed a method for social interaction), the logsum has been proposed and discussed as a measure to value accessibility (e.g. De Jong et al., 2007; Chorus and Timmermans, 2009), and data availability has improved, as in many other areas partly fuelled by the use of ICT and by the increasing availability of 'big data'.

Nevertheless several challenges remain. This paper aims to give an overview of a selection of research challenges for the next two decades or so. The focus is on putting relatively new topics on the agenda, not on suggestions for improvements to given accessibility indicators. The paper mainly aims to inspire researchers rather than provide a complete list, although practitioners and policy makers could also benefit. I focus on overland and air transport, excluding water transport.

Section 2 discusses research challenges in the area of indicators for accessibility, section 3 the challenges related to evaluation. Some concluding remarks are presented in section 4. Several of the ideas presented in this paper have been discussed in recent literature, not only by me and co-authors, but also by others. Therefore I do not claim to present a list of *new* ideas, but rather to give a comprehensive overview.

2. Indicators

A very fundamental question is: What is accessibility? Or: How do we define accessibility? In his seminal paper Hansen (1959:73) defined accessibility as 'the potential of opportunities for interaction'. But there are many more definitions. Most include both destinations or activities, as well as travel resistance. The more options to reach candidate destinations or to fulfill activities, and the lower the travel resistance (time, costs, effort), the higher the level of accessibility. For example, Geurs and Van Wee (2004: 128) define accessibility as "the extent to which land-use and transport systems enable (groups of) individuals to reach activities or destinations by means of a (combination of) transport mode(s)." Once a definition is chosen, indicators need to be specified before the concept of accessibility can be operationalized. This section discusses the challenges related to different indicators.

Short distances, slow modes

Traditionally the accessibility literature has not focused much on short distances and slow modes, two closely-related areas, although over the last decade or so interest in this area has increased significantly, examples being Lundber and Weber (2014), Bossauw et al. (2014), Krizek and Johnson (2006), Forsyth and Krizek (2010), Manaugh and El-Geneidy (2013), Moniruzzaman et al. (2014), and Owen et al. (2014). Research in these areas should be trip purpose/activity specific. For example, it is important in research into job accessibility to realize that most people do not have a job in the direct vicinity of their home and that many people do not want a very short commuting time or distance (Redmond and Mokhtarian, 2002; Mokhtarian and Salomon, 2001; Ory et al., 2004). Having activities such as (primary) schools,

kindergarten, grocery shops, and basic medical services available close to home is likely to be more important. But in some cases visits to such local destinations and to jobs can be interrelated, because people can combine, for example, shopping and a commute trip, as shown by Widener et al. (2015). Despite the increasing attention paid to short distances and slow modes in the accessibility literature, I think important gaps remain. One gap is the importance of context – a lot of literature focuses on one case or area (city, region, country), and, because of the significant differences in climate, walking and cycling cultures and slow mode infrastructure across the world (and even within countries), questions remain on the importance of context. A next gap relates to the valuation people make of different accessibility levels for slow modes.

Related research questions include:

- How important are context factors for (the valuation of) the accessibility of destinations at short distances and of slow modes?
- How important is it for people (and for which groups of people?) to have destinations like shops, schools and medical services available at, for example, 500 meter instead of 1 km?
- How important is it to be able to walk or cycle to such destinations?

Multiple modes

Most accessibility analyses focus on one mode only. A challenging research field is the development of indicators and methods to express access in the situation when multiple modes are available. This research should also take into account the fact that combinations of modes can be relevant in multiple ways. Firstly, people can choose between multiple modes, and thus have multiple options for single mode trips. The logsum approach (see below) includes multiple travel options, but only due to the uncertainty of the modeler. Without this uncertainty, only the most attractive option would be included. This contradicts the idea that people value having multiple options available even if they do not currently use some of them, as expressed by the option value (see below). And they may value a higher value of robustness, which benefits from having multiple options available (see also below). Secondly, they may combine modes in multimodal trips. In that case multimodal accessibility is relevant. This is particularly relevant for people traveling by train because they need to travel to and from the railway stations both at their point of origin and their destination. Thirdly, it is important to note that single mode transport systems can have mutual influences. Let us assume a researcher is interested in the improvement in accessibility resulting from the potential opening of a regional airport. Let us also assume that the city already has a High Speed Rail station. The opening of the airport might result in a decrease in the services provided by the HSR, due to competition. On the other hand, the HSR could also be a feeder for long distance air travel, in which case new HSR services could also be added (Dobruszkes et al., 2014; Albalade et al., 2014). If such interactions are ignored the accessibility analysis may be flawed. Fourthly, the transport and the land use system interact. Coming back to the example just introduced: due to the combined presence of HSR and an airport, the region could become more

attractive both for companies and individuals, leading to land use changes. These changes could have an impact on some forms of accessibility.

Related research questions include:

- Which accessibility indicators express multimodal accessibility best and in which cases?
- How important, and for which categories of people/companies, is the availability of multiple modes of travel to destinations? For which category of activities?
- In which cases and to what extent do different modes complement or substitute each other, and what does this mean for accessibility analyses?

ICT

In this section I will firstly discuss the impact of ICT on accessibility, and secondly the importance of ICT for the generation of data useful for accessibility analyses.

Information and Communication Technologies (ICT) have increasingly become a part of life, in several respects. Many people can e-work, e-shopping is rapidly becoming more common, e-learning is discussed in many universities world-wide, if not: implemented, and further implementation can be expected in the near future. People communicate via smartphones and skype. People travelling by public transport can make their travel time productive or more attractive using ICT, e.g. by working online or contacting others online. Satnav systems reduce not only travel times but also travel time uncertainties and discomfort because, for example, drivers do not have to plan their route or search for a parking place. ICT enables people to plan more easily and improve their travel and maybe even activity schedule, pre- and on-trip. In other words, linking such developments to the core parts of accessibility presented above, ICT intervenes at both the activity and resistance side.

Indicators need to include ICT's impact on accessibility, at least for some applications. But the literature on how this could or even should be done, is still in its infancy (Van Wee et al., 2013). With respect to activities it is important to realize that at the conceptual level this may already be possible. At the more practical level the impact of ICT on activities is growing rapidly, so the value of an accessibility indicator including ICT may change rapidly in the coming years or decades. At the conceptual level ICT's impact on travel resistance can be included relatively easily via the concept of Generalized Transport Costs (GTC), and the components of GTC: ICT can impact travel times, the marginal value of travel time savings, travel costs, and effort.

Examples of important research questions related to ICT's impact on accessibility include:

- What is the impact of ICT on people's access to which (categories of) activities?
- To what extent and under which conditions is ICT a substitute for or complementary to physical access? (see for example pioneering work by Mokhtarian and Salomon, 1997; Mokhtarian, 2003; see Van Wee, 2013, for a discussion).

- Are there differences between generations of people with respect to the use of ICT and the impact of ICT on their (perceptions of) accessibility? This topic is sometimes discussed in the context of ‘peak car’, or ‘peak travel’, suggesting that young people are less car oriented than in the past, and that the increasing use of ICT is one of the possible explanations (see Goodwin and Van Dender (2013), for an editorial of a special issue on this topic).
- To what extent can ICT reduce levels of social exclusion?
- To what extent can ICT be a ‘pain killer’ for short- or long-term disruptions in the transport system? (see Van Wee, 2011)

We continue the discussion on ICT by focusing on the increasing availability of ICT generated big data. I expect recent ICT-related developments to generate data that may be useful for accessibility-related research (See Witlox, 2015, for a discussion and overview of literature). Firstly, ICT can help generate data in more conventional ways, such as using GPS-based data track and log systems (e.g. Bohte, 2008). In addition major changes in data availability can be expected due to the general trend in big data, generated by social media, the use of smartphones, satnav, and other technologies. Such data can firstly be used to explore travel behavior (trip frequency, destinations, duration, mode choice, and route choice). Secondly social media in particular can be used to explore trends in opinions, e.g. Hawelka et al. (2014) estimated volumes of international travel via tweets. Many indicators that include parameter settings based on empirical research can benefit from the increasing availability of big data. Examples include distance decay functions in gravity based accessibility indicators, and indicators for the robustness of the transport system based on having multiple options available - the selection of options can be based on travel behavior (such as in the case of route choice).

A big challenge is to find out to what extent these data are representative for the population the researcher aims to study. Bias in the use of social media towards smartphones and other ICT occurs beyond any doubt: younger generations use such technologies more than average, and within the older generations there is a bias based on attitudes towards such technologies and privacy concerns. But how important is this bias, and how will it change over time? In line with the general debate on big data (see Witlox, 2015) I argue that the use of ICT will raise not only many options for accessibility analyses, but also methodological challenges due to the characteristics of these data sources.

Relevant research questions include:

- In which cases and to what extent can big data be used to improve the parameter settings of accessibility indicators?
- To what extent can big data be used to derive opinions of people with respect to the appreciation of different forms of accessibility?

Robustness

The literature on accessibility so far has concentrated on having destinations within reach, considering (elements of) generalized transport costs. To the best of my knowledge hardly any accessibility literature

has paid attention to the importance of the robustness/reliability/vulnerability/resilience/flexibility of the transport system in relation to accessibility. From now on I will use 'robustness' for all these terms. Robustness is important at several time scales, from less than one hour (e.g. temporary disruptions of the road system due to an accidents) to many decades (e.g. how will accessibility be influenced by oil availability or stringent climate change policies?). And it includes minor disruptions but also evacuations in case of disasters. Reggiani et al. (2015) explicitly link resilience and vulnerability to connectivity, a concept related to accessibility, and conclude (page 13) that "the connectivity concept offers an appropriate angle for employing and interpreting resilience and vulnerability as operational research and planning tools for transport systems". Van Wee and Liao (2014) propose a family of accessibility measures for the robustness of the transport system. These "have in common that they express the number of options to travel between a given origin and destination, or to fulfill an activity program" (Page 1). But this is only a first proposal. Modifications of mathematical operationalization as suggested by Van Wee and Liao are possible, as well as alternative (families) of measures. Measures can also be compared to the perceptions of travelers of the robustness of the transport and land use system, both in the area of passenger as well as goods transport.

Examples of research questions include:

- How can the robustness of the land use and transport system be included in accessibility measures, both conceptually and mathematically?
- What are the pros and cons of doing this for specific applications, and which concepts and indicators are most useful for specific applications?
- Which parameter settings match the empirical data on behavior and the perceptions of travelers' best?

Option value¹

People do not only value the actual use they make of the transport system, but in some cases also the fact that they have options to travel (or carry out activities) available, even if they do not use them. This concept is often referred to as the option value. The concept of the option value can be applied to accessibility. In line with the definition of accessibility presented above I argue that the option value depends on characteristics of both the transport and the land use system. Although there are a few papers in this area (e.g. Geurs et al., 2006; Laird et al., 2009), our understanding of the usefulness of the option value for accessibility evaluations is still limited.

Interesting research questions include:

- How useful is the concept of the option value for accessibility analyses?

¹ The concept of the option value is both relevant for indicator developments as well as for evaluation reasons. To avoid overlap it is only discussed here.

- Which indicators best reflect having multiple options available, even those that people do not select?
- What is the importance of proximity as opposed to GTC-based accessibility?
- What value do different groups of people and companies attach to which options for access to destinations and accessibility by visitors, by which modes, and under which conditions?

Perception of accessibility

Research into the perceptions of accessibility is scarce (see Cheng and Chen, 2015, for a recent example) as is research into related land-use preferences (see Levine and Frank, 2007, for an example). The suggestion made above to compare the calculated levels of accessibility using data on land use, the transport system and perceptions of accessibility, can be generalized to all kinds of accessibility. This can be accessibility of different locations or activities, by different modes, and for distinguished categories of the population each having their own 'mental maps' of what is within reach. I would not be surprised if, in addition to travel time, distance, costs, and other components of GTC, the attractiveness of the route would count. For example, probably the (dis)utility of walking from a station to the final destination can depend on the perceived attractiveness of the route. A nice route with many pedestrians might be valued more positively than an equally long and time consuming unattractive route. Perceived safety, e.g. by women walking at night, may also be important for the traveler. Another important topic for the perception of accessibility is the awareness of people, of options for activities at distinguished destinations, and maybe even online substitutes, as well as travel options. If people are not aware of options, perceived accessibility and calculated accessibility levels can easily show poor correlations. The inclusion of perceptions in accessibility indicators can give such indicators more behavioral realism. El-Geneiy and Levinson (2011) propose an accessibility indicator based on real world travel decisions (flows between origins and destinations of trips). Note that the indicator does not explicitly include perceptions of accessibility.

Related example research questions include:

- How do (groups of) people perceive different forms of accessibility (e.g. by activity or destination type, mode, time of day)?
- To what extent do calculated levels of accessibility using land use and transport data match perceptions of (groups of) people? Which factors explain the differences between calculated and perceived levels of accessibility?

Air transport, marginal effects multiple options

The literature on accessibility has mainly focused on overland transport (car, public transport, slow modes), and much on less air transport, although several papers that study the accessibility of air

transport do exist (e.g. Lin and Fu, 2014; Ryerson and Kim, 2013; Redondi et al., 2013)). Papers in this area often focus on network developments (see for example Neil, 2013 and Borodako and Rudnicki, 2014; see Paez, 2004, for a study on accessibility in eastern Asia, combining the air and road networks). Some papers did study the accessibility effects of air transport services, but only a few studied the value of such services. Özcan (2014) studied the opinions of citizens of communities in remote areas in the USA about flights, concluding that they highly value these flights, but not as highly as an increase in the number of jobs, or the quality of education, or health services. Halpern and Bråthen (2011) studied the opinions about the air services of residents in two Norwegian regions, concluding that the air services make the regions more attractive to live in. Air transport related accessibility analyses can be very helpful for airport planning and other research areas like the relative attractiveness of locations for internationally oriented companies, tourism, and research into the marginal value of additional air connections (in relation to the additional costs of airport infrastructure and externalities of additional flights). Also analyses combining air travel and high speed rail (or even more overland modes) can be useful for the same reasons.

Related research questions include:

- How important is accessibility via aircraft for which categories of people and companies?
- What is the marginal value of having more destinations available?
- What is the marginal value of additional flight frequencies?
- What is the marginal value of having the availability of different airline companies and tariffs?
- What is the value of having options to fly available, even if these are not used?
- To what extent, and under which conditions, do aircraft and high-speed rail modes complement or substitute each other?

Goods transport

The accessibility literature has focused more on the perspective of travelers than on the perspective of goods transport, with the exception of, for example, Bowen (2008) and Gonzalez-Feliu et al. (2014). However, for companies that need to transport goods, accessibility to and from locations of inputs and outputs is relevant. This raises questions with respect to the similarities and differences in accessibility indicators and calculations between these areas. A fundamental difference is that goods do not 'experience' travel, whereas passengers do. All previously mentioned categories of suggestions, as well as their interrelationships, also apply to goods transport.

Related research questions include:

- Which accessibility indicators are useful for which forms of goods transport, for which actors?
- How (dis)aggregated should accessibility measures for goods transport be? Note that research has shown that the goods transport market is very heterogeneous (Tavasszy and de Jong, 2013).

3. Evaluation

Transport innovations²

Several potential innovations can have an impact on the valuation of components of accessibility indicators, and next overall accessibility levels. For example, if cars were fully automatically driven the importance of the time component might decrease, but the importance of monetary costs might go up. The use of ICT has already decreased the importance of the time component for people travelling by train (Lyons et al., 2006). Future ICT developments might increase this impact. Travelling by e-bike will probably also have an impact on users' GTC, via the time, comfort and (perceived) safety component. ICT might reduce GTC by providing high quality dynamic travel information, forecasts of travel times and other amenities.

The overarching related research question is:

- Which transport innovations might have which impacts on which forms of accessibility, for which (groups of) people and companies?

The logsum as an accessibility indicator

A very important question is: what to do with the outcomes of accessibility analyses? I argue that, regardless of any wider evaluation framework like cost-benefit analysis (CBA) or multi-criteria analysis (MCA) the indicators are valuable in themselves, just like reporting the number of (expected) fatalities for alternative transport plans is, even though safety can also be expressed in monetary terms (only). In addition, an important question is: How can the pros and cons of several developments of policy options be simultaneously evaluated? In many countries CBA is the standard method to ex ante evaluate candidate policy options (Hayashi and Morisugi, 2000; Bristow and Nellthorp, 2000; Grant-Muller et al., 2001). Consequently there is a need to express accessibility effects in monetary terms. Note that the most important benefits of new infrastructure are reduction in travel times, and these are included in a CBA, generally by multiplying the number of travelers, the reduction in travel time, and the so-called value of time (VOT) (e.g. Gunn, 2001), or – more precisely – the Marginal Value of Travel Time Savings. In this way accessibility gains are included. However, this is not the only method available. The so-called logsum approach is becoming increasingly popular as a measure to evaluate accessibility in monetary terms. It is based on the assumption that the log of the denominator of a logit model for discrete choices can be used to calculate the value of the options the decision maker has available. This indicator has several advantages, which are summarized by Geurs et al. (forthcoming). Firstly it directly includes the utility of choice options, which is very helpful for project appraisals using a CBA framework. Secondly

² I discuss this topic only here (section Evaluation) because innovations can strongly influence evaluations of GTC components. Innovations are an important topic for accessibility analyses anyway, and could also be included above. I chose to only include the topic here.

it is fully consistent with a transport model that is used to calculate travel behavior impacts of the policy options under consideration. Thirdly, the logsum is capable of dealing with changes in the spatial distributions of origins and destinations. Fourthly, a variety of choice options measured by multiple attributes of alternatives can be included. Finally there are practical advantages, one of them being that the logsum can be calculated directly via the transport model that is used to estimate travel behavior changes anyway.

There are, however, also limitations, see Geurs et al. (forthcoming): the value of having multiple options is ignored, as is the 'love of variety in consumption'. Expected utility (which is used in the logsum indicator) may differ from experienced utility. In addition, using willingness to pay to calculate utility is disputed (see below), as is the assumption on the link between income and utility. Next it is important to realize that the logsum as an accessibility measure is difficult to explain, including to the clients of accessibility research. Finally, due to autocorrelation the IIA-assumption might be violated in the case of destination choice³.

Related research questions include:

- Which are the pros and cons of the logsum as an accessibility indicator, for which applications?
- To what extent can the logsum as an indicator be modified to reduce its weaknesses?
- How can the outcomes of logsum analyses be communicated to suit clients best?

Distribution effects, equity, social exclusion

The concept of accessibility is broader than that measured by a CBA framework based on the willingness to pay for reductions in generalized transport costs. Other factors include equity, related distribution effects, and levels of social exclusion. There is a growing body of literature linking accessibility to such issues. Paez et al. (2010) applies the concept of relative accessibility to express the accessibility levels of different groups of the population, one important aspect of distributions. Paez (2013) reviews approaches for measuring (and planning) accessibility across social groups. Grengs (2015) explores the non-work accessibility of vulnerable groups in the Detroit metropolitan area, and found that the results depend on trip motives. Vulnerable groups experience advantages in accessibility to convenience stores, hospitals, childcare facilities and religious organizations, and disadvantages with respect to shops and supermarkets. In two other papers he explores the job accessibility of different social groups from an equity perspective, emphasizing the role of car availability (Grengs, 2010, 2012). Fan et al. (2012) study the role of light rail in providing access to low-wage jobs from an equity perspective. Golub and Martens (2014) and Foth et al. (2013) study the accessibility impacts of transport investments from an equity perspective. Lucas et al. (2015) propose an evaluation framework to explicitly link ethical theories, in particular egalitarian theories and sufficientarianism, to social exclusion and accessibility. Their framework is based on the Gini index that can be used to express levels of (in)equality in any distribution.

³ Antonio Paez, personal communication, 23-4-2015.

The development of indicators to study the equity of accessibility is developed reasonably well. Gaps relate to the inclusion of such indicators in broader evaluation frameworks, normative judgment and an explicit focus on different types of equity. Van Wee and Geurs (2011) give an overview of the literature in this area, and conclude that these topics are 'poorly addressed in transport appraisal in general, and in CBA in particular' (page 361). They recommend the explicit use of ethical theories. Egalitarian theories can be used to express distributions of accessibility over the population or population groups. However, they argue that equity analysis is complex due to the existence of several types of equity (Thomopoulos et al., 2009), heterogeneity in population (groups), the existence of multiple forms of accessibility (by mode and multimodal; by destination type), and the many ways to express accessibility in indicators. What makes the use of accessibility measures for social exclusion even more complex is the fact that it requires normative judgments: Under which conditions are which people considered to be socially excluded? And: does it matter if people move voluntarily to a location with low levels of accessibility? Also the inclusion of distributions and its evaluation is normative. How important is a more equal distribution of accessibility compared to an overall increase in total and thus average accessibility?

Van Wee and Geurs (2011) provide an overview of research challenges in this area, some of which I briefly summarize here. Firstly these relate to the development of indicators for distributions and for social exclusion. Secondly there is a need for the development of methods to value distribution effects and social exclusions. Thirdly they recommend analysis of the impact of components (land use, the transport system, and others) of accessibility on distribution effects and social exclusion. Fourth, as already discussed above, research could study the extent to which ICT can provide an alternative for having physical access to destinations, and consequently reduce levels of social exclusion.

Despite some first attempts, several research challenges remain, such as those discussed in Van Wee and Geurs (2011). Related research questions include:

- How to measure equity and distributions of accessibility over which population groups, areas, etc.?
- How to define social exclusion, and link it to accessibility indicators?
- How to value inequality in distributions of accessibility and changes in social exclusion levels?
- How to include distributions of accessibility, and other equity relevant aspects of accessibility in evaluation frameworks?
- Which land use and transport policies can reduce which inequalities and social exclusion levels?
- To what extent can ICT solve problems related to inequalities and social exclusion?

Freedom of choice

People do not only value the final choice they make, but also the freedom to make choices. The concept of the 'freedom of choice' is hardly linked to the accessibility literature, but it is widely debated in the area of philosophy (and more specifically: ethics) (Van Wee, 2011). Probably the concept is partly related to the concept of the option value, which also expresses the value people attach to having

options available (see above). But the option value only relates to having the options available, not to the level of freedom to choose between options. Related research questions include:

- How to define and operationalize the concept of 'freedom of choice' in the context of accessibility?
- To what extent is the concept of the option value useful to measure the concept of the freedom of choice, and to what extent are both complementary?
- Is it sufficient to only measure the importance of the concept of freedom of choice via the (potential) traveler, or is a societal dimension involved, and if so: how?
- Do people and politicians value the level of the freedom of choice of others, and if so: how important is this concept?

Comparisons of indicators for real world cases

The literature on different accessibility indicators focuses on the pros and cons for specific purposes, but only a few papers explicitly compare the values of indicators for given real world indicators. Papers comparing accessibility approaches and specifications generally conclude that different approaches and specifications lead to conclusions that strongly differ (e.g., Linneker and Spence, 1992, Kwan, 1998, Thill and Kim, 2005, Neutens et al., 2010). Such comparisons can be very important, for several reasons. Firstly it is scientifically of interest to do such comparisons, to find out how important for the outcomes the choices to be made for indicator selection as well as parameter settings are. Secondly such comparisons are very important for policy and wider societal reasons, not only for the same reasons as relevant for scientific reasons, but also because scientifically sound indicators are relatively difficult to explain, and easy to explain indicators are scientifically less sound (Geurs and Van Wee, 2004). If, for example, the logsum and other utility based indicators, or time-space based indicators, which are difficult to communicate, give the same pattern for a given real world case as contour indicators, which are much easier to explain, then researchers can present their results using contour measures, knowing that the conclusions match those of analyses based on more advanced indicators. But if 'easy to interpret indicators' result in misleading conclusions, then the advanced indicators should be used, and the challenge is in the communication of the results.

An example of a study doing such a comparison is presented in Tillema et al. (2011), comparing two types of accessibility measure to assess the effects of road pricing policy measures: geographical accessibility measures and economic social surplus measures. They conclude that the outcomes are poorly correlated. The choice therefore should be based on the research goal – in this case the indicators cannot easily be substituted without leading to different conclusions. Another example is a study by Neutens et al. (2010) comparing place-based and people-based measures to evaluate urban service delivery. They also conclude that the differences between indicators, both between and within families of indicators are large.

Examples of related research questions include:

- To what extent do different indicators or different parameter settings of a specific type of indicator lead to similar or different results in real world cases?
- How to select the 'best' indicator(s) for a specific case?
- How to trade-off gains in scientific quality and losses in the ease of communicating the results?

The wishes of the client and the inclusion of accessibility measures in evaluation frameworks

A next challenge is to link accessibility evaluations to evaluation frameworks, such as Cost-Benefit Analyses (CBA) and Multi-Criteria Analyses (MCA). If accessibility evaluations are part of a wider evaluation framework the choice of indicators will depend on the choice of the framework. If a CBA is used, the utility-based measures have a big advantage, both theoretically (because of the use of the concept of utility) as well as methodologically and practically, especially if a logsum measure is used, because it can relatively easily be calculated using a transport model that will often be used anyway. An MCA is more flexible and can relatively easily incorporate all accessibility measures, and even multiple accessibility measures, and in some cases can explicitly show implications over different actors or actor categories as in the case of the Multi Actor Multi Criteria Analyses (MAMCA) – see Macharis et al. (2012).

What is poorly understood are the preferences of clients of accessibility analyses in general, and of clients of MCA and CBA in particular. Researchers could study their preferences for indicators, as well as their inclusion in wider evaluations, particularly MCA.

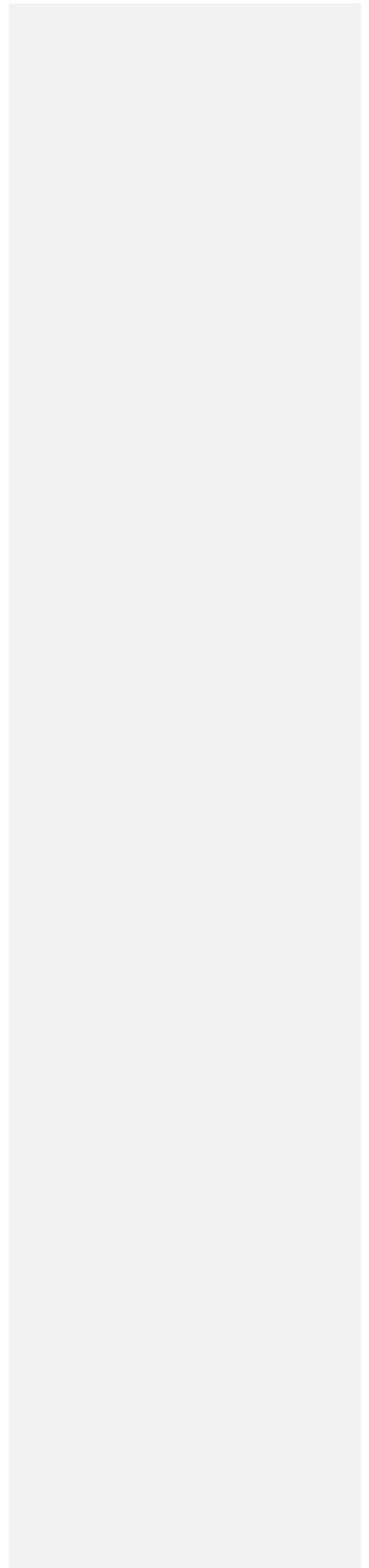
Related research questions include:

- What are the pros and cons of the inclusion of different types of accessibility indicators in different evaluation frameworks?
- What weight should accessibility have in overall assessments?
- What differences in accessibility indicator values should have which difference in scores?
- How do different (categories of) users of accessibility analyses prefer to have results of those analyses communicated?

4. Concluding remarks

Several of the suggestions above are interrelated, as visualized in Figure 1. The modes-related suggestions (slow modes, multiple modes, air travel, goods transport by various modes) are one category of suggestions. A second category includes indicators for evaluation (robustness, option value), and evaluation challenges as discussed in section 3. The robustness and option value both express the valuation of alternatives. In the case of the option value it includes non-use values, in the case of robustness it can include options that are used in unforeseen circumstances, or even not-used options that people value because they feel less vulnerable. ICT can be seen as a 'mode', but it can also be seen as a factor having an impact on both modes on the one hand, and evaluations (including robustness and

option value) on the other hand, and therefore is added as a third category. Fourth, perceptions are a separate category that relates to all three other categories: not only the real world options are relevant for people, it is also the perceptions of those options that count.



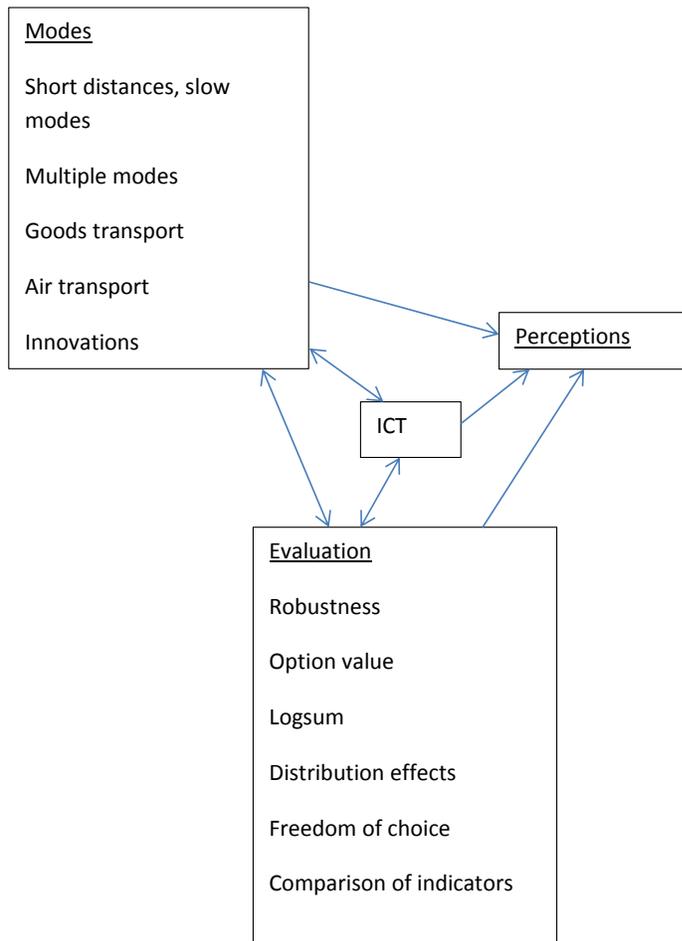


Figure 1: interrelationships between suggestions for future research

The topics above are not only relevant for future accessibility research as stand-alone topics. In addition combinations of these topics provide avenues for future research, examples being the option value of air travel options, ICT as a substitute for medical services that are not available at a short distance, or the perception of the walkability of the route between one's dwelling and activities at short distances.

Research as suggested in this paper can enable the accessibility literature to become more mature, and increase the policy and wider societal relevance of accessibility analyses. As explained above the paper does not aim to give a complete overview of research challenges, and has almost completely ignored challenges to modify currently often used accessibility indicators. And the suggested research questions

for each topic are only examples – many more questions can be raised. In addition the paper does not prioritize the avenues for future research. I think the prioritization could be based on the expected gains from a scientific and societal perspective, and the related costs/effort. I do not provide a definition of gains, but only some indications. From a societal perspective gains could imply that accessibility research contributes to an improvement in the inclusion of the accessibility effects of candidate policy options in ex ante evaluations and therefore to a more mature position in the decision-making regarding such policies. From a scientific perspective gains could relate to reducing important gaps in the accessibility literature, increasing the consensus on how best to assess accessibility effects for specific cases, and inspiring future researchers. Costs and effect can be more easily described because these mainly relate to the time (and related monetary costs), and in some cases data collection costs, needed to develop methodologies and conduct accessibility research.

Some final remarks: Although I will not compare the relative importance of all the challenges discussed in this paper, I think the most important challenges relate to the evaluation of accessibility effects, maybe even monetization; this is really an underexplored area – it is poorly understood how all kinds of accessibility effects should be included in wider evaluation frameworks. And I think increasing consensus on how accessibility effects are best evaluated in specific cases is very important, and could contribute to making the accessibility literature more mature. We should increasingly go beyond stand-alone case studies assessing accessibility effects, and give guidance on which approach is best for which case.

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