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Toegang geweigerd: Digitale ongelijkheid in het slimme mobiliteitstijdperk

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Samenvatting

Digitalisering verandert onze dagelijkse mobiliteit, via bijvoorbeeld chipkaarten, digitale reisinformatie en nieuwe mobiliteitsdiensten. Digitalisering in mobiliteitsdiensten ('slimme mobiliteit') biedt allerlei voordelen, zoals meer gepersonaliseerde informatie, meer reisopties en kostenbesparingen voor zowel leveranciers als gebruikers. Ook zijn er mogelijkheden om het mobiliteitssysteem te vergroenen met behulp van informatie- en communicatiediensten (ICT), bijvoorbeeld door reizigers minder afhankelijk te maken van de auto. De trend richting meer ICT in de mobiliteitswerelddiensten zal waarschijnlijk doorzetten.

Niet iedereen is echter in staat om de digitale transformaties bij te houden of ermee om te gaan, zelfs in een land met een hoge (mobiele) internetpenetratiegraad, zoals Nederland. De afhankelijkheid van ICT voor mobiliteit kan uiteindelijk voor sommige mensen nadelig uitpakken waardoor ongelijkheid ontstaat of versterkt wordt. Dit kan leiden tot (meer) sociale uitsluiting. Deze bijdrage voor het CVS bekijkt op kritische en interdisciplinaire wijze de digitaliseringstrend in mobiliteitsdiensten en put daarbij uit onderzoek naar digitale ongelijkheid om licht te werpen op de mogelijke uitsluitende effecten van deze digitalisering.

Een belangrijke conclusie uit eerder onderzoek naar digitale ongelijkheid is dat fysieke toegang tot technologie zich niet noodzakelijk vertaalt in louter de positieve, gewenste, resultaten. Motivatie, de juiste apparatuur, voldoende digitale vaardigheden en frequent gebruik zijn ook cruciaal om toegang tot digitale technologie te vertalen in effectief gebruik van de technologie. Studies in Nederland tonen aan dat ouderen, mensen met een lager opleidingsniveau, mensen met een lager inkomen en – in mindere mate – vrouwen, minder profiteren van internet en digitalisering. Aangezien steeds meer diensten en routines standaard 'digitaal' zijn, is het belangrijk om te beoordelen in hoeverre niet-digitale alternatieven hiervoor beschikbaar zijn in termen van de benodigde middelen voor gebruikers (geld, tijd, ondersteuning, etc.).

Literatuur over de potentieel uitsluitende effecten van digitalisering in mobiliteitsdiensten en over de (gevolgen hiervan voor de) 'slachtoffers' hiervan is er nauwelijks. Empirische bevindingen in de Nederlandse context zijn beperkt beschikbaar en zijn soms tegenstrijdig. De theorie staat nog in de kinderschoenen. Daarom is onderzoek nodig, vanuit een beleidsmatig en sociaal perspectief alsmede met een academische blik. Hoewel onderzoek naar digitale ongelijkheid en mobiliteitsonderzoek twee verschillende gebieden lijken te zijn, laten wij zien dat deze interdisciplinaire aanpak waardevolle inzichten kan bieden voor mobiliteitsprofessionals, beleidsmakers en wetenschappers, in een tijd waarin digitalisering in mobiliteit steeds dominanter wordt.

1. Introduction

Over the past few decades, the adoption and increase in use of digital technologies has become a major trend. This trend is called digitalisation, affecting everyday lives, organisations and countries globally. Manifestations for the general public include the smartphone revolution, the massive growth in social media use, and the transitions from physical services and infrastructure to internet banking, e-government and e-health services to give just a few examples.

The transport sector is no exception: digitalisation in transport and around travelling is already happening in ways that have transformed how people travel. From real-time multimodal planners to GPS and applications providing access to (new) mobility services like car sharing, digitalisation has the potential to simplify mobility and to provide greater control and choice to travellers. With the spread of the internet and connected mobile devices, travellers are increasingly invited to rely on digital tools and knowledge on how to navigate the digital world (Aguiléra, 2019; Pangbourne et al., 2018). Yet not everyone benefits from digitalisation to the same extent. Some people even experience more disadvantages than advantages. Indeed, in order to benefit from services where a connected device is needed as a digital key (e.g. to unlock a vehicle), as a proof of payment or as a travel assistant, one needs to have the appropriate device and digital skills. Furthermore, growing concerns about privacy may dissuade the use of digital tools. When the spread of technologies is accompanied or followed by cuts or changes in physical infrastructure or services such as station staff, not engaging with such technologies might result in a form of exclusion.

This paper stresses the relevance of researching the potentially exclusionary effects of digitalisation in transport, from a social and policy perspective as well as from an academic perspective. It does so by presenting the developments of digitalisation in transport and by drawing on digital inequality research to analyse these developments and their potential impacts on people. Based on this interdisciplinary approach, we highlight the need for more research in this field and we present avenues for research, both from a policy and from an academic perspective.

Note that we focus specifically on digital transformations in (public) transport services, and not in privately-owned forms of transport such as private cars. The main reason is that people have arguably more freedom of choice and control regarding (the pace of) digital transformations in privately-owned modes of transportation than in transport services. For example, in 2019, someone with an aversion to new technologies could still choose to purchase a vehicle without semi-autonomous driving and parking abilities. By contrast, digitalisation in transport services is "speeding up" (Canzler & Knie, 2016) and leaves fewer options to travellers.

This paper is organised as follows: in Section 2, we explain what digitalisation in transport services consists of, the trends that support it and the improvements it brought. Next, in Section 3, we present digital inequality research as a framework. Then, in Section 4, we justify why research is needed and present some research avenues, both from a policy and from an academic perspective. This paper ends with a conclusion highlighting the main research gaps and avenues, as well as our follow-up research on this field.

2. Digitalisation in transport services

In this section, we first provide a short overview of what digitalisation in transport services means and we link it to the concept of smart mobility. We then present how current trends in the Dutch context play a role in the development of digitalisation in transport services. Next, we underline how digitalisation impacted transport services' users, focusing on inclusionary effects.

2.1. What is digitalisation in transport services?

According to Leviäkangas (2016), digitalisation in transport is largely relying on the concept of Intelligent Transport Systems (ITS), which started to develop in the 1970s (Nowacki, 2008). ITS are defined as "the application of modern ICTs (Information and Communication Technologies) to transport systems" (Leviäkangas, 2016). Investigating the digitalisation of a given transport system is a complex task as it covers a variety of aspects (Leviäkangas, 2016); this is why we will only focus on the most noticeable forms of digitalisation in transport services for travellers.

One of the first visible features of digitalisation for transport services' users was electronic ticketing in public transport. Replacing tokens, paper and magnetic ticketing, contactless ticketing (or 'smart cards') took off in the 1990s thanks to the exponential growth of the internet and the increased sophistication of mobile communication technologies (Blythe, 2004). Around the same time, research started to acknowledge the importance of providing public transport (PT) passengers with real-time information (Nelson, 1995), and technology was making this possible; early trials started in London in 1986 (*ibid.*). From the mid-1990s on, advances in computer systems applications and embedded computational functionalities gave ITS a boost (Nowacki, 2008). For transport services' users, this translated into more and improved on-board information, real-time information at stops and stations, the development of automatic ticket vending machines and internet kiosks, the widespread deployment of smart cards and improved demand-responsive transport services (Blythe et al., 2000). In general, traditional actors in the transport service industry (mostly PT companies) have been seizing digitalisation as an opportunity to increase the efficiency and the quality of services while lowering costs, to provide improved information to customers and to explore new services (UITP, 2017).

In the 21st century, the convergence of two ICT revolutions, namely the internet and personal and connected devices, enabled the success of mobile phones and especially smartphones (Aguiléra, 2019). Aguiléra and Rallet (2016) identified three categories of digital technologies available through personal connected mobile devices that have transformed mobility:

1. Tools to organise mobility, to assist the traveller before and during trips,
2. Tools that allow travellers to conduct various activities while on-the-go and to conduct teleworking,
3. New mobility services available through online platforms, giving rise to new players in the transport sector.

Categories one and three mentioned above concern, at least partly, digitalisation in transport services specifically. Tools to organise mobility are tools to plan, book and pay for mobility, like real-time trip planner apps and mobile ticketing systems. These applications, websites or systems may require a form of activation before the trip itself. The integration of all of these functions into one (digital) platform is nowadays what we

call Mobility-as-a-Service (MaaS). ICTs have also enabled new transport services to emerge: Uber, bike-sharing and car-sharing services would fit in the third category mentioned above. To this categorisation, we can also add "post-trip" aspects like claiming money back or giving one's opinion to the transport service, which have also moved online. Products and services mentioned here interconnect data and technology. They would fit in as smart mobility initiatives. Although smart mobility seems to be more of a label with currency than a specific set of products and services (Marsden & Reardon, 2018), the label has prevalence because digitalisation has brought forward numerous innovations that promise to change the way people move around (*ibid*.). Beside mobile developments, digitalisation is transforming the automobile industry, as traditional manufacturers race to develop autonomous vehicles. These are progressively entering cities' landscapes in the Netherlands, as a new form of pilot transport (shuttle) service (Boersma et al., 2018; Trouw, 2019). Digitalisation in transport services takes multiple forms.

2.2. Trends influencing the evolution of digitalisation in transport services

There are multiple economic, demographic and technical trends that have an influence on where digitalisation in transport services might be heading towards. In the Netherlands, a steadily growing (urban) population and a rising prosperity mean that the need for mobility will increase in the coming decades (CPB & PBL, 2015). At the same time, if the country is to comply with international climate agreements, the transportation sector needs to become considerably cleaner (see *Ontwerp van het Klimaatakkoord - hoofdstuk Mobiliteit*, Rijksoverheid (2018)). This is especially true for passenger mobility, as it is deemed to offer more options for emissions' reduction than freight and aviation (PBL, 2018). Between 2030 and 2050, 'clean mobility' is envisioned as a 'service', transport services are to be 'easily accessible' and car ownership 'less necessary and attractive', at least in urban areas (Rijksoverheid, 2018). The focus on transport services is clear here. In addition, as ICTs keep on developing and internet use is on the rise for all population groups in the Netherlands (CBS, 2019), smart mobility is often seen has having a central role to play in this shift towards more sustainable mobility patterns (see *Nederlandse Digitaliseringsstrategie*, Ministerie EZK (2018), *Schets Mobiliteit naar 2040*, Ministerie I&W (2019b)[1]. It is interesting to note that the shift towards a cleaner transportation sector is called the 'smart and green mobility transition' by the Ministry of Infrastructure and Water Management, as defined in Lodder et al. (2017), 'smart' and 'green' seemingly going hand in hand. Scholars acknowledge that with the opportunity to leverage on smart mobility services to transition towards less car-dependent patterns, the trend to rely on ICTs in transport is likely to keep going on (Banister, 2019; Groth, 2019). Therefore, we can expect ICTs to play an increasingly important role in transport services.

2.3. 'Digital transformations' in transport services: a "better state" for everyone?

A term that is often used interchangeably with digitalisation is 'digital transformation'. A 'transformation' usually presupposes going from state I to state II, where state II is a "better state" than I (Cambridge Dictionary, n.d.). Digital transformations in transport services have indeed offered many travellers a number of improvements. We will present

[1] In these rapports, public transport also falls under the designation of smart mobility, especially as public transport makes more and more use of 'smart solutions' (Ministerie EZK, 2018).

two of them here, linked with the technologies presented in Section 2.1. Note that there are many more links between ICTs and mobility, like complementarity/substitution debate (Mokhtarian, 2002; Schwanen & Kwan, 2008), the experience of travel time and space (Lyons & Urry, 2005; Sheller, 2004) and face-to-face interactions (Line et al., 2011).

First, as hinted above, there is more information available on travel options, transport services, real-time changes, etc. (Aguiléra, 2019). Having mobile internet (instead of fixed-access internet) makes it possible for travellers to get real-time information *during* the trip and to get personalised information (Aguiléra & Rallet, 2016). Additionally, more (real-time) information available might have lowered the (psychological) barriers to travel, especially when technological innovations target specific groups, like mobility-impaired people (Cho & Erin Lee, 2017). Transport applications can provide features that are personalised to specific needs, thereby addressing language barriers, physical disability and low-income issues (Gebresselassie & Sanchez, 2018).

Second, the range of transport options increases as ICTs enable the arrival of new services and players in the field (Boutueil, 2019). These new services can be used to meet the needs of groups who previously had a low range of transport options available. Research shows that new models of demand-responsive transport in conjunction with ICTs can address the mobility needs of rural communities (Velaga et al., 2012). Besides, shared mobility modes, enabled at a large scale through digitalisation, bring the promise to offer a level of mobility that might otherwise be unaffordable, and therefore decrease financial disadvantage for underprivileged society members (Clark & Curl, 2016). In this line, some professionals and scholars expect that smart mobility services, including MaaS, could contribute to increase social participation and mitigate social exclusion (Jittrapirom et al., 2018; Matyas & Kamargianni, 2017).

However, the changes brought about by ICTs in transport have also increased the overall complexity of the mobility system. Digitalisation in transport is not only about having a smartcard to pay for one's trip or having the latest ride-hailing app. It is also about having to check in and check out, including when changing service providers (in the example of the OV-chipkaart). It is also about having the latest version of the ride-hailing app so that it runs without crashing, and consenting to have your credit card registered in the service provider's system. As Snellen and de Hollander (2017) explain, not everyone can cope with these changes. Ticket offices have been replaced by "machines and chip cards", people are "expected to get [their] travel information from the internet and [their] ticket is now called a 'travel product'". Shared mobility modes offer a lot of options, yet for each of them "you need a membership, a card and/or a password", and "Train services are run by different companies, sometimes requiring you to check in and out with your chip card, several times along the way" (*ibid*.). While digital transformations undeniably bring a "better state" to many, they require certain (mental) skills, psychological flexibility and resources which might also make travelling more difficult to some people. In this paper, we posit that research on digital inequalities can bring relevant insights to transport professionals, policymakers and researchers. This is presented in next section.

3. Research on digital inequalities

Research on how various social groups access Information and Communication Technologies and how different types of engagement with technology lead to offline social (dis)advantages has developed a lot in the past 25 years. It is called digital inequality (or

digital divide) research. This section first provides a brief history of digital inequality research. Then, it presents Van Dijk's model that links social and digital inequalities, followed by a summary of determinants of digital inequalities in the Netherlands.

3.1. An overview of the digital inequalities research

Research on the digital divide is multifaceted, reflecting the complexity of the topic, described by Bruno et al. (2011, p. 27) as "a multidimensional phenomenon that includes a set of complex divides […], caused by a variety of factors". However, it was not always so. The term digital divide became popular in 1990s in the United States, during a decade of staggering growth of the internet and personal computers (Lupač, 2018, pp. 45-51). Researchers started to explore barriers, motivations and reasons for (not) using the Internet (Katz & Aspden, 1997). Over the years, these motivations have evolved from mostly people not seeing the usefulness of the internet, to defiance against privacy. Initially, the digital divide distinguished between people who had access to an internet connection and those who had not. This is now referred to as the first-level digital divide (Van Deursen & Van Dijk, 2018). Nowadays, as the internet has become accessible through a variety of devices, the first-level digital divide also encompasses material access (device opportunity, device and peripheral diversity and maintenance expenses) (*ibid*.).
In the years 2000s, as internet became more prevalent in Western countries, some scholars started to question the idea that access to technology would provide all the benefits of the technology (Selwyn, 2004; Van Dijk & Van Deursen, 2014). To nuance the digital divide as originally understood, Hargittai (2001) introduced the second-level digital divide: the skills divide. It is based on the idea that there are differences between groups in terms of skills necessary to effectively use the internet. Subsequently, scholars have classified types of skills (Helsper & Eynon, 2013; Van Deursen et al., 2016). The second-level digital divide also includes differences in use, i.e. usage gap (Van Dijk, 2005). Later, the digital divide discussion progressively shifted to a focus on the tangible outcomes of internet use, labelled the third-level digital divide (see examples in section 3.3). This divide exists when access to the internet, its use and the possession of digital skills do not lead to beneficial outcomes (Van Deursen et al., 2016). Figure 1 presents these levels of the digital divide and how they fit within Van Dijk's model of access to ICTs, as presented in next sub-section.

3.2. Modelling the link between social and digital inequalities

Early on in digital divide research, scholars were interested in the relationships between social and digital inequalities. A renowned model is that of Van Dijk (2005). The 'Causal model of Resources and Appropriation Theory' is based on four elements that consecutively influence each other. Personal and positional categorical inequalities, like educational attainment or age (first element) create inequalities at the level of the distribution of resources, such as social network and income (second element). They produce inequalities regarding people's access to ICT (third element). Van Dijk defines access to ICTs as "the complete process of appropriation of a new technology": see Figure 1 for the stages of access to technology and their link to the levels of the digital divide. In this figure, we also present an example applied to transport. In turn, access to ICTs has a direct impact on one's level of participation to society (fourth element), which then influences back personal characteristics and distribution of resources (elements one and two).

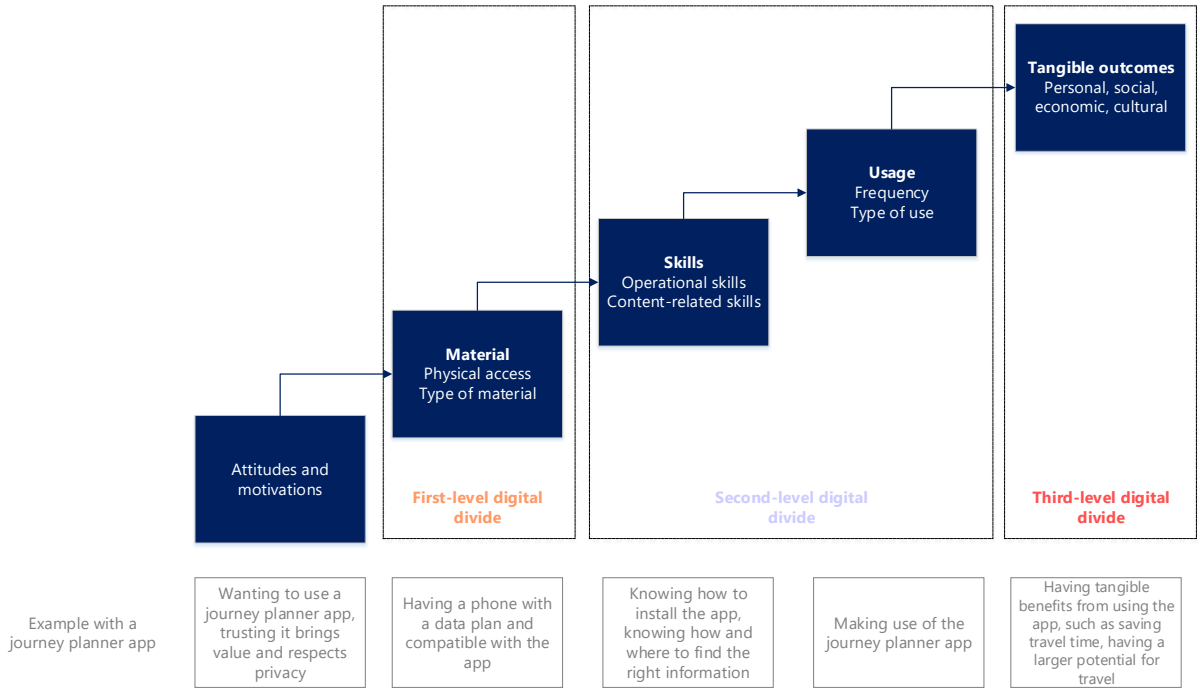

Figure 1: The stages of access to ICTs (Van Dijk, 2005) and the levels of the digital divide.

Van Dijk's model focuses on the exclusion of individuals due to the integration of ICTs in all aspects of society and allows for a detailed level of analysis.
Digital divide research is still relatively young and dynamically evolving along with technologies. Some criticisms of Van Dijk's model or research using it include a narrow focus on socio-economic status, little attention towards social support and proxy use, the lack of some feedback loops between elements and 'motivation' as the entry point (Mariën et al., 2016; Mariën & Vleugels, 2011). Indeed, as ICTs are becoming more and more ubiquitous and profoundly entangled in institutions and daily practices, some scholars are questioning the idea of motivation as a precondition to access technology (Mariën et al., 2016). Besides, little or no use of ICTs do not necessarily indicate social disadvantage (Lupač, 2018, pp. 147-150). According to Lupač (2018, p. 161), in order to better investigate digital inequalities, it is necessary to assess how indispensable ICTs are in a given context. He mentions two aspects that impact indispensability of ICTs in a given field: how embedded these technologies are in everyday routines and in institutions of this field and how available non-ICT alternatives are, taking into account that an alternative costing a lot of extra resources (time, money, etc.) is not necessarily a 'real' alternative.

3.3. Determinants of digital inequalities – focus on the Netherlands

When the digital divide was still understood as a dichotomous concept, it was said to generate a 'new source of social disadvantage', as there was a relatively quicker rate of internet adoption among people with a higher socio-economic status (Lupač, 2018, p. 48). A recent study conducted among a representative sample of the Dutch population shows that attitudes regarding the use of the internet do not differ much among gender and age groups (Van Deursen, 2018). Older adults remain nevertheless more likely to have fewer motivations to use the internet, and 22% of the adults aged 66 and older never used it, or 6% of the Dutch population aged 12 years and older (CBS, 2019; Van Deursen, 2018).

In terms of material access, older adults and to a lesser extent people with a lower education level are less likely to have access to the internet (Van Deursen, 2018). In general, men, working people and people with higher education levels are more likely to have access to diverse and quality material, which in turn influence skills, usage and outcomes (Van Deursen & Van Dijk, 2018).
In terms of skills, 22% of the population had few to no digital skills in 2015 (CBS, 2016). Although operational skills are high among the Dutch population (e.g. turning on and off a computer), strategic and information skills (such as knowing where and how to look for information) are lacking among people with lower educational levels (Van Deursen et al., 2015) and with low literacy skills (Baay et al., 2015). A longitudinal study in the Netherlands indicates that the gap between people with higher education levels and people with middle to lower education level widened in terms of digital skills between 2010 and 2013 (Van Deursen et al., 2015). This could be due to the increase and the fragmentation of information sources (Van Deursen, 2018). Social support from relatives does not seem to fully compensate for the lack of digital skills (*ibid*.).
In terms of usage, people with a higher socio-economic status (in terms of income and education level) use more frequently the internet and for a diversity of activities, including activities that further improve their social status. This suggests the existence of a usage gap among the Dutch population (Van Deursen, 2018; Van Deursen & Van Dijk, 2013).
Finally, in terms of outcomes, studies show that the internet offers more positive and tangible outcomes to people with a higher social status (Van Deursen, 2018; Van Deursen & Helsper, 2015). This means, for instance, that they are more frequently able to be up-to-date with government information, they can find products cheaper than at a local store, and they indicate feeling healthier thanks to online medical information.
Van Deursen (2018) notes that the groups that could benefit the most from the ICTs are precisely those who have limited access to ICTs. Digital exclusion is intertwined with social exclusion in complex ways though. The relation between both concepts is claimed to be bi-directional, but the causality between both remains uncertain (Mariën et al., 2016): which inequality was here first? Access to technology is one of the many factors potentially leading to social exclusion, as Kenyon et al. (2002) noted early on. Furthermore, Mariën et al. (2016) noted that quantitative and qualitative studies yield different conclusions on the link between digital and social exclusion. Quantitative studies tend to find more of the "social status leads to digital exclusion which in turns perpetuates social exclusion", while qualitative studies usually show a more nuanced picture: socially advantaged groups can be digitally disadvantaged and socially disadvantaged groups can also use ICTs to their immediate advantage. As such, more research, especially using a mixed-method approach (qualitative and quantitative) is desirable on that topic.

4. The need for further research

4.1. Justification for the need for further research from a social and policy perspective

As previously evoked, Dutch ministries and the government in general actively promote and support digitalisation, and probably many people benefit from digitalisation in transport services. We have also seen that the trend to rely on ICTs in transport services is likely to keep going on. Initiatives such as MaaS, supported by the ministry of Infrastructure and Water Management (Minister en staatssecretaris I&W, 2019), exemplify

this. In addition, the Netherlands does have the highest internet penetration rate in Europe and is, with Sweden, the country with the highest use of mobile internet (CBS, 2018). Furthermore, many would argue that using transport services without being confronted to ICTs or without being digitally literate is still possible in the Netherlands in 2019. There are alternatives: there is no need to have a smartphone to get on a bus, paper tickets are still available at train stations (even though checking in and out still needs to take place) and one can go to an agency to rent a car for a weekend trip.

However, with some background on digital inequality research, we can see why this type of reasoning is misleading. There are three reasons:

1. First, having an internet connection at home or via a smartphone does not necessarily mean that people are able (or willing) to benefit from what these technologies have to offer. Attitudes, motivation, having the right type of material (up-to-date, of good quality, diversified), having digital skills (operational and content-related skills) and usage all matter. Studies show that gaps on these matters exist in the Netherlands, as previously presented. More research is needed to understand who is affected when using transport services.
2. Second, as digitalisation permeates more and more in transport services, it is likely to become more embedded in the system, taking us back to the question of indispensability of ICTs: can we still call a situation where one has to systematically spend (considerably) more resources than others an 'alternative'? This question is especially pressing when one of the key aspects of the mobility policy as defined in recent strategic reports is that it should be accessible to everyone (see *Iedereen onderweg*, Ministerie I&W (2019a), *Schets Mobiliteit naar 2040, speerpunt 4: Bereikbare en leefbare stedelijke en landelijke gebieden*, Ministerie I&W (2019b), *Onbeperkt meedoen! Actielijn Vervoer*, Ministerie VWS (2019)). Indeed, social inclusion is one of the key principles in (transport) policymaking. More research is needed to understand to what extent ICTs have become indispensable in transport services, and how that has affected people in terms of social exclusion.

   Actions have already been taken at a policy level to address digital inequalities arising from digitalisation, such as support for people with few digital skills and the implementation of websites easier to navigate (Staatssecretaris BZK, 2018). Such programs could also focus explicitly on transport services. Additionally, providing offline alternatives that do not systematically require more resources such as extra time or extra money could also provide a solution here. Not only are such considerations valid for people who are not able to cope with digital transformations, but also for those who are not willing to – the demarcation between both groups being blurry.
3. The third point, at a more strategic level, is that data generated by sensors, smartcards, applications, surveys and websites can in fact further promote discrimination and social inequality. Indeed, data is used to build models, for instance to forecast future travel demand, which then reproduce existing imbalances in the transport system as they are based on current travel patterns (Martens, 2006). As O'Neil (2016) cautions in her book *Weapons of Math Destruction*, data can reinforce existing biases with the semblance of objectivity.

4.2. Justification for the need for further research from an academic perspective

Is there (international) literature on the potentially exclusionary effects of digitalisation in transport services? In order to identify literature on this topic, we conducted a small

literature search. First, we identified the relevant keywords. We focused on the nexus between the themes of digitalisation, mobility and social inclusion, as depicted in Figure 2. These themes were assigned keywords, chosen to be broad enough yet target exactly the core of this search, and we looked for literature that overlaps between these themes, in English in Scopus (peer-reviewed material only) and in Dutch in Google. We found 502 papers in English and 27 papers in Dutch in August 2019. Then, we screened titles and abstracts, and if in doubt full papers, to find out which of them connect the three themes by putting in relation the use of transport services with the access to ICTs (in the broad sense defined by Van Dijk (2005)) and focusing on inclusionary or exclusionary effects. The final selection left us with 8 papers in English and 6 papers in Dutch: the field is therefore still unexplored. Besides, the exploration started only recently: 8 of these papers were published in 2018 or 2019.

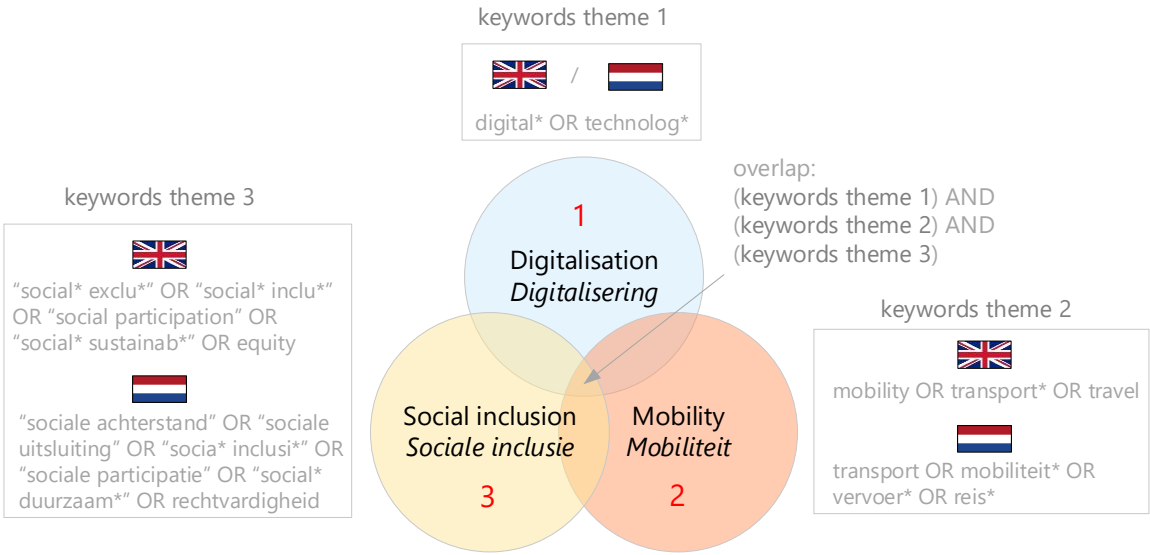

Figure 2: Approach for the literature search.

The selection of papers uses roughly three types of approaches, as discussed below.
Firstly, there are Dutch studies with empirical findings relating to underprivileged groups and their relation to technologies in transport services when travelling. The approach is qualitative; results are sparse and seem contradictory. While studies find that people with a mild cognitive impairment and a few job seekers get on well with journey planning apps/websites and the OV-chipkaart (Bastiaanssen, 2012; Van der Meulen et al., 2018), participants from focus groups in Zeeland reported that PT has become increasingly complex to use with digitalisation (Kantar Public & KiM, 2018). Still, these results were not the main focus of these studies, and they employed dichotomous metrics like use/no use.
Secondly, there are papers that started to conceptualise the links between mobility, digital inequality and social exclusion. Transport poverty literature is relevant here. According to Jorritsma et al. (2018), inspired by the frameworks of Lucas (2012) and Kaufmann et al. (2004), the probability of transport poverty increases with the combination of social disadvantage (influencing access to ICT), the lack of skills (including digital skills) and the (perceived) inadequate transportation options (including information about such options). In the era of mobile connected technologies, digital skills and the right material are prerequisites to access shared ('smart') mobility services (Brown, 2019; Vanoutrive,

2018). Overall, there is at this moment a nascent but still very limited understanding in transport research that having access to technology does not necessarily translate into the beneficial outcomes that technology can give, like digital divide researchers argued two decades ago.

Thirdly, only two papers specifically address access to ICTs, mobility and social exclusion theoretically and empirically. Varghese and Jana (2019) used 'access to ICT' as a metric with gradations (use of smartphone/use of laptop/Internet use) to study the potential of ICTs to improve access to opportunities. For the reader familiar with digital divide research, the findings are expected: 'social advantage' had a significant positive relationship with 'access to ICT', demonstrating how different social factors induce digital exclusion. Still, Varghese and Jana (2019) specifically point out that ICTs cannot be considered as a panacea to reduce social exclusion. The author of the second study asks for more considerations relating to transport poverty in multimodality research. According to Groth (2019), current patterns of social exclusion via transport may well be reproduced and reinforced within smart mobility trends. This comes partly from the socially and spatially selective way digitally-based mobility initiatives are implemented, and partly because access to technology is still not obvious for everyone. In his empirical research, Groth (2019) found a correlation between mode options and smartphone distribution, leading him to suggest the existence of a multimodal divide, i.e. "the reproduction of low mode options in the guise of supposed improvement through smart mobility". Besides, he cautions that a perfidious form of social exclusion via mobility concerns people who avoid installing mobility applications to protect their privacy. Still, Groth (2019) used a dichotomous definition of the digital divide as "the division of the society into mobile onliners and offliners". This small literature search shows that there are still many unexplored avenues.

5. Conclusion and suggestions for further research

In this paper, we critically examined the consequences of digitalisation in transport services and we draw from digital inequality research to shed light on the mechanisms that can result in social exclusion due to digitalisation in transport services. Digitalisation is changing the way transport services are provided, and therefore the way people make use of these services. The trend to rely on Information and Communication Services (ICTs) in transport services in the Netherlands is likely to keep going on, and benefits many people. Yet even for a country with a high (mobile) internet penetration rate such as the Netherlands, some people might be left behind because they are not able to cope with or willing to follow the pace of digitalisation in transport services, and everything that these transformations bring along. Indeed, having physical access to technology does not necessarily translate into the beneficial outcomes that technology can give. Literature on the potentially exclusionary effects of digitalisation in transport is still in its infancy though. Investigating how digitalisation affects the access to mobility services is especially critical when one of the key aspects of the mobility policy in the Netherlands is that it should allow for and foster social inclusion. Therefore, more research is needed on that topic, from a policy and a social perspective, as well as from an academic perspective.

The KiM has started a research project on that topic. In this project, we will conduct a systematic literature review that extends the literature search presented in this paper. It

is meant to provide policymakers and scholars with a complete synthesis of what is already known on this topic, an overview of gaps in knowledge and avenues for future research. We also intend on gathering examples and practices from other sectors, to understand how they have been dealing with digital transformations (e.g. e-health). In addition, this project includes fieldwork, meant to explore this topic in the Dutch context and to draw out latent issues related to digitalisation in transport services.

Furthermore, we already suggest multiple avenues for research that deserve further exploration. It would be interesting to dive deeper into who encounters difficulties in transport services because of digitalisation in the Netherlands. We suggest using digital inequality research as a framework, and in particular Van Dijk's "stages of access to ICT" framework, in order to avoid binary outcomes. Here, two approaches are possible. A first approach would be to focus solely on at-risk groups, like older adults. In studies representative of the whole population, such groups are often considered as homogenous entities, while they are in fact not (see Alsnih and Hensher (2003) on older adults). Therefore, studying these groups could help bring more nuances and therefore support the implementation of targeted policies. However, digital inequality literature shows that it would be erroneous to believe that only specific 'vulnerable' groups, like older adults and people with low literacy skills, are not able to benefit from technologies. To avoid missing latent issues at the population level, a second approach would consist of focusing on the whole population, and quantifying digital inequalities at this level. This would also contribute to understand better which level of access to ICTs is needed to navigate the transportation system in the Netherlands. For this specific research avenue, investigating how digitalisation has permeated in the transportation system over time and critically examining the changes it brought along for travellers would be of particular interest to establish the indispensibility of ICTs in transport services.
In both approaches we mention here, qualitative and quantitative studies are valuable. Quantifying the issue would make it more specific and allow for concrete policy responses, yet as transport scholars argue, a qualitative approach is also interesting to properly take into account people's experience and therefore broaden perspectives on transport inequality and, in turn, on transport policy (Banister, 2019; Mokhtarian, 2015). As such, mixed-method research (quantitative and qualitative) would be particularly appropriate.
An important question is the contribution of digital inequality to social exclusion. To begin with, one could investigate to what extent digital inequality is reinforcing and/or creating transport disadvantage, as the combination of transport disadvantage and social disadvantage is seen as a cause for social exclusion (Jeekel, 2018; Lucas, 2012).
Last but not least, we acknowledge that there are other negative aspects that come with digitalisation in transport services and that would require further research as well. Technology can be misused (e.g. hacking) and can fail (e.g. power cuts, low battery). It is relevant to investigate how app-based mobility service users experience these forms of uncertainty. Privacy issues and their impact on travel also require further research, as underlined by Groth (2019). Finally, another research direction worth exploring is the link between 'green' and 'smart' mobility, as recent studies show that smart does not always mean environmentally sustainable (see e.g. Fehr and Peers (2019)).

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