Manuscript Details

Manuscript number	RETREC_2017_218
Title	Using platform logics in the creative destruction of urban transport – a transitional path to sustainability
Article type	Research Paper

Abstract

The transport sector faces challenges relating to the climate, local environment, congestion, funding and equality, and uncertainties over political leadership, self-driving vehicles, citizens' reactions, and how the system is understood. Despite ambitious goals and investments, problems escalate via motoring's self-supporting processes: more cars, more roads, longer journeys, urban sprawl, more cars ... . Neither technical streamlining nor public-transport investment can trump the process. This paper examines if we can use methods provided by the fourth industrial (r)evolution to promote the creative destruction of urban-transport systems and embark on a transitional path to sustainability. The starting points are: transport's role in creating accessibility; the sector's inherent logic and vast unused capacity, particularly in infrastructure; and the methods and business models of the burgeoning digital-platform monopolies. A feasible future is described, based on a digital multimodal urban-transport platform for information and payment. This provides the base services: space on streets, roads, rails, car parks and public transport. The technology exists but institutional problems abound. Radical public-sector innovations are required. The paper identifies opportunities and obstacles. Finally, it evaluates the potential to realize these ambitious goals (and the risks involved), focusing especially on public transport's role in a reorganized system of this kind.

Keywords	digital platform; business model; transition; dynamic pricing; complex system; multimodal integration; climate change; behavioural design; service

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Using platform logics in the creative destruction of urban transport – a transitional path to sustainability?

Paper presented at the Thredbo 15 conference in Stockholm, 13–17 August 2017, Workshop 7. The 'uberisation' of public transport and mobility as a service (MaaS): implications for future mainstream public transport.
Revised in November 2017.

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Acknowledgements: This paper has been produced within the MistraSAMS research program at the KTH Royal Institute of Technology, Stockholm and is funded by the Swedish Foundation for Strategic Environmental Research.
The author wishes to thank David Banister, Björn Granberg, Karolina Isaksson and Bert van Wee for valuable comments on a previous version of this paper.

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1. Introduction

Many remedies have been suggested to solve the growing transport problems that cities are facing (Santos et al. 2010a, b). The present paper focuses on challenges in the global North – hugely expensive economic problems and frightening inefficiency; major congestion and a lack of predictability; ecological problems resulting in climatic effects that are hard to address (Gössling & Cohen 2014), damage to local environments through noise pollution, barriers, exhaust gases and particle emissions, and the use of valuable urban space; and social problems such as inequality in illness and death, and in access to necessities such as work, and amenities such as shopping and recreation (Niedzielski & Boschmann 2014; Gössling 2016; Boarnet et al. 2017). The problems are so great, and ambitions so high, especially in terms of the climate, that small gradual changes are insufficient, if they cannot quickly overcome the resilience of the unsustainable transport system.

Numerous proposals aim to increase capacity, build more roads, more efficient engines, or develop more eco-friendly fuel, measures that have failed to show any genuine transformative power. Any improvements are consumed, wholly or partly, by increased consumption, larger vehicles and longer journeys. Life-cycle perspectives are routinely overlooked: the fact that, even in an electrified future, the manufacture, maintenance and eventual disposal of vehicles, energy sources, batteries, and infrastructure have a significant environmental impact. Major investment in public transport, cycling initiatives and courses to wean motorists off cars yield only marginal benefits, if these carrots are not used alongside sticks.

Recently many have put their hope, in vain, in sharing services such as the commercial Uber, non-profit ride-sharing, or the group of transport services packaged as Mobility as a Service (MaaS. Kamargianni et al. 2016). Nor has the proposal of more data and increased 'smartness' led to ideas with game-changing potential, despite many years of supporting vehicle telematics (section 3.6) and Intelligent Transportation Systems. (ITS is – not a transport system itself but a movement strongly focused on IT.). Improved services for traffic information, travel planning and navigation are also included in the comprehensive arsenal of measures that raise exaggerated hopes. The situation with demand-related congestion charges and parking fees is different. Although these have real potential, focus is often lost because prices are seldom adjusted and the income generated is used as just another form of taxation.

Many of these services, which are good in themselves but insufficiently transformative, will be indispensable parts of a future climate-adapted transport system. The reason for their limited success can be found in the way the transport system works. In cities with congestion problems there is also latent demand (Downs 1962). If pressure on a particular road declines, when motorists transfer to public transport, then other road users will take their place. This, surprisingly, is a blind spot common to virtually all the above proposals.

The fact that the transport sector as a whole presides over a vast unused capacity is often overlooked too. The sector is one of the most inefficient in terms of the relationship between the work it carries out and the available capacity, which, in common with latent demand, is because 'in no other major area are pricing practices so irrational, so out of date, and so conductive to waste as in urban transportation' (Vickrey 1963:452). For the same reasons, the century-old strategy of predict and provide (Owens 1995) failed to solve problems by increasing capacity at times and places of peak demand. Given that the road network regularly grinds to a halt when it attracts more traffic during rush hours, the flow of traffic is lowest when demand is highest.

The idea of pricing in relation to demand has met with stiff resistance. Where it has been introduced, though, the correlation between price and demand is weak and the effects are therefore limited, albeit clear. Thanks to IT – the third industrial revolution – the means of introducing flexible dynamic-pricing systems have successively increased (the same is true of parking), although without making any significant impact.

The fourth industrial revolution (some talk of evolution) has introduced major changes in many branches and sectors of society. These include radical innovations with completely new patterns of behaviour, ways of meeting existing needs, and amazing possibilities for coordinating and streamlining. So far the transport sector has seen only modest change because its infrastructure is not yet involved (Paaswell 2014). What is lacking is a firm, comprehensive grip on the entire transport sector, together with a consistent, radical focus on users (Gullberg 2012a, b; 2015a). This allows us to imagine an urban world without congestion; with room for children to play on the street without fear of lethal air pollution or being run over; with good, cheap public transport and help available for everyone to find their way; where traffic information is reliable and where we can arrive on time; and where an ecosystem of transport and other services allows companies supplying geographically defined services to develop their innovations and businesses.

But given that motoring's self-supporting processes – more cars, more roads, longer journeys, urban sprawl, more cars and so on – remain unchallenged, a far-reaching process of creative destruction would very probably be required. According to this concept, attributed to the economist Joseph Schumpeter (Reinert & Reinert 2006; Schumpeter 1942), new systems of production marginalize and destroy old ones, often in a quite rapid course of events.

But with motoring's self-supporting processes: more cars, more roads, longer journeys, urban sprawl, more cars and so on, still unchallenged, this would most probably need a profound process of creative destruction (a concept attributed to the economist Joseph Schumpeter Reinert & Reinert 2006; Schumpeter 1942) whereby new production systems marginalizing and destroying older ones often in a rather fast course of events.

This paper aims to bring together, albeit in outline, three fields of knowledge that are usually seen as separate entities: the nature and functioning of the transport sector; the logic and transformative potential of digital platforms; and the characteristics of how services are produced and consumed. Highly condensed summaries of the extensive literature in these areas form the foundation for a synthesis that combines a systems perspective on the transport sector, with a strong user orientation, by using the opportunities provided by digital platforms.

The paper is arranged as follows. Part 2 describes the transport sector's accessibility services and how increased mobility came to replace proximity in order to create accessibility. Part 3 details the sector's forms of production, inherent logic, unused capacity, and complex nature. Part 4 describes the methods and business models of digital-platform companies, and their ability to influence behaviour. Part 5 defines the characteristics of good-quality services, to be applied when drawing up suggestions for the range of services that could be provided by the proposed digital platform. These sections form the basis for Part 6, which outlines a conceivable future with a digital-transport platform and adapted business models. Thereafter Part 7 examines obstacles and opportunities for introducing such a platform. In conclusion, Part 8 evaluates the platform's potential to fulfil the ambitious expectations directed at the sector and the role of public transport in a future of this kind. Threats to personal integrity and the risk that a system built on benefit maximization undermines society's morals are also discussed.

The fourth industrial revolution provides the opportunity to replace increased mobility with a restrained orchestration of proximity and mobility as a means of creating accessibility. However, urban development with increased mobility seems most likely, given the major investments in developing autonomous vehicles, and the absence of effective policies to include this type of vehicle within a sustainable developmental process (Sprei n.d.).

2. Accessibility services of the transport sector

'People [just like other animals are] destined to move … to find food and satisfy other material and social needs. … This principle does not change because we … delegate transport to others who carry it out by machine' (Hägerstrand 2009:202).

The main role of the transport sector, to create accessibility by moving people and goods, has long been obvious to scholars without making a significant impact on transport policy. Accessibility enables people to benefit from goods, services and activities (Litman 2015), but it also provides the opportunity, for example at a regional level, to unite in time and space the necessary skills and resources for various types of societal activities and processes (and to remove waste and exclude other obstructing elements).

The point is not transport itself but the opportunities it provides. Demand is derived; benefits arise in the sectors being served because geographic distances are bridged between supply and demand in its widest sense.

Yet the actual transportation between O(rigin) and D(estination) is not of sole importance. Accessibility too, in other words the opportunities available to carry out transport, to reach resources and amenities, represents a significant option value (Litman 2015:11).

Transport cannot be 'stored' and nor can its production be moved elsewhere (Owen Jansson 2006:72). When people are transported, as with other personal services, those using the service must be present, which is not the case with goods transport. As a minimum, people must physically take part, contribute their time, perhaps pay, drive, and maybe suffer discomfort, unpunctuality, stress, the risk of injury or death, and the loss of their sense of control and their privacy. The transport economy treats these sacrifices as part of the function of production, in other words necessary trade-offs that allow the service to be produced (Small & Verhoef 2007). Conversely, travel time may sometimes be a bonus: a chance to listen to music in the car, or an opportunity, otherwise unavailable, to socialize with one's teenage children (Dowling 2000).

Some forms of transportation are made for their own sake, with no destination: a drive in the car, a Sunday stroll. In addition, people transporting themselves always entails extra-instrumental aspects, given that they take place, to varying degrees, in public space, under the gaze of others, providing people with a longed-for, or awkward, opportunity to present themselves (Goffman 1956). The composition of the car park is a clear example of this phenomenon, cars being typical positional goods (Hirsch 1977; Veblen 1899), valued in terms of their status in relation to other cars. Thus some parts of the urban-transport sector can be seen as status markets (Aspers 2011), where the key feature is not what is consumed, but rather who are the producers (defined by trade marks) and consumers (and their hierarchies, section 3.5). Before motorization, transport was both laborious and expensive. The dominant principle for creating and maintaining accessibility was to limit distances travelled via co- and close-locating. In terms of cities, the first industrial revolution made little change here. But steamships and railways made long-distance transport much more efficient, which quickened urbanization and increased city density. Things were different in the second industrial revolution with the electric motor, internal combustion engine and very cheap energy. Constantly increasing mobility became the dominant formula for maintaining and preferably increasing accessibility, and in consequence cities became progressively dispersed, daily journeys ever longer. The transportation of people and goods has grown enormously. Information technology: the third industrial revolution, which offers more opportunities for coordination, control, and payment for services, has not altered the main thrust of current development.

3. Forms of production, inherent logic, unused capacity and complexity of the transport sector

The transport sector's method of creating accessibility by increasing mobility is partly self-destructive. Forms of transport that are easy to use, cheap and quick contribute to more dispersed localization with reduced accessibility as a result. Conversely, co- and close-locating of homes, workplaces and businesses tends to increase accessibility and reduce the demand for transportation. The inhabitants of a typical US city cover twice the distance as those in an equivalent European city to reach the same range of services (Owen Jansson 1996:38). The interaction between transportation and localization is a classic research theme, without making a significant impact on transport policy.

The production of availability is further complicated by the fact that mobility occurs via several modes of transport, separated in terms of organization and operation from one another, and varying greatly in capacity and environmental and distributional effects, at the same time as they influence each other, often in contra-intuitive, overlooked ways: in a complementary fashion, linking into a single journey; and when competing for transport users, funding, and for room in the city and its shared infrastructure.

The movement of people and goods is dependent on infrastructure, within which vehicles move with their loads. Three predominant forms of production differ from one another in terms of the relationships between end users, vehicles and infrastructure.

Self-service: private vehicles using someone else's infrastructure – primarily the street and road network. This dominates the transport sector in the form of motoring, the main feature of the self-service economy (Gershuny 1978). Passenger transport: walking (no vehicle!), cycle, car, other types of motor vehicle and boat. Goods are conveyed in personal lorries, vans and cars.

Public transport: nowadays mainly passenger traffic (although future goods transport is discussed in Fatnassi et al. 2015); a seat in someone else's vehicle according to a fixed tariff, usually according to a timetable and travelling along a fixed route on shared or reserved infrastructure: tram and bus on the street and road network, trains, the metro; aerial lifts; Bus Rapid Transit (BRT); additionally a hybrid comprising reserved-lane buses using lanes not completely separated from the street and road network; and boats.

Ordered transport: A seat or load space in someone else's vehicle, according to agreement, via using third-party infrastructure. Passenger transport: taxi and similar services and shipped goods. Hybrids exist and are evolving.

A fourth form of production comprises the pipes and cables that transport energy, heating, cooling, water and sewage, and the airwaves and digital cables that spread information. These are important for cities as they relieve the street and road network, as would the proposed general underground pipeline system for transporting solids and powders (Kulińskaa & Odlanicka-Poczobutt 2016). In most cities the lion's share of the infrastructure – rail and street and road networks – are in public ownership, the latter in the public domain, accessible to all citizens. These kinds of infrastructural networks are strongly inclined to be natural monopolies, and morphologically the entire section of intended passage, from Origin to Destination, must be available, which can be facilitated if public bodies ensure the right of way (Millward 2005:17).

Along with space on the streets, roads and parking spaces, local public transport is one of the base services of urban transport, on which all travel and transport depends. Here the public sector often enjoys a monopoly. Local public transport is normally partly financed by the taxpayer (Small and Verhoef 2007:159, Dienel 2009:275), which is often motivated by its social importance, as a merit good (Musgrave 1987) and sometimes for its mitigating influence on congestion (Schrank et al. 2015).

3.1 Unused capacity and differences between the modes of transport

In a region such as Stockholm only a few percent of the overall street and road network is affected by congestion, and then only at limited times of the day, week and year. Yet it is still worth drawing attention to this phenomenon. First, a far greater proportion of road users are affected by congestion-related delays and unpunctuality. Second, current congestion tends to define dimensions for policy decisions for future expansion of the street and road network.

Unused network capacity is considerable. At peak times it can be further increased in order to mitigate congestions, without new investment, by changing modes of travel and the way vehicles are used. In the average car, during the 5 per cent of the time it is actually used, only 25 per cent of the seats are occupied (which is the same degree of coverage for parking spaces (Shoup 2011; Hagman et al. 2007)). Just to illustrate this huge overcapacity, if these figure were doubled, then all rush-hour passengers on Stockholm's public transport, which is well known for its large market share, could be accommodated in the cars then on the road, albeit without travelling to each passenger's intended destination (Lundin & Gullberg 2011:92).

Buses, as well as bicycles, on city streets in mixed traffic can carry seven times as many passengers as cars, whereas pedestrian traffic is capable of conveying 15 times as many people per width metre and unit of time. A tram can carry between ten and twenty times as many passengers per unit of time, and its passengers take up only a twentieth of the urban space of car passengers. In a reserved bus lane, the number of travellers can increase by a factor of 15. The metro can accommodate 25 times more passengers than cars on city streets, and over six times more than on urban motorways (Gullberg 2015b).

Capacity differences can also be expressed in terms of surface use. To replace a metro train with an equivalent-capacity urban motorway would require seven lanes in each direction, or 17 in the case of a city street. A commuter who changes their mode of transport from rail to car increases their surface usage by a factor of 60 for the journey time alone, or by a factor of 850 if eight-hour car parking is included (Vuchic 1999). In other words present accessibility could be maintained and expanded, even with a significant reduction in infrastructure and vehicle numbers, if these were used more effectively, and particularly if high-capacity forms of transport were prioritized.

3.2 The street and road network as a commons

The street and road network is a human-created commons, used for the public good and open to all three forms of production. A large proportion is prioritized or fully reserved for motor traffic: a motor-dominated street and road network reserved for a 'club' of licence holders with access to vehicles who are 'sharing … an excludable (rivalrous) public good that is a club good' (Cornes & Sandler 2007:347). The network may be used on demand, requiring neither agreement – with the road owner nor consultation with other users. The system is loosely connected; the relationship between the infrastructure and its use/users is weak. Usually traffic flows unhindered, but with too many users at any one time, using the same routes, the service deteriorates for everyone and ends in queues. The network is susceptible to congestion, flow decreases and capacity reaches its lowest point when demand is greatest.

A social dilemma has arisen: everyone loses by doing what is best for them. Traffic jams would not occur if vehicle flow was slower when capacity was about to reach its limit. This would allow more cars to reach their destination during this otherwise congested time period, and they would arrive much sooner too. This means those setting off later would still arrive sooner. Relatively small changes have major consequences. For example, on Sweden's busiest road a reduction of 500 vehicles just before congestion occurs could accommodate an additional 8 000 vehicles during the eliminated congestion period (Gullberg 2015b). In other overload-sensitive network systems such as power, telecommunications and data, huge efforts are made to avoid a collapse of this kind.

3.3 When overload threatens

The means to exclude or otherwise influence the use of the motor-dominated street and road network when it is threatened by overload is crucial for managing the social dilemma described in the preceding paragraph. For a resource to be excludable would depend on social convention and cost as well as technical means (Cornes & Sandler 1996:9f). There are five ways to deal with the problem of the commons or social dilemma, of which the first three depend on the influence of influx (Gullberg & Isaksson 2009:34f).

1 Hierarchy/regulation. Means of rationing are readily available: restricting the number of vehicles, prohibiting driving licences or registration plates that end with certain numbers on certain days of the week, but difficult to adapt to the wide variations in demand over time and space. '[M]ost clubs do not charge user fees according to congestion conditions' but if they did it would be a means to 'determine 'membership size' for [a] congested highway' (Cornes & Sandler 1996:401, 352). Ramp metering on slip roads at known congestion blackspots has better accuracy but insufficient power.

2 Market/price. Congestion charging so far correlates only weakly to actual demand in time and space. Comprehensive charging for road use, especially 'with the actual crowding experienced ... usually does not [happen], since such efficient schemes are difficult and costly to institute' (Cornes & Sandler 2007:411). Yet technical breakthroughs have meant that costs, both transactional and purely economic, have declined considerably, which is also true of parking. Nevertheless, real-time dynamic pricing exists only on limited stretches of road in private projects. The resistance of public opinion appears to remain strong.

3 Co-operation/agreements. Opportunities to develop trust and shared norms among drivers who are about to create congestion are small, which impedes collective solutions (Ostrom 2003:257). Digital car-sharing services increase contact opportunities, but not enough. Any alleviation is undermined by rebound effects (see next paragraph).
4 Increased capacity with new or widened roads where congestion is greatest. So far this has failed to solve gridlock problems. In the short term increased capacity quickly attracts more traffic; in the long term it stimulates decentralization, increased traffic and congestion. Induced traffic of between 0.2 and 0.8 has been measured for limited projects – 20 to 80 percent of traffic on the new road can be attributed to its construction – the so-called rebound effect. (Small and Verhoef 2007:174). Viewed over a longer period of time, and a larger part of the motor-dominated street and road network, the effect may probably exceed 1, the so-called backfire effect (Gullberg 2015b).
Alternatively if public transport, using a dedicated network, is built parallel to the congested road the effect is different. If motorists transfer to public transport, which is likely in the case of heavy congestion, then this would strengthen the demand and thus the possibility of improving public transport with a more frequent timetables and/or lower prices. The more people travel, the better transport can become (the Mohring effect, see below in section 3.4). However, the positive effect of reduced congestion declines when the roads attract more cars. On the other hand a new road, in unfortunate cases, can even lead to a worsened traffic situation, yet another example of how when everyone does what is best for them, everyone loses. Conversely, closing a road can lead to improved traffic conditions (the Braess paradox, Small & Verhoef 2007:95).
5 Taking no action would likely lead to increased congestion for cities with growing populations and economies, although any increase would be mitigated somewhat by congestion used as an (irrational) rationing method.

3.4 Rail and other forms of public transport

Public transport, especially on reserved lines/lanes, is far superior to the other forms of production in terms of capacity, area efficiency and the environment. Although for many this is the only option, in its conventional form it faces difficulties in providing traffic at times and places when demand density is low. With a separate infrastructure, public transport avoids the kinds of congestion that afflicts the motor-dominated street and road network, because coordination between infrastructure and vehicles/rolling stock is strong and regulated in closely controlled systems of this kind. In heavy traffic, delays and capacity deterioration may occur when public-transport columns form because of delays in boarding and exiting. Public transport on the street and road network is also affected by the social dilemma (described in section 3.2). Public-transport passengers have a potentially positive effect on each other. The more people travel, the better the basis and possibility for a more frequent timetable and/or lower prices (Mohring effect, Mohring 1972). Conversely, motorists on the motor-dominated street and road network hinder each other in congestion, but support each other by increasing political pressure for more roads.

3.5 Business models and market segmentation

End-user transport costs vary according to the form of production. In self-service, marginal costs apply, whereas in public transport (minus tax subsidies) and ordered transport, average costs apply (Cornes & Sandler 1996:524). For self-service, no payroll costs are involved (unless the end-user is a company employing a driver), whereas ordered and public

transport are imposed with salaries and taxes. A common factor to all forms of production using the street and road network is that the costs incurred for its use do not reflect demand and negative external effects. An important component of self-service motoring is parking, where financial demands on property developers to provide high standards are passed on directly to tenants. This is in clear contrast to a business model where car ownership would require the funding and operation of parking spaces.
Business-model variations between the forms of production can produce unintuitive results, for example that the *widening* of a road that runs parallel to a dedicated public-transport line can lead to a *deterioration* of both forms of production where latent demand prevails, according to the Downs-Thomson paradox (Owen Jansson 1996:97f; Small & Verhoef 2007:95).

The ability of transport users to exploit their consumer power varies between the different forms of production. In (local) state-controlled public transport, opinion forming and pressure on politicians applies. In the self-service sector, people express themselves through the choice of vehicles they buy, even though political pressure may still be necessary in terms of the provision of street and road networks (Gullberg 1989). Motoring's self-service nature requires a far greater commitment from road users and households than other forms of production. As co-producers motorists are responsible for driving and maintenance, and in economic terms a car-owning household usually spends far more of its income on transportation than a non-car household. This increases the road user's personal involvement, financially and emotionally, in how urban mobility services are produced. The road user, via the role of the car as a dominant status symbol, is part of a very different kind of market than the consumer of ordered and public transport, where service properties are of central importance. The latter is what Aspers (2011) ideal-typically defines as a standard market, in contrast to a status market, which is characterized by the nature of the organizations or individuals who are producers and consumers. This also means that the types of information sought on these contrasting market types are fundamentally different.

Differences between modes of transport in terms of business models, taxation of labour, infrastructure funding (including car parking), and emotional attachments have helped to ensure that the most inefficient, environmentally damaging forms of production have in many areas outcompeted efficient, eco-friendly public transport.

3.6 Mobility, accessibility and complexity

The combined transport sector, as we have seen, consists of several subsystems with very different characteristics. They are managed separately in terms of politics, administration and economy, despite strong and often ignored interactions between them. This makes the sector a complex system (Macário 2011), amplified by loose links within the street and road network and the movement of vehicles that takes place on it. Because of the intricate interaction of the sector as a whole with localization and digital connectivity in the common production of accessibility (Lyons & Davidson 2016), complexity is further increased. This produces difficulties in predicting the consequences of subsystem changes for other subsystems and for the transport sector as a whole.
At the same time, and in some ways a contradiction, great stability has prevailed since the early 20th century via the dominance of the private car, whose logic, formal political backing and support by influential lobby groups, all based on a broad, positive public opinion, has

transformed urban regions, at the same time as the profound consequences of motoring have been overlooked. This may be explained in terms of the system's strong resilience to internal and external change (Hoffmann et al. 2017). To transform this situation, in which the least energy- and area-efficient means of transport dominates, requires reduced complexity, which would allow the system to be more easily managed and the various subsystems to interact according to more uniform principles.

One way to reduce complexity is the use of dynamic pricing, to more closely connect the street and road network with vehicles, an idea first proposed in the 1840s (and after that by Smeed in 1964 among many others. Balwani & Singh 2009) that has still to make any real impact (Gullberg & Isaksson 2009). Theoretical progress has been summarized by Tsekeris & Voß (2009), including the possibility for price variation according to user, vehicle and road, taking into account social and spatial equality, and interaction with other parts of the transport system and beyond.

With its roots in the late 1970s, the term vehicle telematics has come mean an ongoing, multi-faceted trend towards vehicles with increased automation and internet access. From the end of the 20th century onwards, high hopes lay behind huge investments in research and development, such as the Eureka Prometheus project (1987–95 of 749 million Euros (Eureka n.d.)). Optimism at this time encouraged the idea of combining dynamic pricing for infrastructure use with all modes of transport (Höjer 1997; Yaro 2002; Wagner 2003). But neither the transport and IT sectors, nor politicians and authorities, were ready for this new kind of integrative thinking and policy making. Several features have seen further development, by among other Tsekeris & Voß (2009), albeit focused on road pricing. After the major breakthrough for platform companies and ubiquitous mobile computing in around 2010, several proposals, applications and concepts have seen the light of day. But these have not connected with the three above proposals from around 2000, even taking the latest IT developments into account (see however Gullberg 2012a, b, 2015a). In a review of smartphone-based vehicle telematics, dynamic pricing is mentioned only in reference to Uber (Wahlström et al. 2017). And an advanced overview of the many opportunities made available by the previous twenty years of technological development mentions the ability of 'traffic authorities … to manage traffic dynamically according to the situation [exemplified only by] a dynamic scheduling of traffic lights.' (Mekki et al. 2017:268.) Neither does the extensive collection *Disrupting Mobility, Impacts of Sharing Economy and Innovative Transportation on Cities* (Meyer & Shaheen 2017) deal with the question of dynamic infrastructure pricing, despite articles on Intelligent Traveller Information Systems (ITIS), the need for coordination and behavioural change (Lisson et al. 2017), on how urban accessibility can be created (Rode et al. 2017), and on the policies that should be pursued with reference to probable trends until 2045 (Mendez et al. 2017:7).

Research and policy discussions over the last decade have spectacularly ignored opportunities to use pricing mechanisms to coordinate infrastructure, vehicles and users, with the potential to reduce the complexity of the transport sector, and thus contribute to its transformation. The assertion by Bratton (2015:4, 44) that 'a general logic of platforms [is] a fundamental principle for the design and coordination of complex systems' provides good reason for further investigation.

4. Platform companies: methods, business models and behavioural hooking techniques

Over the last decade, major social changes have taken place with the IT industry at the epicentre. Five platform companies have topped the list of the world's highest valued businesses. Aided by new technology and digital-platform logic, everything has been remodelled, from warfare to news reporting to how our identities are created. This phenomenon has been described as the fourth industrial revolution, although some prefer the word evolution. Whatever the term, very obviously the playing field for many businesses has changed fundamentally.

Digital platforms interact with numerous other IT-related phenomena such as the internet of people and things (ubiquitous mobile computing), big data, artificial intelligence/deep learning and the cloud. A platform is a form of digital infrastructure where two or more groups can meet, an intermediary located between users and producers. Its digital nature (platforms are no new phenomenon: older examples include streets and squares) puts it an excellent position for gathering vast amounts of data, and also encourages users to commit to the platform and contribute to its development. A platform expands with the help of double or multiple network effects: the more groups and people who use it, the more valuable it becomes, which creates an inherent tendency to monopolize. Rapid growth also stems from the economy of scale: the greater the number of users, the lower the cost of accommodating each newcomer. The platform owner decides the rules of the game, which yield considerable power if the platform has grown large. Platform companies, via the vast amounts of data they collect, can coordinate, optimize, and flexibly develop and control their processes (Srnicek 2017).

A platform is an institutional logic, neither a state nor a market, 'a standards-based technical-economic system that simultaneously distributes interfaces through their remote coordination and centralizes their integrated control through that same coordination' (Bratton 2015:42). They provide users with great freedom, often with the ability to create, gamify and constantly remain on the platform, at the same time as the owner exerts control over them, not according to a predetermined masterplan but by having 'set the stage for actions' (Ibid.:47). With online ubiquitous mobile computing and continually updated customized information, users can instantly retrieve, and be reached by, offers whenever and wherever their need or desire is greatest, or when they are most susceptible (Ng 2014). New technology allows and/or demands new business models. The great value of personal data means that new, online services can be offered apparently free of charge in exchange for user data, sometimes as a freemium combined with a paid-for alternative that includes with enhanced features. This too has contributed to the exponential growth of these companies.

Platforms have huge potential not only to streamline, reduce transaction costs, and make the best use of available resources, but also to greatly increase and control consumption as a whole. They achieve this, in among other ways, by being proactive, anticipating actions, demands and dreams that are about to arise, or could conceivably do so. Some of these are then selected for cultivation. It is this eminent ability to coordinate heterogeneous users and products that makes platforms an excellent tool for minimizing uncertainty and improving the manageability of complex systems.

4.1 Behavioural design

Looking closely at highly successful digital platforms, it becomes obvious that they exert their behavioural influence mainly according to established methods such as B.F. Skinner's principle of reinforcement. Yet something very new is the situation in which users now find themselves, as described in the fourth paragraph of this section (Bargh & McKenna 2004). A 'more specific, detailed, and personalised service than at any other time in history [can be provided] through web-based and smart devices.' Users are enticed into continued interaction and exposure to influence via reinforcements in the form of successively refined, individualized offers in recommender systems, based on user history (Chung et al. 2017:1). User choice is influenced by how alternatives are presented, and users are tempted to return to the platform by 'an itch, a feeling that manifests within the mind and causes discomfort [when online behaviour becomes a habit] until it is satisfied'. This tendency is enhanced when a user has made a personal investment, tying their work to the platform (Eyal & Hoover 2014:34, 135ff).

Many scholars, both in psychology and in the new field of behavioural economics emerged before the fourth industrial (r)evolution to improve decision making. The former group includes B.J. Fogg, the founder of 'behaviour design' (formerly 'persuasive design') (Fogg 2009), who lives with the hope 'that his work is making the world a better place' (Leslie 2016). The latter group includes Richard Thaler who coined the term *nudge*: 'choice architecture that alters people's behaviour … without forbidding any options or ... changing … economic incentives' (Thaler & Sunstein 2008:6, cited in Cash & Hartlev 2017:101). The aim is to 'nudge people to make better choices (as judged by themselves) … but malevolent nudgers can have devastating effects' (Thaler et al. n.d.). Accordingly, Fogg has become sceptical: 'I look at some of my former students and I wonder if they're really trying to make the world better, or just make money' (Fogg cited in Leslie 2016). There is no doubt in the mind of one alumnus, Nir Eyal. The publication of his successful business model *Hooked: How to build habit-forming products* (Eyal & Hoover 2014) would appear to confirm his teacher's fears.

Merging these two genres soon amplifies the dualism between the expressed desire to do good, and the progressively refined methods to influence behaviour. On the one hand the aim is to 'support people in becoming the person they wish to be' (Zimmerman 2009, cited in Tromp & Hekket 2016:25) and to unite individual and collective concerns. In practice this can take the uncontroversial form of promoting sustainable behaviour (Cash & Holm-Hansen 2017:37). On the other hand we see the use and development of priming – an implicit form of intervention '[u]nconsciously influencing … behaviour …[which] has a number of advantages[: it can] … maintain freedom of choice rather than constraining behaviour; be deployed pervasively … without requiring directed interactions with the user; be used to subtly influence pro-social behaviour over the long term … without compromising user experience' (Cash & Holm-Hansen 2017:33).

The result, as Morozov (2013:349) describes, is that 'while you believe you are making conscious choices, parties you are not even aware of are actually influencing them invisibly.' Good intentions are not necessarily part of the design of these methods.They can be used for whatever purpose the choice architect desires. In addition to the risk that these methods can serve vested interests and destructive forces, they also tend to undermine an individual's power of judgement, when everything is inclined towards unconscious and subconscious decision making.

The huge impact of digital platforms, and the acres of time we devote to them, suggests their influence has been, and remains great. But to determine the exact size of the phenomenon, which like motoring is ubiquitous, presents great challenges. Regardless of this, it would appear that digital platforms, and the interactions that take place on or via them, are becoming increasingly important for 'how practices evolve', in the words of Shove (2010:1279).

One method, which contrasts with behavioural design and nudging by eliciting reflection and ethical decision making, goes by the name of adversarial design (DiSalvo 2012; Morozov 2013:329). Instead of predetermined morals being surreptitiously introduced via reinforcement, nudging and subliminal influence, this design exposes the tensions, conflicts of interest and wider implications that pervade most choices. Whereas behavioural methods form a basis for automatic decision making, adversarial design draws attention to the consequences of various options, thus creating a standpoint.

4.2 Modest effects on urban transport systems

The transport sector has also felt the effects of this new technology in terms of connected vehicles, automatic traffic control, platforms for guidance, real-time information, and the ability to book Uber or Mobility as a Service. These and other services allow individual transport users to make better-informed choices, at the same time as *the traffic situation as a whole remains unaffected*. Changes to the transport sector on a system level have so far been modest, because the sector's base services have yet to adopt the new opportunities for coordination, efficiency, product development and user-adaptation.

5. Platform service quality and content

The services provided in urban transport are generally of poor quality. Travellers never know with any degree of certainty when, or with what form of comfort, they will reach their destination (Gullberg 2012b). Reliability is poor, in striking contrast to other branches where 'it has become the common goal ... to satisfy … customers' (Dabestani et al. 2017). Services can be evaluated using three parameters: 1. technical/instrumental or outcome – what. 2. functional/interactional or process – how. 3. image (Grönroos 1982). The technical aspects of transport services concern what movements are feasible and, of these, which are actualized (FitzPatrick et al. 2015). Functional aspects involve 'the interactive nature of services and refers to the two-way flow that occurs between the customer and the service provider … including both automated and animated interactions' before, during and after transport, and in many cases permanently (Kang & James 2004:267). Image applies to the service provider's reputation, but may also relate to the choice of car brand, or the status of transport alternatives, which might persuade motorists to stop commuting by car (Redman et al. 2013). Common values in terms of level of service (LOS) focus primarily on technical quality, but as Litman (2015:13) has shown, information has a great bearing on accessibility.

<u>Technical quality</u> (Kang & James 2004; Schiefelbusch 2009; Macário 2011):
Scope/range – feasible movements of people and goods; availability – distance to public transport stops, car parking, and other obstacles; time taken, punctuality, price, comfort, safety, positive/negative social contacts; journey completed without problems; environmental impact.
<u>Interactive quality</u> (Kang & James 2004; Schiefelbusch 2009; Meier 2009; Egol et al. 2014):

- Information/interaction – easy to understand, customized, reliable, continually updated and manageable; transport alternatives/product information; contract/guarantee; booking; payment; user guides; disruption notification and support for making alternative travel plans.
- User options to choose interaction channels and interaction intensity: from no contact; to personal initiative, open to receiving reminders and suggestions; to being constantly logged onto the platform, giving feedback, co-producing, creating and sharing experiences

and material – acting as a traffic watchdog in other words.
- Access to extra material: sightseeing, augmented reality, third-party offers, vendor ecosystems.
- Follow-up (Kang & James 2004): reliability: provided as promised; responsiveness: keeping customers informed and readiness to respond to requests; assurance: making customers feel safe, providing knowledgeable answers; empathy: individual attention to customers, understanding their needs; tangibles: appealing facilities and materials.

Transport services have drawn-out processes with several critical points where opportunities for interaction with the supplier are particularly important. There is, from the point of view of options, a continually ongoing delivery – a steady flow of opportunities (Cornes & Sanders 1996:55). In the fourth industrial revolution, there is an increasing tendency for technical and interactive aspects to blend together, to such a degree that it is true that mobility is becoming ubiquitous (Tuominen & Ahlqvist 2010; Conti et al. 2012).

5.1 Contents of the proposed platform service

Interactive quality

The digital platform would provide:

Choice of service level and terms of use of personal data (search results, choices and itinerary, subject to informed consent):

No interaction, travel/transport the same as today (uncertainty about dynamic pricing is managed using maximum prices); interaction only by user initiative; some/all types of deals are desirable; premium users: co-producers, third parties.

Information immediate, updated, reliable and proactive about all available (for transport users – customized) travel and transport options (including ride sharing paid for via the road owner), services replacing or reducing physical movement, combination/intermodality (door-to-door), parking, dynamic pricing, travel times, comfort.

Agreement/payment option to book/order/subscribe and ease of payment for the option selected, whereby an individual, specified and easily monitored agreement is created.

Guarantees, automatic compensation guaranteed arrival at the agreed time, automatic follow-up and compensation for delays and other errors.

Directions for use guidance/navigation throughout the journey for all and all combined modes of transport, including walking, cycling, public transport and goods transport.

Notification of potential or actual disruption/deviation Notification of changes to expected travel times or to travel or transport costs that are subscribed to/normally chosen, along with proposed alternatives; decision-making support/suggestions of alternative modes of transport and routes, deployment of replacement transport if a journey in progress is disrupted.

Invitation to co-production and involvement by third-party companies car sharing, exchange of ideas, watchdogs, injury reporting, sharing of experiences. Motorists/freight companies are invited to be co-producers (prosumers), with compensation by the road authority. Platform open to transport sharing, links to social media and groups of like-minded people (communities). Additional services such as reserved seats on public transport, priority motorway lanes, extra insurance when punctuality is vital, and environmental competition between commuters from different suburbs and between companies. This would create an ecosystem with endless opportunities, with a major advantage over its competitors thanks to the multimodal digital platform's vast capacity to coordinate. This feature is lacking in other proposals such as that by Karim (2017).

Technical quality
With appropriate balances between its aims, the platform has the potential to provide dramatically improved accessibility; an increased range of mobility services, especially in public transport; shorter travel times; greatly reduced congestion; more choice/less compulsion to use cars; more use of carpools, rental cars, taxis, walking and cycling; transport and car sharing, even in taxis and community transport; more public transport with the choice of uncongested times/carriages; and increased intermodality and accessibility without physical movement. Spare capacity would be used instead of investing in infrastructure, vehicles and rolling stock, at the same time as operating and maintenance costs would be substantially reduced.

6. The platform’s backstage
In many respects the urban-transport sector, so burdened by problems, has features that make it particularly suitable to be remodelled using the streamlining methods that successful platform companies employ. The sector's base services have yet to be optimized either collectively (at a system level) or one by one. This means that a considerable unused capacity is available, that major differences between modes of transport can be exploited, and that small changes will produce large effects on congestion. Moreover, the impact will probably be great, given that all residents and businesses in an urban region are affected. The necessary features already exist but need to be developed and combined: information, pricing, dimensioning and operation. These relate to 1. Public transport. 2. The street and road network. 3. Parking spaces. Addition features are 4. A multimodal travel planner based on traffic information and short-term forecasts. 5. A traffic and transport control centre covering all modes of transport.
Through a combination of this kind, in proactive real-time (looming traffic problems can be predicted) on the digital platform, the range of base services can be dynamically, uniformly and coherently developed using algorithms optimized for goals such as efficiency, climate and environmental considerations, health, and equality. This takes the form of individualized responses in the platform's travel-planning function and notified changes to subscribed transport. The now-altered decision-making situations of transport users, if enough people respond, lead to reduced or eliminated congestion. Gradually their choices and the whole transport system will shift in line with the platform's algorithms.
Large amounts of traffic data are used as raw material: historical data; real-time data from cameras, sensors and smartphones in motion; data scraping; weather forecasts etc. Personal data from the platform may also be used: search results, and agreements and routes, if informed consent is given.
Data analysis produces output, not only to users but also to suppliers of base services and ordered transport, and to the next stage of analysis. Continual reiteration of this kind gradually improves the accuracy and services of the platform, the more it is used.
The complexity of the transport system decreases when previously absent links between the modes of transport, and between the street network and vehicles, are established via the platform. Various components no longer counteract one another. Many repressed areas or blind spots of transport policy will become apparent: the importance of the sector for equality (Macário 2014:112); vast unused capacity of the street and road network and its almost infinite exchange as well as use value (Ng 2014); strong structural effects of the motoring system; the presence of latent demand; public-sector innovation; close ties between the

transport sector on the one hand and property values/localization on the other (Macário 2014:109); and the importance of accessibility rather than mobility (Sclar et al. 2016). Because the platform service is expected to be highly valued, anyone demanding and/or offering spatially defined services will have the opportunity to attract numerous types of producers and consumers/users. It will therefore develop into a vigorous ecosystem for innovation by involving third-party developers. Clear agreements between producers and transport users will pave the way for product differentiation and user-driven innovation.

The proposed platform, and business models, would simultaneously use all the five methods in section 3.3 to deal with the social dilemmas that easily arise in overload-sensitive systems. Hierarchy: deciding the rules of the game. Market: individual transport-user choices. Cooperation: enabling parties to establish contact and work together. Expansion: increasing rail- or road-network capacity when congestion looms. Inaction: leaving the physical infrastructure unaltered (or reduced).

The platform will offer a collection of services whose value increases by being brought together. Srnicke (2017:49) calls this 'an on-demand platform of product type' citing the example of the Spotify music service.

If enough people subscribe to the digital-platform service, even non-subscribers would enjoy improved accessibility and a vastly improved traffic situation.

7. Platform reform: obstacles, opportunities and potentials

Many interests and types of circumstance have chained urban transport to its current car-friendly path of development, although other perspectives are now beginning to emerge. Despite this, comprehensive change faces strong resistance.

In transport-sector organization, the production of base services is strictly divided, in various public hands and monopolistic forms. This provides protection against competition and impulses for change. A strong emphasis on production focuses on creating and managing infrastructures at the expense of users and service perspectives. A widespread lack of understanding of how the transport system works as a whole, and how it interacts with localization logics, does not improve the situation. Many reform ideas are limited to only one mode or aspect of transport. The 'predict and provide' principle is still applied with no, or a disavowed, understanding of its nature as a self-fulfilling prophecy. There is a prevailing inability to imagine the sector working in any fundamentally different way than it already does (Enoch 2015).

Public-sector organizations and the powerful motor-industrial complex (one of the most successful lobby groups of the 20th century and beyond, comprising the automotive, construction and oil industries) guard their interests. Strong support is drawn from a significant motoring movement, anchored in many individuals' identity and lifestyle. We can also add major financial commitments on the part of property developers and owners in addition to those of car-owning households. The urban structure, with a thin suburban population, makes the car a compulsory part of everyday life for most city dwellers. Together these interests form a robust, mutually dependent city-building regime (Gullberg & Kaijser 2004).

At the same time, this grip is being challenged, not least in cities, by the problems described in section 1. Increasing knowledge about the nature of the transport sector, and awareness of a growing crisis, suggest radical policy innovations, such as a multimodal digital transport platform, might find support. Commitments within COP21, with its firm focus on the transport sector, may have a bearing in this context.

7.1 Trust in technological innovations

Hopes have been raised that technological innovations such as new fuel types, especially electricity, and so-called eco-friendly cars and/or self-driving vehicles can solve these problems. Milakis et al. (2017) describes a range of possible first-, second- and third-order effects of self-driving vehicles, whereas Evans (2017) also includes the probable impact of electrification. What the effects might be is highly uncertain, but the likelihood of both radical and unexpected changes is obvious, although certainly not only for the better (Chen et al. 2016), and perhaps not at all in the case of the transport system. Wadud et al. (2016) predicts that autonomous vehicles might mean either a one hundred percent increase in greenhouse gas emissions, or a reduction by half the amount, yet with a worsening outcome in proportion to the level of automation. Positive energy effects do not depend on 'automation per se but rather are consequences of other related changes such as vehicle operation and design or transportation system design' (Wadud el al. 2016, cited in Sprei n.d.:4). Moreover, the climate impact of electrification is wholly dependent on how the electricity is produced (Nordlöf et al. 2014) and how batteries are manufactured.

Not even if we include, like Sprei, shared mobility (Mobility as a Service or MaaS, car pools, ride sharing, and ride hailing services such as a Uber etc.), as a third potentially disruptive innovation (for a discussion of the term, see Sprei n.d.:1f) do the prospects for the transport sector appear particularly bright. However, major changes can be foreseen for the automotive industry (Tongur & Engwall 2014) and the supply of electricity. Nor does a combination of the three trends of autonomous vehicles, sharing and electrification 'seem to [result in] an imminent disruption of mobility' (Sprei n.d.:4). Sprei´s conclusion is that 'we can't rely on that technological innovations alone will lead to a desirable disruption from society's point of view', adding that 'taxes, congestion charging, parking and road tolls … can be designed in a way to foster shared use of vehicles rather than single occupancy or empty vehicles' (Ibid.:4f). The big risk is that overconfidence in purely technological innovations to 'solve' all our problems will block the way for research and development of necessary institutional innovations.

7.2 Physical infrastructure and digital platforms

In his conclusions, Sprei comes very close to the notoriously overlooked insight that the control of infrastructure provides opportunities to coordinate the transport sector, and thus also align the three innovations discussed above in a socially acceptable direction. This oversight is common to industry figures who claim to be 'rethinking the entire system' but are only imagining cool vehicles without writing a single line about the system upon which they are wholly dependent (Burns 2013, former General Motors R&D vice-president). The oversight is also found among prominent representatives of mobility research who, despite intensive debate on the transition to low-carbon mobility, appear to have lost contact with the physical-material aspects of the transport sector, and thus with a necessary system perspective too (Teenos et al. 2017). A tendency to narrow the perspective, usually driven by some tech-crazed business interest, is endlessly repeated in the scientific and business conference themes of smart mobility, smart city, smart life and so on, without asking the question of how the new and most powerful transformative tool of the past decade – digital platform logic – can be applied in the creative destruction of the urban transport sector.

The logic of digital platforms, so successfully demonstrated by the dominant internet giants, can serve as a model and inspiration for the public sector, but not in terms of profit-making.

We can learn that major, rapid adaption is possible with the help of interactive, personalized and attractive offers to users via platforms. Spreading insight about these opportunities increases the chance of reform, especially if a sufficient number of motorists see the point in paying in a relatively small charge that would probably eliminate heavy congestion. Massive resistance from the car lobby has been, and remains an almost insurmountable obstacle for necessary reforms within the transport sector.
Reformed urban transport services, as described here, have the potential to benefit other policy areas too. These include the local environment, noise and air pollution, aesthetics, street life, health, social contacts, equality, safety and property development. Limited public resources are a strong motivator for change, and here the proposed model has huge potential, which may prove useful when fuel tax revenues start running out with the rise of electric vehicles.

7.3 City branding competition

Although the urban-transport sector's base services, and thereby the sector itself on a system level, are not exposed to competition, cities do compete through city branding where transport and the environment are major components. Industrious and visionary mayors can push forward new traffic innovations: Ken Livingstone with the congestion charge in London, Enrique Peñalosa with bus rapid transit (BRT) in Bogotà and Anne Hidalgo with war on traffic-generated air pollution in Paris. The fact that cities can thus be geographical niches (according to Owen Jansson 2006:72, transport is neither storable, nor movable. For transition theory, see Geels 2005; Geels & Schot 2007) for innovation increases the chances of a breakthrough for platforms. If some cities lead the way, the chances increase that others will follow, as with congestion charging (Gullberg & Isaksson 2009).

7.4 Platform ownership

Many factors point to the platform being publicly owned, with the public sector acting as a market organizer, creating a market place (Ahrne et al. 2015) where the public sector's base services can be offered to intermediaries and end users, and where other producers will be welcome to participate too.
Privatizing motorways, which represent only a limited part of the total transport infrastructure, has proved problematic, being described as at 'a very early stage ... with a large number of project failures' (Beria et al. 2015: 31). Privatization, as a rule, is a slow route to efficiency (Molander 2017), which provides another argument for public ownership. Privatizing the entire street network may be possible, but not without its problems, especially given that urban transport has many societal goals to achieve, aside from matters of efficiency and profit.
One of the strongest arguments for a digital transport platform under public, democratic control lies in the vast opportunities for hidden manipulation made possible by the increasingly sophisticated methods currently under development (part 4). In private hands a profit motive would be an obvious guiding light, whereas the platform in public hands can be designed to promote politically identified targets, and be fully open to scrutiny. The publicly produced transport services that this paper describes as the sector's base services would be provided in ways to benefit stated goals and, in common with widely used private platforms, without dictating certain forms of behaviour. We can compare this to building a new road. Nobody is forced to use the road, but it acts as a nudge to drive. The methods described in part 4 have rightly been criticised for influencing people's behaviour without providing them

with any understanding of what is happening and why. In public hands, guiding principles will be a key feature based on the fact that everyone using the transport network is dependent, directly and indirectly, on one another, with room available for adversarial design (see part 4).

To subscribe to a digital transport platform must be voluntary (those opting out would continue to travel as before), which increases the likelihood of its introduction. If enough 'people with [a] low sense of ownership of vehicles and a more utilitarian view of mobility' (cited in Sprei n.d.: 2), including commercial traffic, initially subscribe, then tangible, positive effects will be assured.

7.5 A path to a sustainable urban transport?

Many of the benefits in the most optimistic scenarios for autonomous vehicles, such as greatly reduced costs and dramatically increased accessibility, are related to altered vehicle use and transport-system design. Benefits of this kind could in many cases be obtained via a functioning transport platform, adapted business models, and the dramatic improvement in transport services that would ensue. This suggests that even certain individuals, for whom travel serves as a status signifier, that is acting on a status market (Aspers 2011), would be enticed to use the platform services. Altered behaviour leads to a change in attitudes, rather than the other way around. This can contribute to the 'shift in attitudes' that '[a] major disruption of the transport system will probably' require (Sprei n.d.:2).

Urban regions serve as geographical niches in terms of local transport (part 7.3), and can therefore be described as global arenas for experiment and competition. Following a successful introduction of a digital transport platform in one urban region, other cities might follow suit in an ongoing branding competition. This would represent a feasible path to sustainable urban transport systems, with the potential for geographic expansion to more thinly populated areas when platform traffic increases.

Despite the obvious benefits that a digital transport platform with new business models, and payment for use in relation to political goals, would bring, it is far from certain that these benefits will be realized. Other, more conventional routes will probably be followed, such as autonomous vehicles, unless necessary rules for infrastructure use are introduced to restrict the virtually unlimited expansion of mobility and decentralization that would otherwise occur. Radical reforms emanating from the public sector, measures that do not simply follow the path of least resistance, demand strong political leadership and thorough crisis awareness. However, a platform solution might suffer the same fate that Borins (1988) wrongly predicted for electronic road pricing: '[a]n idea whose time may never come'.

8. Conclusion

To face the major challenges in urban transport and to live up to our high ambitions, at the same time maintaining or increasing availability, creatively destructive changes are needed in transport systems and locational dynamics alike. Two possible lines of development can be identified.

<u>One</u> is business as usual, appearing in two parallel versions. The first is vehicle and mobility oriented, reliant on autonomous vehicles, electrification and shared mobility with continued faith in technological solutions. The second rely on the dominant psychological theory of societal change, effectively criticised by Shove (2010), who coined the term ABC thinking (Attitude, Behaviour, Choice). If individuals can be persuading to change values and attitudes

they are also supposed change their behaviours and make sacrifices that can meet the climate challenge.
One is business as usual, which appears in two parallel forms. The first is vehicle and mobility oriented. It relies on autonomous vehicles, electrification and shared mobility, and continues to have faith in technological solutions. The second relies on the dominant psychological theory of societal change, which has been effectively criticised by Shove (2010), who coined the term ABC thinking (Attitude, Behaviour, Choice). If individuals can be persuaded to change their values and attitudes, they can also change their behaviour and make sacrifices to meet the climate challenge.
This would leave the economic battlefield open for competition between carmakers, who have a clear interest to earn as much money as possible from selling vehicles, and the ICT industry, which is eager to harvest as much personal user data as possible. Here future fusion and resultant monopolization is a foreseeable outcome.
The other development focuses on systems, infrastructure, service quality and accessibility – the digital-transport platform presented in this paper, which would allow a balance between various interests and the promotion of politically adopted goals. Such a platform would provide better control – transparent behavioral design – over how infrastructure is used, which will be important when vehicles of varying autonomy begin using the motor-dominated street and road network. We would thus avoid being at a loss when faced with the distribution of private and collectively owned vehicles, parked and circulating cars, and permanent and motor homes, and we would be able to fend off threats to conventional public transport, all of which will be significant for the climate, local environment and equality in the future. There is massive investment in the former alternative; the latter has yet to find a place on any agenda.
The allocation between private motorists and public transport is also important. The latter, especially using dedicated lanes or lines, has a huge advantage in terms of capacity, performance, climate impact and equality, and must therefore form the basis of any future adapted urban-transport system. Public transport also contributes to another, more spatially concentrated, form of localization. The opportunities to gradually strengthen public transport, while improving various important conditions for private motorists, such as reduced congestion, increase the chances of the platform working as a feasible unifying instrument for future reform.
Major platform companies have been hugely successful in swiftly changing people's habits and behavior. Evidence suggests the same would be true of the transport sector, which opens the door for realizing very ambitious goals. Yet the problems may be reversed, the methods so effective that far too much power would fall into the hands of the individuals or companies who might seize control of a transport platform. Therefore public, democratic control of such platforms is a necessity, as are guarantees that personal data will not fall into the wrong hands, and will be managed using informed consent.
The fourth industrial (r)evolution can, strangely enough, enable us to create a well-functioning market, by way of greater government control or hierarchy, empowering citizens to make informed transport choices with known outcomes, three mechanisms regularly seen as being at odds with one another.
The second industrial revolution replaced proximity with increased mobility as a means to create accessibility. With the fourth industrial revolution it is possible to replace this unbridled quest for mobility with coordinated localization and transport of people and goods. Such a restrained orchestration of proximity and mobility may prove to be the future method to

create accessibility. But whether this opportunity is discovered and embraced, before the mighty vehicle-focused strategy shuts the door to system changing alternatives, remains highly uncertain.

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