Understanding progress in a changing society

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Introduction: Understanding Progress

Philosophers and social scientists have been grappling with the concept of progress for centuries. The modern presumption, until relatively recently, has been that progress is uneven but nevertheless inevitable. This optimism is now fading. Recent forays into the question asserting, in the face of challenges such as climate change, conflict and political polarisation, that progress is continuing (such as Pinker 2018, or Harari 2014, 2016) – or indeed can and should be encouraged as well as celebrated (Collison & Cowen 2019) – have proven controversial. How can the question of progress be assessed?

The desire to define specific concepts and measures of whether or not a society or nation is progressing is more recent, dating back to the dawn of the Industrial Revolution. That era saw both economic advances captured in measures of national output and the social ills so vividly documented in reports and fiction alike. The modern metric – at least of economic progress – since the mid-20th century has been growth in GDP, but there have been critiques of this standard measure dating back to at least the 1970s. These include the need to account for environmental sustainability, the omission of depletion of valuable resources such as ecosystems, and the role of activities outside the market on the one hand; and on the other hand, the invisibility of gains from technological change in conventional measures (Coyle 1997, 2014).

Income and wealth distribution have also moved centre stage – after being side-lined in economic policy debate for decades – given the dramatic increases in inequality in many countries since the early 1980s. This includes inequality in terms of spatial distribution, and the impact this may have had on political trends (see for instance Piketty 2014, Milanovic 2016) The concepts needed to understand progress change with each epoch, and arguably we have not yet found the best framework for understanding a society in the process of being restructured by digital technologies: to take one well-known metaphor, data is not really like oil, but what is it like?

These various issues have converged and gained momentum more recently. One aspect of the current debate is what is usually described as the 'Beyond GDP' movement (see Coyle, 2017; Stiglitz et al., 2018; Agarwala & Zenghelis, 2021). The environmental impact of economic activity has more clearly brought climate and aspects of biodiversity close to tipping points beyond which irreversible damage will occur (Stern 2007, Dasgupta 2021). The 'Beyond GDP' agenda also includes concerns about wellbeing, social cohesion, and the unpaid but essential activities such as care at home and volunteering, which are largely unmeasured.

A second aspect concerns the impact of continuing technological change. Digital technology has fundamentally reshaped consumption and (increasingly) production, yet its impacts are hard to measure both in terms of consumer welfare and productivity. Some would argue this is because the impacts are insignificant compared to previous technologies (Gordon 2016, Bloom et al 2021), while others consider there are time lags (Brynjolfsson et al 2020), structural impediments such as market barriers to entry (Philippon 2019, Eeckhout 2021), or issues concerning concepts and measurement (e.g. Coyle & Nakamura 2022, Hulten & Nakamura 2022, Coyle 2023 RIW). There are also significant concerns about some potentially damaging wider employment and societal impacts of digital technologies, as signalled by tougher policy and regulatory proposals in many countries. These concerns span areas ranging from online bullying and misinformation, to data use and privacy, to market concentration and competition (Anderson and Gilbert 2022, Bessen 2022).

At the same time, digital services are highly valued by consumers (Coyle & Nguyen 2023) and have enabled substantial innovation in both products and business models, albeit hard to identify in existing statistics (Byrne 2022). There have been calls for more interdisciplinary 'progress studies' (Collison & Cowen 2019) and hopes that the rapid advances seen in AI will enable advances such as much faster drug discovery (Cockburn, Henderson & Stern 2019, Baek et al 2021).

Given such a vast potential canvas, this report focuses on economic issues (although these are not wholly separable from other social issues), and on two important domains of life, transport and finance. The reason for selecting these is two-fold. Both are foundational for all other activities; everybody needs to move from one place to another, and to engage in financial transactions. And both have been substantially transformed by digital technologies, more so than other essential areas such as housing, clothing or food; so they offer fruitful examples. In doing so, the report aims to bring some focus and granularity to the broad question of understanding progress, and to use these domains – with detailed case studies – to scope the research questions implied by the broad desire to assess progress (or regress) in society.

There are vast, rapidly growing economic literatures on both the natural environment and the digital economy. The range of the academic and other research is immense. These overlap in terms of questions such as the environmental and energy footprint of digital or the scope for innovation in green technologies as one tool to mitigate climate change impacts and achieve growth in high-skill jobs. More fundamentally, as Karl Marx observed in *Das Kapital*, technology and nature are intertwined: "Technology discloses man's mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them," (Marx 1867:329).

Moreover, the financial crisis and the pandemic have given new impetus to public and policy interest in broader approaches to measuring progress. A number of governments in smaller countries have introduced wellbeing approaches (Iceland, New Zealand, Scotland, Wales). The World Bank and other institutions also advocate for inclusive wealth measures, embedding sustainability, distribution and a broad array of economic assets including human and social capital (World Bank 2021). And the UN's Sustainable Development Goals set a very broad albeit unwieldy framework for considering progress.

The scope of this report

Ideas about progress evolve in response to events. It is hardly surprising that there is intense intellectual interest in concepts and measures of progress, across a very broad waterfront. The interest extends from the most fundamental philosophical questions concerning economic welfare to the nitty-gritty of statistical questions such as the construction of price indices and measurement of productivity. No single project of this kind could tackle the entire debate about the role of digital technology in modern life or solve fundamental conceptual issues regarding progress.

Our focus is largely on technological change (rather than climate or biodiversity), and largely on its economic aspects. The economic literature on digital technology alone is extensive. Questions covered by the research relevant to our broad question about assessing progress include, among others: the impact of digital use or AI on employment and job quality (e.g. Acemoglu & Restrepo 2020, Frey & Osborne 2013); the consequences for the definition and measurement of GDP and productivity (e.g. Coyle 2014, 2023); market structure and competition in digital markets (e.g. Philippon 2019, Eeckhout 2021, Posner & Weyl 2018); consequences for agglomeration and economic geography (e.g. Moretti 2012); the role of data and digital tools in business performance (e.g. team Brynjolfsson 2002, Coyle et al 2022); the impact of digitisation on trade (e.g. Baldwin 2016); the consequences of AI for research and innovation (Cockburn et al 2018).

In this report we apply a different kind of lens to the question. Although these sorts of aggregate economic outcomes are important, the bottom line is what difference 'digital' has made or can make to people's life experiences. Goods and services as defined in conventional economic terms matter for how they better enable individuals or communities to lead the kind of lives they want (Lancaster 1966; Coyle & Nakamura 2022; Hulten & Nakamura 2022). Do they save people time, or provide more choice? Do they make spending time in different activities more enjoyable? Do they enable improvements in health? Do they enhance opportunities, for work, household activities, or leisure?

We therefore selected two domains that are fundamental to the daily experience of life: transport and finance. Both domains have experienced significant changes in provision and business models due to the use of data and digital tools. This report is not a systematic literature review, but rather an analysis of the issues in these two areas, drawing on previous research and illustrated with case studies. Each section scopes remaining open questions and sets out policy and regulatory implications. Rather than taking a standard economic approach of attempting to estimate the overall impact of data and digital tools on output, social welfare or consumer surplus, we focus on the need for the benefits of the technology to be widely shared, and for the technologies to enhance people's opportunities rather than restrict them.

In many countries, income and wealth inequality stand at the highest they have been since the early 20th century, while many families' incomes have been stagnant for some years. The result is that there is no shared understanding that society is heading in the right direction; one recent poll found a startling 85% of Americans thought things are going in the wrong direction[1], while 'only' half of Britons thought this about the UK.[2] What difference are digital technologies making? The research and policy communities are intently focused on 'AI for Good', or 'responsible and trustworthy AI', and this focus will only intensify as more powerful AI tools are deployed in practice. These aims can only be met if the great majority of people in any society can perceive benefits in their own lives. This is what this report explores in the two domains of transport and finance.

We end with a discussion of the issues raised in trying to understand the role of digital technology in these domains, setting out the scope of what research and what policy approaches are needed to help bring about a positive direction in innovation, diffusion and use of the technologies. The broad sweep of innovations economists refer to as 'general purpose technologies' – the printing press, steam, electricity, broadcasting and now digital – are always disruptive (Coyle, 2001) but have generally, over time, greatly improved the quality of life and health for most people. The challenge for innovators, such as those developing AI tools now, for businesses deploying the technologies, and for policymakers and regulators grappling with setting the right framework for the economy, is to ensure this happens now.

Conclusions

There is a great deal of work under way to measure better the digital economy, in academic research, and by statistical agencies and international bodies. This detailed exploration of two key areas of life is intended as a complement to these more aggregated approaches. The transport and FinTech examples highlight three broad themes needing more focus by policymakers and researchers. Addressing them will be necessary if there is to be broad-based trust in progress in the digital economy.

The first is **data generation, access and use**; and the regulatory and business models that ensure the benefits of data use are widely distributed. What data is generated and how? Does it omit certain groups? Are people's own perceptions of how to record their lives reflected in the data gathered? Who can access and use the vast amounts of data being generated for existing purposes, and who benefits from the resulting services? Top-down measures of data value do not account for trade-offs and interdependencies between aggregate and individual outcomes. Little attention has been paid to missed opportunities and forms of exclusion in measures of progress – to those who are digitally less visible.

The second issue is the **wedge between private and social value** in data-driven digital networks. How are external benefits from network effects captured and distributed? Some of the externalities are positive and may be largely captured by private providers; there is a key co-ordinating role for public bodies in ensuring social benefits are enabled and crystallised. And there is often a partial trade-off between private and social interest. Other network externalities are negative, and more demanding of public oversight and regulation.

Third, **geographic distribution** is important when looking to understand the effects of digital services; people live in places and their opportunities are shaped by where they are. Technology clearly offers the potential to reduce place-based inequalities but may in fact be reinforcing them. Localised research is important to better understand the needs of a community and ensure that those who may not be recorded – or who are under-indexed – in emerging data models, are represented in decision-making that affects such fundamental aspects of their lives.


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Urban transport

Introduction

Mobility and transport are core to people's experiences and opportunities, affecting their ability to participate in economic, social and political life. Yet transport options are often highly unequal, with the affordability and ease of transport services determined by where someone lives (given existing infrastructure and services) and their socioeconomic circumstances. Ensuring efficient and safe transport options for all citizens, and thereby mitigating inequalities, is a critical question for provision of transport services. Unlike many utilities, there is generally no universal service obligation on providers, although there will be minimum service level requirements in their licensing agreements.

In recent decades, innovation in data use has become an important element of discussions about how to improve transport options. While there seem to be clear opportunities for some easy wins – such as providing users with more rapid, detailed and personalised information on services, thus saving them time and money and reducing uncertainty – it is not straightforward to define what progress looks like through enhanced data use in transport. There are important questions about how data use intersects with different dimensions of inequality and exclusion, about the distribution of costs and value creation, and how data use might affect varied and changing user demand.

This section explores the following questions around data in transport services, focusing on cities (and therefore not on long distance routes and regional inequalities):

- What business and governance models have emerged around the use of data for urban public transport?
- What distribution and types of value (and costs) have resulted through these business and governance models?
- What key challenges and limitations of different models have emerged?

Scope and methods

While transport is a vast field of study, as a starting point our exploration focuses on two areas: fixed route public transport services and private ride-sourcing services in urban areas. This section thus excludes data use in relation to physical infrastructure, private cars, non-motorised transport services (unless part of the ride-sourcing services), walking, and logistics transport. It draws on analysis of primary documentation (Freedom of Information requests, company and government records, contemporaneous media coverage), and on secondary sources, including for the case study of data use in London's transport system.

The section first sets out key trends in data use in transport. It then focuses on how progress has been considered through these different areas of data use, and what measures of progress have been used. Third it explores the governance and business models that have accompanied the rising use of data in transport, how they relate to indicators of progress and what challenges have arisen in achieving public and private sector aims. It then explores the case of data use in London, using this to tease out some context-specific factors that inform how transport data use and governance unfold. Finally, it concludes with some reflections on progress, data and transport, and what critical questions about progress and how it might be measured remain.

Trends in data use in transport

The amount of transport data being produced is increasingly substantially, and will continue to do so, with estimates for example that one autonomous vehicle could produce four terabytes of data in an hour and a half (Winter 2017). This particular amount is a design choice rather than innate. Yet the increase in data generation holds the potential for improved quality of services, more innovation and economic growth. Some argue there is a trend to 'digital by default' in public transport (Durand et al. 2022). The European Commission Sustainable and Smart Mobility Strategy (2020) suggests digitisation is critical to safer, more efficient, accessible and sustainable mobility (European Commission 2022a). Within this general trend toward greater digitisation of transport, this section summarises the key areas where data is being used: transforming the point of service; making the smartphone and smart payment card central; developing more data-driven systems and integration with other services (e.g. finance).

Data at the point of service

Data use has already transformed how travellers experience, interact with, and use transport services. Two key changes have taken place at the point of accessing services: improved real time information provision, and digitisation of payments, including contactless options, smart cards and automated fares. Smart cards are a key innovation and can accommodate multiple functionalities: including carrying e-money, organising tickets, encoding concession rights, anonymisation or personalisation, and single, season ticket and pay as you go tickets (Urbanek 2017). Examples include Transport for London (TfL)'s contactless payment cards (Stone and Aravopoulou 2018) and Mastercard's City Possible programme, in partnership with Cubic Transportation Systems, which operates open and closed loop systems in different cities including Sydney and London (Pettit et al. 2022).

Smartphones and smartcards

Smartphones and smartcards are therefore often the interfaces through which a transport user engages with the system: paying fares, linking to drivers, obtaining information, and storing personal transport-related information. The use of smartcards and smart phones also generates data trails. This provides an information source that can be analysed and combined with other data to inform system-level decision making. Noting the General Transit Feed Specification (GTFS), a common format for transport data, Pettit et al (2022) suggest the smart phone in transport is resulting in an:

"Unusually virtuous circle: the phone serves both to access and generate data, yielding ever-more nuanced and exhaustive insights into city-scale mobility and, in turn, allowing users and planners to make ever-better use of a limited resource, though few outside of Google are ever likely to see this data 'in full'." (Pettit et al. 2022:5)

Data-based systems

Data use is increasingly being integrated into the workings of the transport system. Different modalities of use are linked and feed into one another. Integrated data systems increasingly underpin public transport services, combining and communicating between smartcards, GPS enabled transport vehicles, and on-board computers for ticket distribution (Urbanek 2017). Cooperative intelligent transport systems (C-ITS) enable information to be exchanged between vehicles, and with road infrastructure (European Commission 2022b). These integrated systems can also be interoperable with other data-based services, such as with digital financial services for payments.

Crist and Combe (2022) use the analogy of a 'stack' to describe emerging transport data systems, with digital and physical layers together providing a service (Crist and Combe 2022). As layers of a more complex system, it is difficult to consider the effects of data use in isolation from other aspects of transport delivery. Crist and Combe (2022) illustrate this with on-demand ride-sourcing: while ride-sourcing is premised on a platform that uses data to link drivers and riders, its offering is both physical and digital. There is a technological layer comprised of a user's mobile device and the network, a communication layer in which that user's device connects to a remote server and driver, and the vehicle itself, the driver and their mobile device. In other words, there is no direct connection; the platform mediates everything.

Integrated data systems can support real time system-level operations. For example, the Sydney Coordinated Adaptive Traffic System (SCATS) is able to adjust traffic signals in real time, in response to changing demand and system capacity (Pettit et al. 2022).[3]

Data in decision-making

Data use in transport systems thus not only adds value by improving services and user experience, it also reshapes decision making (Stone and Aravopoulou 2018). For example, the Miami-Dade County partnered with the fitness app Strava to use its data on active travel behaviour to help in planning infrastructure for cycling (Pettit et al. 2022). Digitisation of services thus generates data on people's existing transport choices. As the amount and granularity of data increases, the potential for more complex modelling of behaviour, which could be useful to policy and decision-makers, becomes increasingly feasible. Attention has focused on the use of smart card data to support decision making, given the different functionalities and information on individual transactions and movements (Urbanek

2019 p. 70). Data from smart cards and automated fare systems have been used to deduce trip purposes, model route choices, provide indicators of transit performance, and also inform policy, by recording behaviours before and after a specific policy change (Faroqi, Mesbah, and Kim 2018). For example one study suggests using machine learning models to predict passenger trips and their purpose, from the combination of smart card from Transport for London and points of interest data, which are locations categorised by activity type (e.g. work, entertainment, eating, etc) generated through the Foursquare Location API (Sari Aslam et al. 2021).

In sum, data is used in transport services at individual user, operational and strategic levels. The functionalities and data trails created through smart phones and smart cards seem to sit at the heart of the different ways that data informs transport services. Data transforms how the individual acts, as well as enabling strategic and operational decision-making to take into account the many individual behaviours of transport users. Data and digital services are increasingly foundational to the running of transport and to people's options and experiences of services.

These existing patterns point to unrealised opportunities for both individual and aggregate gains through data use. They also involve some key assumptions and dependencies in how data is used. Organised around smart phones and smart cards, digitisation assumes each individual can access smart devices, data-enabled networks and digital services, including increasingly often digital financial services. At an aggregate level, data is also assumed to enable decision-makers to have access to a more precise and reliable set of insights into people's transport behaviours. While this presents opportunities for value creation for individuals, cities and private providers, it also suggests a potentially self-reinforcing system, whereby existing behaviours of those who already use data-based services become more visible to decision-makers and more central to planning and policy decisions.

Those who are not captured in this data – perhaps because of existing forms of exclusion, rather than a lack of wanting or needing transport services – may not be accounted for in decision-making. The distribution of value and forms of exclusion are potentially cemented in place.

Progress through digital and data use in transport

"Using infrastructure better requires making value judgements about what 'better' means. It could refer to optimising passenger flows, making freight movements more reliable, increasing economic impact, or achieving health, environmental or social outcomes. Another question is: better for whom?"
(Government Office for Science UK 2019:70)

There is great promise of environmental, social and economic value creation through data use in transport. Increasingly sophisticated and tailored information access for different stakeholders is key: data is useful when it is accessible and used. Individual transport users can have greater choice about travel options and be better informed about the delays or crowding/congestion that make travel (such as commuting) an unpleasant experience (Durand et al. 2022). Service providers can use granular, real-time information to improve the security and reliability of services (Stone and Aravopoulou 2018; see also European Commission 2022a). Improved real time and granular information is critical to the delivery of a service.

Yet there are several core assumptions about value embedded in this view that data and information will benefit users and service deliverers. These need to be surfaced to have a clearer picture of the visions of progress that underpin investments in data in transport services.

Derived demand value of transport

Data use in transport services is often couched within an expressed concern for wellbeing and equality. Mobility, and the transport services that facilitate this, both has value itself, in the experience of the service, and has a derived demand value, in what it enables people to do or achieve. Mobility, "Contributes to the functioning and quality of people's lives, as individuals and as a society," (Government Office for Science UK 2019:8). Other needs or desires that people have around work, access to services, socialising or leisure, are realised through mobility.

A person's access to economic and social opportunities will vary with their location. However, access to and ease of mobility are

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valuable goals for everyone, regardless of where they live or their personal and socioeconomic characteristics. Public transport services often have clearly articulated mandates to promote and ensure road safety and the public good.[4] While transport services and networks are not all pure public goods (in the classic sense of non-rival and non-excludable) it is generally presumed that mobility in some form should be available to all; yet this does not translate into the strict universal service mandates imposed on some other types of infrastructure such as postal, energy and water utilities.

Mobility as a service

Digitisation of transport invokes assumptions about how people will behave, and the choices they will make in response to improvements in the cost, quality and efficiency of transport services. Increasing concerns about congestion in cities, and the environmental implications of vehicle ownership, have contributed to aspirations for 'mobility as a service', as opposed to people 'owning' their means of transport. Data is assumed to help create the conditions for this shift to mobility as a service, including helping to make it appealing to people by such means as reducing the fixed 'time cost' of using public transport.

While there is some debate over what is and is not mobility as a service (Smith, Sochor, and Karlsson 2018), the idea is generally premised on a model where people access and seamlessly navigate multiple transport modes on a common interface or platform, driven by the rise of more integrated data services and multi-modal transport apps (European Commission 2022a; Jittrapirom et al. 2017; Rantasila 2015). An individual can plan their journey across multiple modes of transport, and efficiently book and pay through one platform or app. This model is premised on integrated financial, transport and organisational systems, and requires coordination between operators, modes of transport and regulation. This increasingly integrated and seamless transport experience is seen to provide an increasingly appealing alternative to transport ownership, and more efficient transport system (Stone and Aravopoulou 2018).

Currently there are different partial models of mobility as a service in operation, for example, apps that enable planning across transport modes but not payment, ride-sourcing apps, and ticketing apps (Government Office for Science UK 2019:83). There are also different views as to whether market-driven, public-led or public-private partnerships would be most effective. Planning for mobility-as-a-service raises questions about how different parties' incentives might play out in the differing models, and what this will mean for both economic outcomes and broader societal benefit (Smith et al. 2018). Exploring the incentive structures will be crucial to understand what forms of regulation or policy framework would enable mobility as a service to function effectively and also deliver broad benefits including for vulnerable or disadvantaged groups.

Recognition of human and environmental benefits

People's use of transport services can generate negative externalities; concerns about congestion, safety and pollution are central. Data use could help to mitigate trade-offs between individual preferences and environmental outcomes. For example, the UK Government Office for Science presents a vision of the future of mobility where data use helps facilitate the convergence of environmental and user-oriented ends; a 2019 report states:

"Meeting today's transport challenges, for example reducing congestion and air pollution, while providing the seamless, user-centric services that people and businesses want and expect, will depend on making the right policy choices. Increasing data use and connectivity will also have a greater role to play in the future." (Government Office for Science UK 2019:4)

The European Commission also has presented the benefits of data use in transport as multiple, complementary and simultaneous (European Commission 2022a): more connected and automated mobility results in environmental gains, and improvements in safety, business outcomes, and equitable services.

The assumptions in such policy discussions of data use suggest how progress in transport might be considered:

- Multiple indicators of progress are needed to consider individual and system level outcomes;
- Progress must not be judged or articulated only in terms of economic ends, but also consumer value and environmental aims. Data use can help ease trade-offs between these aims;

- Progress depends on changes in users' behaviour, which can materialise in response to the affordances of data-based services;
- Assessing the impact of data use must take into account both the direct experiences of transport services, and what it enables people to achieve;
- Transport access across people and places is a key consideration; progress will require not only improving existing access and mobility, but also reshaping opportunities to enable journeys that cannot happen or are unaffordable now.

Measuring progress

Within these assumptions about what progress in transport entails, measuring progress entails using multiple measures of value that take into account individual outcomes for transport users, economic and social indicators, and system/city level outcomes.

Different measures of progress are not necessarily aligned. For example, some individual users might prefer a system with multiple transport operators in competition, which might reduce wait time and fares. However, multiple operators in an uncoordinated system, can increase system level inefficiencies, resulting in more congestion and more pollution (Kondor et al. 2022). A good example is the provision of privately-operated bus services, which tend to compete on the busiest commuter routes into city centres, but under-provide connecting or quieter routes that nevertheless provide network and social value.

From a business perspective, firms might benefit the most by focusing on improving services and information for people who are better off. However, this could mean that lower income people or those living in outlying areas receive poorer services, or are excluded, increasing inequality and limiting some individuals' wellbeing. These differences highlight the need to pay attention to which measures are selected, and specifically, how they are weighed and considered in relation to one another.

There have been attempts to quantify the value generated through data use in transport but they have some limitations. For instance one study, using TfL and open data, attempts to quantify the combined estimated value for travellers, TfL and for the economy (Deloitte 2017),. They arrive at an overall figure of £130 million annually. This is based on estimates of the value of real time information helping travellers to make more efficient (and assumed healthier) decisions; value generated for app-based companies from revenue and job creation; and value to TfL through savings from third-party services and access to partners' data. While the study attempts to account for the distribution of value created, it does not confront potential tensions or trade-offs between outcomes , for example, greater individual choice might be accompanied by more congestion. Also, it assumes changes in behaviour as a result of data use (e.g., transport users opting for healthier options), rather than observation of actual behaviour change.

To consider these potential trade-offs, we next review measures that have been suggested for individual, business and system-level outcomes.

Individual

Gains to individual transport users through the application of data use are usually measured indicators tied to experience of and access to transport. A key measure is time (e.g. waiting time, time to travel from point A to point B) (Ceder 2021). Other attributes affecting a person's travel experiences and choices are: level and quality (e.g., reliability, comfort, timeliness) of service; cost; accessibility; and connectivity.

Public authorities have focused on different features. The UK Government Office for Science groups indicators into three characteristics: safety, reliability and affordability (Government Office for Science UK 2019; see also Wolf, C. et al. 2020). TfL's digital strategy identifies the added value of using data in public transport in London in relation to: high quality user experiences in line with expectations (fast, efficient); consistent and user-centric interfaces; and a seamless and integrated experience (Stone and Aravopoulou 2018). Singapore focuses on time, setting a goal for all citizens to be able to access public transit within 10 minutes of where they live, and commute to the city centre within 30 minutes (Wolf, C. et al. 2020). Some have attempted to measure the value of transport options to individuals based on the affective value ascribed to a transportation experience (Lira and Paez 2021), and whether there is dissonance between what transport people use and positive affective values. The added value of data use to individuals

“Greater consideration of the journeys not taken, and the data not available, would provide a richer view of individual benefit through data use in transport.”

could be measured according to the degree to which it affects these different attributes of a user's journey.

Most such measures focus on direct user experiences of transport, as opposed to what people can achieve (or not) as a result of transport availability. However, there is some scholarship that considers inequality and exclusion across individuals' transport experiences. Some of this literature consider how transport can contribute to social exclusion (Lucas 2019).[5] Studies of transport-related social exclusion (Mattioli, Lucas, and Marsden 2017) consider how factors such as socioeconomic status, location and mobility needs affect transport options, and thereby social participation. Some of this work looks at outcomes achieved through mobility: increased economic opportunities and other quality of life benefits (Lucas, Tyler, and Christodoulou 2009).

Greater consideration of the journeys not taken, and the data not available, would provide a richer view of individual benefit through data use in transport.

Not only do individual user preferences differ, such that the use of data can improve their transport options and experiences, but individual non-users could also potentially benefit from the use of data at the system level by providers and planners. What are the gaps in provision and accessibility? Could digital services enable some gaps to be cost-effectively addressed? What framework of planning and licensing, and what business models, would facilitate this?

Business

Revenue generation – and at minimum not making a long-term loss – is a concern for both public and private transport providers. Therefore, the use of data is often anticipated to achieve business gains, and to generate economic growth through the possibility of innovation and increased demand.

This presents two questions: first, whether data use enhances the financial sustainability or profitability of existing public and private sector transport bodies by adjusting their operations; and second, whether new, value-added companies emerge with business models tied to the use of data. Deloitte looked at revenue generation and job creation in London to estimate commercial gains through data use (Deloitte 2017:19). However, as will be discussed in the London case study below, achieving sustained profitability can require significant upfront investment and is not assured – because as a network service, transport involves large externalities, and private, profit-dependent services are unlikely to satisfy systemic or social need.

System level

Because transport services are concerned with mobility for people in places, system level outcomes can be measured in relation to spatial boundaries, such as municipal boundaries. Value generation considered at the system (or city/ municipality) level include indicators such as aggregate safety, environmental outcomes such as pollution and noise, and efficiency. These include: the number of road traffic accidents and road fatalities, congestion levels, overall traffic efficiency, emissions levels and related deaths, air pollution, and energy use (Bojic et al. 2021; Ceder 2021; Kondor et al. 2022; Wolf et al. 2020).

Indicators can potentially be assigned economic measures in terms of cost, such as (changes in) the cost of avoidable congestion (Pettit et al. 2022).[6] For example, the Mayor of London's 2018 Transport Strategy aims to achieve 80% of all trips in London to be by foot, cycling or public transport, cycling and foot journeys. The strategy assumes that digital platforms will change people's behaviours, with greater home working and use of mobility as a service (Mayor of London 2018).

System level measures are clearly not isolated from individual or business outcomes. An overly congested city affects the ease of movement for private ride-sourcing vehicles, potentially reducing the quality of service and increasing the costs for drivers. Air and noise pollution affect an individual's experience of transport, and the efficiency of a trip.

Challenges in measuring progress

While there has been much attention paid to selecting indicators that capture the diverse value gains in transport, important challenges remain in assessing value creation to indicate progress and to inform policy decisions. This requires ways to balance and maximise social, economic and environmental gains through data use. There is every reason to expect a wedge between privately and socially beneficial outcomes in a network sector with some public good characteristics. These tensions need to be made explicit in evaluation of outcomes and policy decisions, and where environmental externalities are involved and distributional questions matter. Therefore, key questions include:

- Accounting for the relationships between individual and aggregate indicators, and between economic and social or environmental indicators; how should trade-offs be evaluated?
- Prioritisation of indicators, and what this entails for the distribution of value across different actors. While some indicators are complementary, others might conflict. For example, private ride-sourcing platforms gain financial benefit from their exclusive data, as do their riders, but urban transport authorities could use this data to plan better for peak services or for reduced congestion.

Considering which outcomes and/or preferences are excluded or unseen due to missing data. Most often, studies focus on realised preferences and behaviours, as opposed to trips that people cannot take or their missed opportunities. A few, thus far relatively limited, studies give some indication of unrealised preferences, for example, by estimating the dissonance between the transport someone uses and the affective value they ascribe to it (Lira and Paez 2021). More attention is needed to consider what is not easily measured, and how this might be included in any evaluation.

Attributing changes in transport outcomes to data use. It can be difficult to identify the added value of data use within a wider set of changes in transport services and conditions, yet empirical evidence is needed to inform decisions about how much to invest in data, business model choices, and who should pay for the fixed costs.

Governance models for data in transport services

Individual incentives can conflict with private ones. There can be negative externalities from individual and business gains, for example, in environmental outcomes such as clean air and congestion. Other policy questions include how to ensure the relevant private markets remain contestable, and how to incentivise continuing innovation using data. Such challenging questions make the governance of data use important.[7] Policy intervention is required to balance different interests, and the distribution of positive and negative outcomes. Regulators have often been reactive in response to lobbying by unions and industry bodies or to media alarms about safety, data privacy, competition and worker arrangements, or indeed to counter-lobbying aiming to water down regulation.

There are strong arguments for external intervention (Coyle et al 2020 – the value of data report). This is due not only to the presence of externalities (network and environmental in transport, non-rivalry in data) but also to the classic trade-off between operator competition directly benefiting passengers and the inefficiencies of multiple operators when there are high fixed costs and/or a physical monopoly (such as rail track or roads): co-ordination will be more efficient but there may be little or no incentive to pass the benefits on to passengers.

Kondor et al (2022) theorise that in the transport sector it is possible to have operator competition in the context of a centrally coordinated demand pool. Ratti (2022) suggests that co-ordination between ride-hailing services can help to provide more efficient transportation, and reduce traffic and carbon emissions. If ride-sourcing platforms are only concerned with optimising their own individual fleet, without any overarching coordination or oversight across competitors, the overall number of vehicles in a city is likely to be more than required, resulting in greater inefficiencies, pollution and congestion. In addition to external intervention, multi-modal third-party apps arguably could be one way to help facilitate this, by enabling individual users to compare transport options, across competing providers in real time (Kondor et al., 2022).

Governance principles

Globally, a number of organisations have set out general mobility-specific frameworks for responsible data use and sharing, principles to guide the regulation and use of data in transport.8 These principles underline the need to consider individual and distributional dimensions of value creation. For example, the World Business Council for Sustainable Development's (WBCSD) 2020 report Enabling data sharing: Emerging principles for transforming urban mobility identifies five principles to guide data sharing around mobility, highlighting equitable creation and distribution of value, and privacy and security by design (Crist and Combe 2022). Expanding on this, a 2021 joint report by the WBCSD, the International Road Federation and the Sustainable Mobility for All initiative sets out building blocks for effective data sharing around mobility. This joint report recommends governance that involves: 1) a collaborative approach, 2) sharing of value across stakeholders, 3) prioritisation of skills development for competitiveness, 4) balancing harmonisation across jurisdictions and local customisation, 5) building of trust frameworks for data sharing, and 6) adaptive policy making. This report in particular takes a normative view on the design of regulation (e.g. adaptive, collaborative, trusted) and its aims (competitiveness, value sharing, trust). In another example, in 2021, the New Urban Mobility Alliance (NUMO), a group of public and private actors, set out seven Privacy Principles for Mobility, focusing on mobility data and individuals (Crist and Combe 2022). These principles articulate an individual's right to privacy in their movements, a need for community engagement and input, clear and clearly communicated uses, data minimisation, protection of privacy, and data protection.

Regulation

How governance principles translate into, and are reflected in, the regulation of urban transport is a separate question. There are different conditions of contractual data access and use to consider in relation to governance (i.e. not including mandated regulatory or official statistics), visualised in MaaS Scotland's adaptation of the ODI's data spectrum (Figure 1). It is important to note that the distribution of data across the sector has evolved over time, including in some instances through government intervention.[9]

Broadly, governance of data in urban transport services can be divided into two categories: 1) regulation of open data, and 2) regulation of private companies, and their operational use of data. With regard to the former, the trend has been towards increasingly more open data,

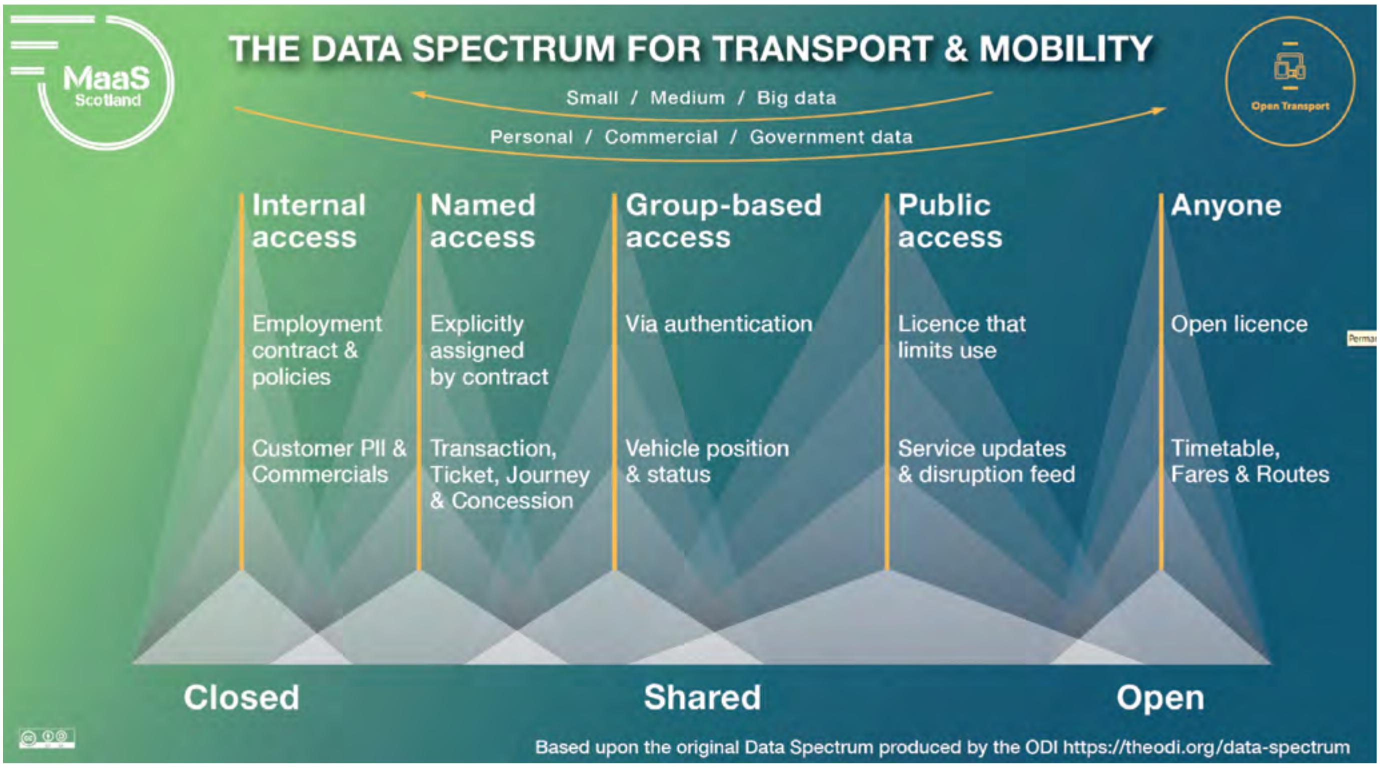

Figure 1. The data spectrum for transport & mobility
https://opentransport.co.uk/the-data-spectrum-for-transport-mobility/

enabled through public-private partnerships, and standards for interoperability. In the case of the latter, regulation has responded to concerns about how private companies' use of data, specifically ride-sourcing firms, affect competition, wellbeing, and the urban environment. Here, regulation has targeted how firms operate in general, their use of data being only one policy concern.

Regulation of open data

In general, open data or data access agreements or regulation are favoured by regulatory authorities for two main, related reasons: the potential it offers for innovation and market entry; and the enhancement of prospective competition in markets where incumbents have the market power advantage of holding large amounts of customer data. There has been a move in cities often towards open data in transport to support more integrated, efficient transport services and customer experiences. Governments have taken a central role often in initiating and determining which data is open, and how it is shared. The German Government supports the Mobility Data Space, a decentralised system for data providers to share data, keep control and link platforms. New York City has a repository of more than 1,350 government produced machine readable data sets, including transport data, through the Socrata open data platform (owned by Tyler Technologies). Seattle also uses an open data platform. The shift to open data in transport is often part of a wider move in government to encourage open data and data sharing (Ricardo Energy & Environment 2017).

Governments' role in deciding to promote and share open transport data has meant that there are examples of policies to guide the sharing and use of open data.

The European Union has set out a framework for spatial information among member states. The INSPIRE Directive (2007/2/EC) sets out an infrastructure for spatial information that might have environmental implications. The Open Data Directive (in force from 16 July 2019) addresses the reuse of information and how this can have economic effects. It sets out terms for encouraging and facilitating open data among Member States. Individual cities and countries also enact their own open data policies and laws. New York City's open transport data is governed by its Open Data Law, passed in 2012, which requires each City agency to identify and publish digital public data in the city's Open Data Portal (City of New York 2020). City agencies are also required to engage with data users, e.g., sharing information about new data releases or hosting open forums (NYC Open Data 2020). Transport for London has an open government license, excluding personal or commercially sensitive data, and enables data use for third party apps (Stone and Aravopoulou 2018). This is done through the TfL website, supported by Amazon Web Services Cloud, and has common licensing and agreed standards for data. The UK Department for Transport published its Open Data Strategy in 2012 (Department for Transport 2012b). This set out anticipated benefits of open data, while also noting privacy and data protection considerations. This, and subsequent government papers on open data, articulate an aim to continually improve data quality and enable interoperability (Department for Transport 2012a; HM Government 2012).

Technical standards and common formats have helped implementation of policies on open data. There are a few dominant standards that are used for a common format for transport data: the General Transit Feed Specification (GTFS), European Network Timetable Exchange, Standard Interface for Real-time information, and American Transit Communications Interface Profiles. GTFS is used globally in more than 18,000 cities. Google was initially involved in its creation, and GTFS integrates with Google Maps (Colpaert and Meléndez 2019).

At the same time, open data is not consistently promoted and implemented across cities globally. First, some standards can be employed within closed data systems. Google and GTFS do not require open publication of data. In some cities, GTFS is used to manage data without data being publicly accessible (Colpaert and Meléndez 2019). Second, cities with less structured public transport systems, such as a lack of consistent schedules or stops, can face additional challenges in operationalising open data systems. There are some technical initiatives to address this, for example, by extending GTFS to accommodate semi-structured transport and demand-responsive transport options (e.g., the Digital Matatus initiative in Nairobi) (Colpaert and Meléndez 2019).

"Governments' role in deciding to promote and share open transport data has meant that there are examples of policies to guide the sharing and use of open data."

Regulation of ride-sourcing platforms

While governance of open public transport data has been shaped through the close involvement of government in promoting open data, the context for regulation differs for transport data held by private companies. Private companies' generation and use of data for transport services has presented a distinct set of regulatory challenges around competition, and value creation and distribution. Regulators have responded in varying ways to data-driven transport service companies.

WEF and Deloitte conducted a study on how cities approach private sector tech firms in transport, within the context of a shift to a more seamless integrated mobility system (Wolf, C. et al. 2020). They identify a spectrum of city-regulated versus market-led approaches, whereby some cities more proactively set regulatory guidelines for private transport actors, and others allow the private sector to set the pace of development. Mitigating negative externalities, promoting knowledge sharing, and setting standards requires some external intervention.

However, there is no single 'best' approach across diverse cities as to when external regulation should be developed, by whom, and the form it should take. Los Angeles provides one example of a more city-led approach; for instance, already in 2018, the city introduced the Mobile Data Specification, to provide common standards for data sharing and enables greater visibility of private providers' operations.

On the more 'market-led' side of the spectrum, Lisbon's city leadership has also prioritised mobility, but with a more responsive regulatory approach. The city has largely developed regulation reactively; for example, it developed regulation for e-scooters in response to specific needs that materialised such as controlling clutter and ensuring safety (Wolf, C. et al. 2020).

Ride-sourcing platform companies present a challenge for city regulators. As these firms began to operate, in some cases intentionally outside of regulatory oversight, they presented concerns about how their business models affect employee wellbeing, market competition, and passenger safety. While these are well-founded concerns, demand for regulation also stemmed from incumbent taxi firms facing unwelcome new competition; in many cities, taxi markets were previously highly uncompetitive.

Amidst competing lobbies representing ride-sourcing apps, taxis and private hire vehicles, and unions and employee rights groups, governments or local authorities have tended to respond by introducing more detailed regulation of ride-sourcing platforms. In April 2017, Jakarta introduced regulations putting a series of constraints on ride-sourcing apps, including: enabling price caps on fares, limiting vehicles by district, and requiring drivers to have a vocational license for public transportation (Chiou 2017). In New York City, there were high levels of tension between yellow cabs and ride-sourcing apps; the City manages taxis through a medallion model, which requires taxi drivers have a physical certificate to operate. The value of the medallion varies with demand, and fell with the arrival of

Regulation of private sector transport provision in the State of California

The State of California has been at the fore of discussion over regulation of and openness to data-driven private transport companies, with the political and media debate reflecting the range of concerns. In 2019, California passed a law that provided gig workers, like drivers for Uber and Lyft, the status of employees. This was overturned in 2021, with Proposition 22 which effectively exempted Uber and Lyft (Scheiber 2021).[14] The competing interests involved were those of drivers and passengers as well as the platforms themselves. Yet the state is far from opposed to digitalized innovation in transport. California was also a site of early permission for self-driving cars; Cruise and Waymo operate in San Francisco with back up human drivers. Cruise has also been approved to launch a driverless ride-hailing service (Associated Press 2022). Autonomous vehicles both use and generate vast quantities of data. The occurrence of a number of accidents has raised concerns about safety, concerns which are likely to lead to regulatory requirements on data access as the services expand.

ride-sourcing platforms (Salam 2021), raising taxi drivers' concerns over their operational viability. In 2018, the city placed a temporary cap on new licenses for riding hailing services (Anon 2022c). Regulation of the market continues to be highly charged politically. However, the accessibility of the apps' data has featured surprisingly rarely as an issue – including access for urban transportation authorities. While Uber has begun to add regular taxis to its app in cities in Austria, Germany, Spain and Turkey as well as in New York City, it continues to control the data generated on the platform.

Business models for utilising data in transport services

While data has the potential to generate value for individuals, cities and business, setting up and maintaining secure and integrated data systems is costly. This section focuses on how private and public bodies have sought to achieve financial viability alongside data use. It focuses on the logic and principles for revenue generation, and balancing of cost and profit (Micheli et al. 2012).

Both private and public bodies using data in transport services must consider what are viable business models around data use in transport, and for which ends? Even public sector bodies face some pressure to attain financial viability, balancing current and future costs and revenues alongside wider public benefits. For example, there has been some resistance among public bodies to calls for open data out of concern for the costs associated with maintaining data sets and potential loss of revenue due to competing applications of data use.[10]

It is difficult to know when and how to assess the viability of a business model for data use in transport. Most firms cannot expect to be profitable from the onset. Many firms are still in the early years of adapting and setting up business models, a period when costs can be high. Taking this into account, this section looks at business viability in three areas: 1) public sector providers; 2) information-based apps; and 3) ride-sourcing platforms. This is not intended to be comprehensive, but rather to suggest key issues for consideration and further study.

Public sector data use

While the benefits of data use for efficient, quality public sector transport services appear clear, how public bodies cover the costs of designing and maintaining data-based systems is less so. Some of this can be managed through government budgeting and subsidies; however, this remains especially a concern for self-funding government agencies, or those mandated to cover their costs through charges. Some can use for example subscription models or tiered fees for supplementary or high quality data and/or services (Welle, Donker and Loenen 2016). How agencies respond depends on where and how data is intended to be used – for example, if they are a data provider for open data arrangements, or if they are seeking to use data to support changes in the quality and efficiency of service delivery. Balancing costs and revenue of public transport services through new innovations likely requires detailed and context specific calculations that take into account user demand and its flexibility, economic and environmental conditions, and wider changes in government policy and political priorities.

In some cases, public transport costs are covered through public funds, with the anticipation that they will end up contributing to value creation more generally. There is also some potential that use will offset or reduce some costs, especially over time. For example, there can be reduced costs of revenue collection with smart payments, or the ability to provide for more efficient and streamlined services based on information on road conditions and use of services.

Often, public agencies will work in partnership arrangements with private tech firms to effectively and securely set up and maintain data-based systems. This reduces the internal capacity requirements, both technical and skills, though it does potentially also introduce new dependences on large tech firms for delivery of public services. Public sector agencies do not necessarily have the capacity or knowledge to implement and run complex transport data systems, and work with external partners, making use of their innovations in data infrastructure and security. Mastercard's City Possible network is a partnership model that supports contactless payments across public transport and operates in cities globally, working with Cubic Transportation Systems (Mastercard

> **“These wide benefits need the data and technology stack to be paid for, yet private incentives will lead to under-provision and too little sharing of data.”**

2021; Pettit et al. 2022). Amazon Web Services (AWS) cloud is involved in hosting and providing back end infrastructure for data sharing, for example for Transport for London. Google has taken on key roles around journey planning for end users with GTFS.[11]

Even with partnerships and some public funding, balancing cost and revenue in public transport is challenging. This challenge is of course wider than data use. Also, it also does not appear to be alleviated with data use: data might bring profound improvements in the quality and experience of transport services, but there are also important costs that need to be taken into account that suggests government subsidies or grants might be necessary. This is exactly what would be expected in the case of public goods – it is an example of the classic ‘free rider’ problem. In this context, the problem appears in the newer domain of data as a public good increasing usage of a transport system that also has public good aspects. Expanded mobility, based on data and digital services, will improve people’s opportunities, save travellers time and money, boost economic activity, and can potentially improve environmental outcomes.

These wide benefits need the data and technology stack to be paid for, yet private incentives will lead to under-provision and too little sharing of data.

Third party information-based apps

Open data has supported the growth of information-based apps. The rapid growth of these information-based apps has substantially improved customer experiences through more accurate and timely information about travel options in real time. However, even for widely used apps, their profitability can be fragile. It can be difficult for app developers in transport to generate profit, even popular apps, which often rely on venture capital in early years (Kitchin 2013). Information-based apps avoid the costs of managing physical assets or an extensive network of employees, unlike a company like Grab or Uber that operates transport services. However, they miss the potential revenues that can be generated from offering a physical service. Also, competition between apps can be high given the increasing accessibility of open data, and users’ willingness to pay potentially low. Within this competitive space, revenue has been sought through fee-generating interoperability with other services, such as booking private hire vehicles, or purchasing tickets.

Ride-sourcing platforms

Ride-sourcing platforms use mobile phone-based platforms that match driver capacity to user demand, potentially using data to increase the number of matches, reducing wait-times for passengers, and arguably offering opportunities for drivers and extending the scope of transport options tome less well-served areas of cities. Driver labour and productive assets are outsourced to individual drivers who have the flexibility to choose when they work. Company revenue is generated through fees incorporated into the driver fares. Data is at the heart of the offer for drivers and riders. Platforms provide information to drivers and riders on location, quality and credibility of drivers and passengers (individual ratings from previous trips), and estimated cost and time. They usually include a live map of drivers, a service to link drivers and riders, and a payment system. Evaluation of the costs and benefits of the platforms has been hotly contested, not least given some court rulings on employment practices (e.g., Adams-Prassl et al 2021), and the fact that academic evaluations have been based on company-provided data.

From one perspective, there is a first mover and size advantage for ride-sourcing platforms. Longer standing and larger platforms have more drivers and an established user base, and therefore more data on patterns of use and preferences that can be used to adapt the service and incentivise drivers and passengers. Equally, it is relatively easy for drivers and riders to switch between platforms. This creates pressure on companies to continually work to retain riders and drivers. It leads to competing pressures within companies to incentivise drivers to stay on the platform, riders to use the platform, while also retaining sufficient revenue to cover costs and realise an overall profit.

Ride-sourcing platforms have faced increasing pressure on their financial margins. Part of this pressure comes from the gap between drivers’ earnings requirements, and riders’ willingness to pay – which is lower for the marginal riders who did not previously use standard taxi services. Also,

Case study: Grab

GrabTaxi was first established in 2011 as MyTeksi in Kuala Lumpur, starting to operate as a small, on-demand taxi hailing app from 2012. By 2014 it had captured most of the ride-sourcing market in some places, such as Vietnam (Nguyen 2022). Grab grew its business through several moves. It operates different transport services in different cities, such as GrabCar in Singapore and Malaysia, and GrabBike in Ho Chi Minh (since 2014). It also has received significant investment, with US$680 million in disclosed funding from 10 investors by the end of 2015. Key investors include SoftBank, a Japanese telecom company, which had invested US$250 million in Grab by 2016. Softbank also invests in other ride-sourcing apps in other locations: Lyft in the United States, Didi Kuadi in China, and Ola in India. This investment has enabled Grab to also partner with other ride-sourcing apps, with Grab customers able to access SoftBank's other investee platforms the Grab platform. The Singtel Group is another key partner. In 2015, they signed an MOU that enables riders to use Singtel's mobile wallet services to pay for Grab rides.

Still, Grab had faced financial pressure because of COVID-19 lockdowns, fuel price increases, and new competitors (e.g., Gojek). In 2022 in Vietnam, there were reports of drivers quitting and customers facing difficulties accessing rides and in waiting times in in Ho Chi Minh City. Grab in Vietnam responded by adapting the incentives for drivers and riders, for example adding a surcharge to riders to deal with high fuel costs and compensate drivers, and then later considering lowering subsidies for drivers. Even where Grab had dominated the market and invested substantially (it committed $500 million in 2019 to Vietnam), it has still struggled to shift from an investor phase to pro-profit phase (Lin and Dula 2016; Nguyen 2022)

platforms face pressure on margins from external factors, including COVID-19 and fuel prices, as well as regulatory change. Rising financial pressures can lead to a reduction in both drivers and demand, which in turn can affect fares, as platforms respond to reduced revenue, and wait times, as there are fewer drivers operating (Downs 2022). Companies have taken multiple steps to navigate these competing conditions, which are discussed in the boxes below. However, the extent to which these adjusted models will result in a sustainable and profitable business model is still to not clear.

Business model viability

Across public and private bodies, profitability has been difficult to achieve in digitalised transport services. This is apparent even where services are highly valued (e.g., market value of Uber was 72 billion US dollars in 2018).[12] This leads to several reflections.

First, there is need for greater recognition of the costs associated with the digitisation of transport services, and more analysis of who can and should cover costs. While data helps to transform the efficiency, quality and experience of transport services, transport remains a physical service with costs tied to delivery and maintenance of physical infrastructure. Additionally, maintaining high quality and secure platforms and services requires work. There are high fixed costs and large externalities in both the physical aspects of transportation and in digital services.

At the same time, from a policy perspective, transport is critical to people's economic and social opportunities. Assuming users can pay full (average) costs is not equitable. Also, users seem to have shown a lower willingness to pay for information-based multi-modal transport apps that combine open data sources. What profits should be expected from investments in data in transport? And, are there arguments to subsidise or supplement other data-driven services to ensure they reach those less able to pay, in order to improve equality of access to mobility options?

Second, a focus on business profitability takes a narrow view of value creation that fails to account for the wider social welfare potential from digital investments that might benefit cities and citizens. One example is that investment in data use in some transport services can, in some contexts, contribute to uplift in property values. New transport links and stations have certainly been found to affect property values in cities like London, where public transit use is high and there are restrictions on car use, with some variation according to external factors such as house type, neighbourhood, and noise and air pollution (Song et al. 2019). This study of the indirect effect of changes in the physical transport infrastructure raises questions about whether changes brought about through data use in transport could have similar effects. Bus rapid-transit lines (BRTs) have been found in some cases to increase property values along the bus routes.[13] BRT differs from traditional bus lines through dedicated service lanes and greater frequency, and the use of radio or GPS-enabled transit signal priority. This provides for a more precise and real time view of buses' movements, thereby operating signal priority in ways that allow for more frictionless travel along their routes. Gains in property value result, although varying by location and household type (Acton, Le, and Miller 2022).

There are also more diffuse benefits from improved transport systems, inherently difficult to identify and measure. These range from better potential matching between employees and jobs, or better labour market access, to time and costs savings for businesses, and enhanced wellbeing. The difficulty of quantification does not mean the benefits are small. While not necessarily affecting revenue generation, attention to indirect effects provides a different reference point from which to assess the value of investments in transport data and to consider the distribution of costs and benefits (Song et al. 2019).

Case study: Uber

Uber, founded as UberCab in 2009, has been at the centre of controversy over its business model, including its use of data to gain an advantage in a specific market. Initially, Uber used costly incentives to attract drivers and riders. Drivers' profit was higher than charges to riders. Uber also tended to enter cities without necessarily complying with private hire vehicle regulation, avoiding licensing costs, while also lobbying key government officials (Borowiak 2019). Also, similar to other ride-sourcing apps, Uber classified its drivers as contracted workers, saving employee-related costs.

Data was part of its efforts to gain a sustained market advantage, including through controversial means. In late 2016, evidence emerged about a program code that enabled employees to view all Uber drivers and passengers in a city (Hern 2017) known as 'God View' or 'Heaven', including spying on individual riders' movements. In 2017, the New York Times exposed Uber's Greyball code, which was used to circumvent regulators.[15] The code identified potential inspectors among the passenger based on data from social media accounts, credit cards, types of phones and geolocation data (Isaac 2017). Still another programme code, 'Hell', targeted the competing ride-sourcing platform Lyft, using Lyft's fixed and unique driver IDs to target drivers working for both companies, and incentivize them to leave Lyft (Griswold 2019; Hern 2017; Wong 2017b).[16] Data use and misuse, combined with news about worker conditions and harassment, contributed to a public campaign to #deleteuber, a US$20 million settlement and lawsuit from Google's Waymo. Following these controversies, Uber underwent corporate changes, including the resignation of its CEO along with other senior executives (Wong 2017a).

Throughout, in many ways, Uber has successfully generated demand, with over seven billion trips in 2019[17] and as the highest market valued ride-sourcing platform (2018 figures).[18] Yet it still has not been able to report annual profits since becoming a publicly traded company in 2019, e.g., reporting a loss of US$6.77 billion in 2020 (Maier 2021). Maier (2021) identifies three contributing factors. First, new regulation requires Uber to comply with better employee standards in some areas. Second, there are competing platforms, which users can compare to Uber through third party multi-transport apps. Third, Uber's technological plans to cut costs have not materialized (e.g., self-driving cars). There are high costs in machine learning and the potential for error, as occurred in Arizona in 2018 when an Uber self-driving car hit and killed a pedestrian (Smiley 2022).

Uber has adapted in response. It has sold off some of its operations, e.g., its southeast Asian arm to Grab and Russian one to Yandex. Uber has sought to attract riders with cheaper options, like carpool share rides (Downs 2022). Additionally, Uber has expanded beyond rides: it operates in delivery globally, and freight and logistics in the US and Canada (Alpert n.d.). In 2021, delivery was its largest source of revenue while rides generated the most profit. Finally, as Grab, Uber has formed partnerships to expand its offering, adding taxi cab operators to the app in multiple countries, including Spain, Colombia, Austria, Germany, Turkey, South Korea, Indonesia and Hong Kong (Chiou 2017). Even in New York City, where Uber and taxicabs have intensely competed, an agreement was made to include taxi cabs on the Uber app (Anon 2022c; Hu, Browning, and Zraick 2022). In New York City, fares are based on Uber's pricing and policies and Uber receives a fee on every ride booked through its platform (Hu et al. 2022).

Transport and Data use in London services

Progress through data use in transport is clearly a multi-dimensional issue, invoking opportunities for individuals, businesses and cities as a whole. With this, governance and business models have evolved, with continued, unresolved challenges. This section looks at how the application and use of data in transport has developed in London. Looking at one city allows for a closer examination of decision making around data in transport. From a transport perspective, London presents an interesting case due to its a high income inequality, and its complex and dense public transit system, which is overseen and run by Transport for London (TfL). This presents an opportunity to consider distributional issues around innovations with data use, especially the experiences of less-connected, marginalised and/or low-income individuals. This case study begins by introducing Transport for London (TfL) and the city's approach to data in transport. It then investigates three core areas of data use: contactless payments, open data, and ride-sourcing platforms.

Transport for London and data use in London

TfL plays a central role in the regulation and provision of London's transport. It was established in 2000 to deliver on the Mayor's Transport Strategy and manage transport services. The Mayor of London appoints its management board (UK Office of Rail and Road, n.d.). TfL has multiple functions: delivering public transport journeys;[19] contracting transport operations; regulating taxis, private hire and cycle safety; managing major roads; and managing passenger river trips (Stone and Aravopoulou 2018; Transport for London 2020). It also partners to undertake large transport infrastructural projects (Transport for London 2020).

Almost since the beginning, TfL has integrated data and data sharing into its activities. TfL's 2020 Business Plan (2020/21 to 2024/25) states:

"Technology and data underpin everything we do. We collect and process vast amounts of data every day, including three million journeys made using contactless payment, around 670 million rows of bus event data and 500,000 rows of train diagnostic data on the Central line alone."
(Transport for London 2020:59)

TfL supports 2000 software applications and systems, and 30,000 daily users on 11,000 servers on the estate (Transport for London 2020). TfL has a digital strategy, which emphasises the user's access to transport information, aiming to support fast and efficient information access, a consistent and user-friendly interface, and seamless

TfL's revenue model and ongoing economic challenges

Much of TfL's revenue is from passenger income (50% of projected funding in 2019/2020).[27] Passenger income as a proportion of revenues is projected to increase by 2024/25 (Transport for London 2020). In 2015, the UK (central) government announced it would phase out an annual operating grant to TfL from April 2018 and replace it with support for investments in London's transport (Waitzman 2021). This has reduced government funding, causing delays around new developments such as the Elizabeth Line (Transport for London 2020). External circumstances and shocks to demand have added to TfL's financial challenges, acutely so with the COVID-19 lockdowns. In May 2020, TfL published an emergency budget that identified a shortfall of £3.2 billion for 2020/21. In response, the Government and Mayor of London (TfL chair) agreed on extraordinary funding agreements, which required TfL to commit to efficiency savings and financial control measures as well as big fare increases. TfL fares are already high in comparison with many other capital cities, so further increases risk reducing journey numbers. At the same time, an earlier pledge by the London Mayor to freeze fares had reduced revenues from 2016-2020. Negotiations over the post-pandemic bailout led to debates over the financial viability of TfL, and whether an ongoing injection of more government money would be needed (Waitzman 2021). These debates reveal the precarity of TfL's budget. Yet TfL remains central to the city's transport from service provision, infrastructure and regulatory perspectives, and fundamental to London's high productivity and economic growth. The dense public transport network in the city enables this economic performance.

experience. This is accompanied by a longer term objective to move towards mobility as a service (Stone and Aravopoulou 2018). Other aims for data use include income generation and support for internal operations and decision making. For example, TfL uses (anonymised) data from its Wi-Fi networks for targeted advertising (Transport for London 2020:24). Data has informed planning with other government services, such as helping to support the Home Office Emergency Services Network (Transport for London 2020). Data also supports forecasting to predict and plan for future demand and fares (Transport for London 2020).

TfL invests resources to support data use internally and by third parties, from maintaining and upgrading technical systems, to improving hardware and software, addressing vulnerabilities, and investment in new technology. Value is measured through multiple metrics that reflect revenue considerations and its role as a public service, including TfL's net deficit, indicators of customer experiences (safety, excess journey time, excess wait time), and indicators of overall use (passenger journeys, environmental impact emissions). Thus, a strategic level, TfL has committed to data use in transport, and has taken the perspective that data use, by both TfL and third parties, can help to improve the quality of transport services, for each user, as well as for the city as a whole.

Data and contactless payments: Value creation and distribution

Digital payments were one of the earliest applications of data in London's transport system. Automated fares date to the 1960s in the UK, with tickets with a magnetic strip that could be read and reprogrammed. In 2003, London was also an early adopter of smart ticketing, introducing the Oyster Card, a smart pay-as-you-go card (Wolf, C. et al. 2020). In 2012, TfL introduced payments by debit or contactless card on buses, rolling this out to the rest of the network in 2014 (Koch n.d.; Verma 2017). Smart cards and payment via smart phones have multiple functionalities: carrying e-money, organising tickets, encoding concession rights, facilitating single, pay as you go and season tickets (Urbanek 2017). TfL's contactless card system automatically calculates the best value fare for a specific journey, charging daily. Contactless payments have become the norm in London. In 2016, the Mayor of London announced that acceptance of card and contactless payment options would be mandatory in taxis, negotiating a deal with payment providers for drivers (Mayor of London, Transport for London 2016).

Much of the funding and impetus for digital payments came from TfL, with support from financial service providers. TfL largely built the software for smart payments in-house, in partnership with Cubic Transportation Systems, given the absence of developers at the time with digital transit payment models (Verma 2017). The main mobile payment systems (e.g., Android Pay, Apple Pay), supported the adoption of TfL's contactless payment system (Koch n.d.; Verma 2017).

Digital payments have reduced the costs of collecting revenue. However, revenue has not been a primary focus in justifying the shift to contactless payments: their value is generally discussed with reference to the user experience: providing more cost-effective and convenient transport experiences. Another potential area of value raised in academic literature is around planning and decision making (Urbanek 2019). Through more granular information on individuals' movements from payment systems, decision-makers have access to insights into people's daily activities on an 'unprecedented scale' (Sari Aslam et al. 2021).

Therefore, contactless payments are couched with a view to improving user experiences and public decision making. At the same time, that this takes place through payment data warrants pause for reflection. The data use means there is positive feedback between users' behaviours and evidence used by decision-makers. This closed loop between those who travel on the network as it exists and the decisions around these users' needs potentially makes invisible those who do not use digital payments. There is a risk that decision making becomes increasingly informed by existing transport behaviours, failing to consider the trips that might be desired but not taken due to inaccessibility and/or unaffordability.[20]

Open data and information-based applications

TfL led in the move to open data in London, enabling developers to use data to create new applications.[21] The 2012 London Olympics were a key impetus for open transport data, to improve information for transport users, given the influx of visitors and demand for transport services, though the shift to open data had begun earlier. In 2007 TfL launched embeddable widgets (e.g. network maps, live travel news) for others to access. Over the next four years, TfL created a developers' area on its website and began to publish real time transit data through feeds and downloads, including the launch of the Greater London Authority's London Datastore in 2010 which provided access to TfL and other datasets. In 2013, Amazon Web Services took over hosting TfL's website. This increased capability to provide unified real time transport data (Stone and Aravopoulou 2018). TfL's unified API was launched the following year (Open Data Institute 2018). By 2017, TfL provided over 80 data feeds with operational and corporate information across multiple transport modes, with 75% of data available through APIs (Stone and Aravopoulou 2018).

TfL's open data is often viewed as a success story in the creation of value for transport users, the private sector and the public sector through third-party applications using open data. TfL's open data has been estimated to have supported 13,000 app developers and 600 new products used by over 40% of the city's population (Wolf, C. et al. 2020). The Shakespeare Review (2013) estimated £15-28 million in saved in transport user time on public transport (Department for Business, Innovation and Skills, 2013, p. 6), while a study by Deloitte estimated the value of open data to TfL, customers and others to be up to £130 million per year (Deloitte 2017).

Despite the seemingly clear benefits to users and to the city, the profitability of individual third-party apps that use open data is uncertain. Citymapper, a transport app with more than 50 million users globally, illustrates some of the difficulties that face free-access, information-based transport apps. Citymapper began in London as Busmapper in 2011, becoming Citymapper in 2012. From one perspective it has been successful in generating investment and demand. It is reported to have raised £45 million in venture capital (Li 2021), and over £6 million through a crowdsourcing campaign.[22] However, while the app's free, user friendly interface is widely used, it has not achieved financial sustainability. Various options for revenue generation are being explored: a paid-for version of the app with additional and personalised information; fees for rides booked through the app (Taylor 2021); and a Citymapper pass in London that can be used to travel in London Zones 1 and 2 for less than the cost of a weekly Oyster travel card (Tavmen 2020:12).

The social benefits of open data again seem obvious: more personalised and detailed transport information and space for private sector innovation, expanding public transport's offering. Yet Citymapper's lack of profitability, while providing a useful and accessible app, point to the tension between the types of public value generated through data use, and private profitability.

Ride-sourcing platforms in London

While there are multiple ride-sourcing apps active in London,[23] Uber has dominated the discussion on the governance of platform-based transport services. In London, Uber operates under the Private Hire Vehicles Act 1998 and the corresponding Private Hire Vehicles (London) (Operators' Licences) Regulations (2000). This gives TfL some control over issuing Uber with an overall license to operate as well as conditions for its operations. However, it cannot cap the number of Uber drivers if they comply with regulation.

After Uber received its first license to operate in London in 2012, just before the city hosted the Olympics, TfL was largely in a reactive mode. Over the following years, Uber's growing presence raised government concerns about congestion and safety. In 2015, the Mayor of London openly appealed to the central government for the power to cap the number of private hire vehicles (PHV) in London. He cited congestion as a driving concern. (Greater London Authority 2015).[24] Mayor Sadiq Khan's 2016 Taxi and Private Hire Action Plan, while not specifically naming Uber, affirmed the importance of quality and safe transport services enabled through regulation and fair competition (Mayor of London, Transport for London 2016). It drew attention to cross-border hiring of taxi and PHVs as a problem contributing to congestion, and called for the city to have additional regulatory power (Mayor of London, Transport for London 2016).

The City of London and TfL faced competing lobbies about whether and how to regulate Uber. Uber argued it complemented the City's transport network (Inrix 2016), through funded research that found, "One third of Uber trips taken in London begin or end within 200m of a tube station," (Uber 2016). On the other side, Uber's relationship with drivers has been heavily criticised. Frank Field, MP, published a report that called gig working conditions like Uber 'sweatshop conditions'. (Greater London Authority 2017a). The United Private Hire Drivers union and the Licensed Drivers Association both lobbied against Uber, around public safety, workers' rights and/or environmental issues (Greater London Authority 2017b, 2017a).[25] Ultimately, the direction of travel has been toward greater regulation.[26] Uber's license to operate in London became a basis for negotiating changes in their operations, as it came up for renewal in 2017, reopening questions about the conditions of Uber's original licence (Greater London Authority 2017b). In September 2017, TfL chose not to issue Uber with a private hire operator license, citing its work as a regulator to ensure passenger safety, and raising concerns with Uber's approach to reporting serious criminal offences, medical certificates, and use of software to evade inspectors (Greater London Authority 2017b).

Uber appealed and was granted two extensions, with a commitment to adapt its operations. However, in 2019 TfL again rejected Uber's license renewal, TfL, citing ongoing risks to passenger safety (Anon 2019). Uber again appealed and was granted another extension (Anon 2022b). Alongside contestations over license renewal, TfL enacted stricter regulation of the platform's relationship to drivers. In February 2021 the UK Supreme Court ruled drivers must be treated as employees (Anon 2022b), setting some precedence for other ride hailing and delivery platforms (Bradshaw and Cumbo 2022). Uber's activities remain open to questioning. In 2022, *The Guardian* newspaper released a global investigation based on 124,000 leaked documents from Uber, which showed evidence of Uber secretly lobbying key UK government officials, elected representatives and TfL (Goodley 2022; Mason, Goodley, and Lawrence 2022).

In sum, since entering the London market, Uber's operations have been under scrutiny for their effect on market conditions and competition, as well as individual transport outcomes and city-level transport operations. In addition, even with these contested business practices, Uber faces financial constraints, compounded by COVID-19. In November 2021, Uber raised fares in London, while also experiencing a shortfall in the number of Uber drivers in the city (Anon 2021). Therefore, Uber has become established in the London transport network yet debates over its activities have brought attention to what constitutes fair competition and business practices for platform-based companies, while reaffirming transport as a service that must benefit individual users and the city as a whole.

Conclusions

This final section reflects on data use in digitised transport services that emerge from the case study of London, within the context of wider scholarship on the nature and measurement of progress through data in transport services. It points to key questions that remain for policymakers seeking to promote and support data use in ways that further wellbeing, economic growth and sustainability in transport services.

Governance and regulation

Consistently, throughout the application of data to transport services in London, the strength and central co-ordinating role of TfL has helped to sustain attention on outcomes for individuals and for the city as a whole. With contactless payments and open data, TfL's role in setting up arrangements for data use shaped the discourse and metrics for positive outcomes. For ride-sourcing applications, TfL had a more reactive role, and ended up drawing on different mechanisms, including regulation and licensing, to attempt to balance individual, business and city-level outcomes.

This points to several considerations about how governance arrangements relate to progress with data use. First, it provides some insight into the factors that enable a regulator to shape the conditions of data use. TfL established the foundation for open data, and helped to ensure third-party apps worked within common formats and standards. Also, unsurprisingly, the power given to the regulator mattered. There were certain policy levers not open to TfL and the City of London, for example, capping the number of private hire vehicles. However, other channels, from license renewal to judicial review provided alternative way to bring attention to different values, e.g., safety and congestion.

Second, even with TfL's interest in positive individual and city level outcomes, data use brings unseen dimensions of inequality and exclusion.

This is most apparent around digital payments, where data from smart cards informs planning of services. This model of data use suggests a positive feedback loop between users with access to digital tools and decision-makers. It potentially fails to consider the trips that people would take but cannot afford, or the routes not served. In cities with high levels of inequality like London, distributional questions are important. Therefore, how inequalities might be reinforced or neglected through data use becomes an important question for policy.

Business models

The London example reaffirms the challenges of establishing sustainable business models around data use in transport services. On one side, there was very little change to TfL's business model. Data use has shifted the balance between costs and revenue in some areas, e.g. with new costs around setting up, maintaining and upgrading data systems, and new revenue streams around targeted advertisements. It also compelled new partnership working. TfL depends on third party firms and private sector partners to manage data systems and provide additional services. However, the primary revenue source, passenger fares, has not changed.

On the other side, some private sector firms have relied more heavily on data for their primary service offering and revenue generation model. Uber's offering to drivers and riders is tied to data: linking them and providing both with an efficient and informed service. Uber balances what passengers are willing to pay, with what drivers require, and with its profit. Third-party multi-modal transport apps also make data central to their offering. In this case, they use and combine open data to provide transport and journey information, and supplementary services, to transport users. They also must balance competition with other tech firms who can also access and use open data, with operating costs, and users' willingness to pay for the app.

The tight margins faced by TfL and private tech firms around the use of data for transport services raise questions about more than simply profitability. Even if firms can achieve a profitable balance of interests, it is important to consider the basis on which this is achieved. Do services mirror existing forms of exclusion or create new ones? Do they reach the more marginalised and/or lower income users and areas? Is there an argument for subsidising certain services from an individual welfare and equality perspective, given the likely importance of mobility to achieving other economic and social ends?

"Second, even with TfL's interest in positive individual and city level outcomes, data use brings unseen dimensions of inequality and exclusion."


January
2021
Total spending
$ 3,784.88
$1000
$500
$250
$0
5
6
7
8
9
10
11
12
Latest activities
Figma
Daily Cash
Yesterday
+ $0.56
3%
Sketch App
Paid
Jan 5, 2021
- $99.00

FinTech

Introduction

Digital technology has significantly affected the financial services industry. In addition to the intensive use of digital in incumbent services, emerging businesses focus on new data-driven models that aim to provide more efficient, cost-effective, and personalised services, making them easier and more convenient to use. These new services are broadly referred to as financial technology, or "FinTech." There have been some attempts to arrive at a formal definition. For instance, Leong and Sung define it as "any innovative ideas that improve financial service processes by proposing technology solutions according to different business situations," (2018, pg. 74). Another example is, "A new financial industry that applies technology to improve financial activities," (Schueffel 2016, pg. 32). These definitional questions also extend to: What players are involved? What is the scope of financial activities and services covered? How and for whom are services "improved"?

The answers have changed as FinTech has evolved. Initially, new entrants with a focus on banking and payments aimed to disrupt incumbents. But entry barriers such as regulatory and capital requirements discouraged such business to consumer start-ups. Many FinTechs therefore moved to provision of business to business software that incumbents could use to improve either their customers' experience (such as mobile banking user interfaces) or to make operational improvements and deliver cost savings. The FinTech label is therefore now widely applied, including services such as savings banks, payday loans or factoring, and has a number of 'verticals' (Gilbert 2021b; Gilbert 2022).

Digital technology has the evident potential to improve financial services in terms of aspects such as accessibility or cost. Around the world, financial access is on the rise. Between 2011 and 2021, 1.1 billion previously unbanked adults gained access to financial services (Demirgüç-Kunt et al. 2022). This has been driven by an increased focus on inclusion, as well as new developments in technology that have facilitated the entry of new individuals and businesses (Tanda and Schena 2019). The COVID-19 pandemic accelerated investments in and use of digital financial services (Fu and Mishra 2022). A 2020 study found that twelve out of 13 surveyed FinTech verticals had already seen significant growth when compared to the previous year (Ziegler et al. 2020). The Financial Stability Board found that the pandemic hastened trends already underway – with notable growth in provision of financial services by incumbent Big Tech companies (2022).

However, trust in financial institutions has eroded over time, particularly among younger generations (Brychko, 2021). The 2007/8 financial crisis raised questions about the societal benefits and costs of financial services.

And while many specific financial services have seen clear improvements, technological innovation may also have enabled "predatory inclusion" (Seamster and Charron-Chenier 2017), including services such as online payday loans, buy now pay later, crypto, or day trading apps; and the demutualisation and personalisation of insurance using telematics or price comparison sites. Long-standing challenges such as financial exclusion, high fees, and the cost/availability of sub-prime credit that could perhaps be eased using digital technology have not been addressed.

"And while many specific financial services have seen clear improvements, technological innovation may also have enabled "predatory inclusion" (Seamster and Charron-Chenier 2017), including services such as online payday loans, buy now pay later, crypto, or day trading apps; and the demutualisation and personalisation of insurance using telematics or price comparison sites. Long-standing challenges such as financial exclusion, high fees, and the cost/availability of sub-prime credit that could perhaps be eased using digital technology have not been addressed."

Trust in financial institutions is closely tied to the economic situation and historically goes down in times of financial crisis (van der Cruijsen et al. 2021), so the present cost of living crisis is a critical time for the sector. Financial data is being combined with other information in unprecedented ways, as financial services converge with other aspects of everyday life. This means that while many have gained access or enjoyed service improvements, issues may be exacerbated for those un- or under-served by the current system, who are likely to sit at an intersection of inequalities. It is well-documented that "it is expensive to be poor" (Ehrenreich, 2014; Yun, 2017). This may include income deprivation, lower levels of education, and lack of internet access. These factors have well-documented influences on financial access and use (Demirgüç-Kunt et al. 2021).

Scope and methods

FinTech is thus a broad term that encompasses many businesses and projects. To focus on the central question – what difference digital has made or can make to people's life experiences and opportunities – the case studies selected here focus on consumer financial services, rather than business to business or government service provision. The questions explored will cover emerging business and governance models, the distribution of value, and the policy and regulatory approaches that have enabled and resulted from digital technologies and data use.

This section will compare the evolution of FinTech in two countries: the United States and the United Kingdom. While their stated goals of the digitisation of financial services have been largely similar, varying regulatory and innovation environments have led to differing business and governance models. The comparison will look at two areas: digital banking and Big Tech financial services.

Trends in data use in financial services

The post-2008 era saw public sector investment in financial infrastructure. This included the development of fast payments systems (FPS), investments into supervisory and regulatory technology (SupTech and RegTech), and exploration of central bank digital currencies (CBDCs). It also included a regulatory focus on financial data (Arner et al. 2015, Puschmann 2017). The increasing use of data has opened new value capture models for businesses, particularly those who serve as data brokers and trusted intermediaries (Vives 2017, Dhar and Stein 2017).

There are several theories seeking to explain what drives innovation in the financial sector. One summary identifies six explanations found in the literature although concluding that no one explanation is adequate (Tufano 2003, p. 308):

- completing inherently incomplete markets;
- addressing persistent agency concerns and information asymmetries;
- minimising transaction, search or marketing costs;
- responding to tax and regulatory forces;
- responding to changes in economic conditions, in particular new or newly perceived risks; and
- capitalising on technological developments.

Regardless of the pathways, financial services have followed the broader trend of datafication (Van Dijck 2014, Sadowski 2019). A European Central Bank report makes the distinction between two categories of technological change in the financial sector: (1) information – data collecting and processing and (2) communication – relationships and distribution (Boot et al. 2021). Here we focus on the first element.

The rapidly expanding collection and use of data has been the result of several factors:

Shift from risk mitigation to customer experience

Historically, the purpose of using micro-level consumer data in financial services has been focused on minimising risk. For example, credit scores are an assessment of a customer's risk of default (Ravi and Kamaruddin 2017). Customer information was also collected for compliance purposes (Gill and Taylor 2004). Money movements were scanned to detect potential illicit activity (Kingdon 2004). The shift towards utilising data instead to provide better services began with the analysis of customer data for personalised marketing and cross-selling, building on methods of segmentation and targeting first developed in the 1980s (Gilbert 2021a). Companies – both incumbents and start-ups – have recognised the growing potential that data and data science methods hold for providing more personalised and efficient services to consumers (Alt and Puschmann 2012).

New regulatory models

Policymaking and regulation post-2008 focused on addressing the "too big to fail" model. A greater emphasis was placed on enabling new entrants and competition. In addition to open banking, discussed in greater detail below, this included: re-structuring regulators, lowering barriers to entry for providing financial services, and greater government-wide coordination. In some areas, governments have been hesitant to put frameworks into place – in part because it is taking time to understand the complexity of new models and in part because of governments' desire to be viewed as friendly to innovation. This means that in some areas there has been rapid growth where players are not (yet) subject to the same compliance burdens as their traditional finance counterparts (Zetsche et al. 2017).

Countries have taken different approaches to regulating data use in financial services. For instance, the United States has taken a market-driven approach, while the United Kingdom has taken a mandatory approach (Cardinal and Thomas 2022). Others, like Singapore and Japan have taken a hybrid approach (Yeong and Hardoon 2022). This is discussed in greater detail below.

Public sector infrastructure investments

Governments recognise their role as important enablers of financial services. There are several public goods upon which the sector hinges. Re-thinking financial infrastructure for digital and data requires government support along four pillars: (1) establishing digital identity; (2) ensuring open, interoperable payments systems; (3) enabling electronic provision of government services and payments; (4) co-ordinating design of digital markets and systems (Arner et al. 2020). This recognition is manifesting itself around the world with investments in everything, from digital identity structures to experimentation with fast payments systems and central bank digital currencies (Nicoletti and Nicoletti 2017, Náñez Alonso et al. 2021).[28] Governments are also seeing themselves as infrastructure providers for financial services – working on developments that

New models to foster innovation in the United Kingdom

The United Kingdom dissolved the Financial Services Authority in 2013. It was replaced by the Prudential Regulation Authority and the Financial Conduct Authority – which had an explicit mandate of fostering competition in financial services. Their efforts to encourage start-ups, such as hosting an Innovation Hub and Regulatory Sandbox, underscore this priority. The two regulators have also worked with the Bank of England on a New Bank Start-Up Unit, which helps firms who are interested in applying for banking licenses navigate the process with the relevant regulators. Concrete steps have included offering a restricted license for new entrants, which involves lower capital requirements and the ability to serve customers on a provisional basis before being subject to full requirements. There have been 54 new banks authorized via the new bank authorization process since 2013.

A global leader in financial regulation, the UK has served as an example for several countries including the European Union, Australia, Mexico, and Brazil – especially in their approach to open banking and finance. Littlejohn, et al. highlight several lessons from their journey (2022, p. 178):

- the importance of an enshrined consumer data right;
- the importance of standards in promoting market scalability and interoperability;
- the need for an independent third-party (trustee) to oversee market collaboration;
- understanding that regulatory governance and policy framework are essential to market legitimacy and attracting investment; and
- understanding that the shift to a data economy requires thinking differently about regulation: it is more about data access than it is about a product or service.

support the "rails" of the system. For example, the Federal Reserve of the United States has been working on FedNow, an instant payments system that will operate 24-hours a day, year-round. The service is set to launch in 2023, beginning with account-to-account and consumer-to-business use cases. In the United Kingdom, the New Payments Architecture (NPA) programme has been in development since 2017. Both utilise messaging standards set by the International Standards Organisation (ISO). The systems also begin with a narrow set of use cases with the ambition of expanding in the future based on demand and technical developments. These public good technical and infrastructure investments are critical to private sector-led innovation and developments.

Lower costs

Digital technology lowers the fixed cost per relationship and allows for widespread data collection and mining that was not previously possible. As one researcher argues, fixed "coding" costs are fundamentally different form fixed costs per client, and have implications for economic welfare and service provision (Philippon 2019). FinTech has benefited from the intersection of several technological developments. On the software side, the internet and cloud computing have lowered start-up costs, as new entrants are not required to build in-house systems and can pay for processing as needed – rather than making a large capital investment upfront (Nicoletti 2013, Gai 2014). Similarly, there are platforms on which banks can be built 'out of the box'.

On the hardware side, the proliferation of smartphones has meant that many people have the tools needed for a virtual, customised branch in their pockets. Physical bank branches involve some fixed costs that virtually disappear with a digital-first approach. This investment happens on the customer side, off-loading some of the operational costs that financial service providers have faced in the past. Mobile 3G and beyond networks are another converging part of the technological innovation and investment (Kim et al. 2018, Mallat et al. 2004). Finally, there are many elements of the creation of the technology that can be fully or partially outsourced via open APIs or service providers. Some companies have built entire business models around low-code or no-code solutions for banking and financial services (Guibaud 2016). While the reduction in fixed costs is important for enabling new entry, there is also scope for reduced operational costs. Both should contribute to higher quality service and lower costs for customers, where competition is effective.

Innovative partnerships

Developing and emerging economies have been particularly noteworthy for the emergence of innovative partnerships. One well-known example is M-Pesa in Kenya, a form of mobile money introduced in 2007 by a telecoms company, Safaricom, with some seed funding from aid budgets and in partnership with a bank (to avoid the need for oversight by the banking as well as the telecoms regulator) (Jack and Suri 2011; Mas and Morawczynski 2009, Mbiti and Weil 2015, Hughes and Lonie 2007). Similar telecoms-centric mobile money services have appeared in other low- and middle-income markets, involving a variety of structures and partnerships. In another type of example, India's Unified Payments Interface relies on many merchant partnerships, all built upon the foundation of the country's Aadhar identification system (Vijai 2019). In the midst and wake of the Covid-19 pandemic, mobile money networks were used to deploy government transfers in several countries like Namibia, Peru, Uganda, Pakistan, and Zambia (Sahay et al. 2020; Nishtar 2020).

Progress through digital and data use in financial services

Investments in and use of data vary based on the type of provider and their choice of business model. As will be discussed in greater detail in the case studies, traditional finance and newer FinTech players diverge in their structure. Consequently, the way data is captured and utilised by each looks quite different. Big Tech's entry represents another model altogether, also discussed in the case study below.

Service (dis)aggregation

A major difference between traditional finance and FinTech is a shift towards disaggregated services. Recent work emphasises the *modularisation* of market structure and the changing nature of the service provider. For instance, Zetterli (2021) divides financial services into four layers: (1) Balance sheet, (2) Product, (3) Customer relationship, and (4) Distribution. While these services were historically integrated, "The key pieces in banking no longer need to go together," he argues. This service disaggregation contrasts with traditional banking and financial players, who emphasised *aggregation.* (Fennell 2019, Haas et al. 2015).

On the other hand, there were historically neat vertical lines around the provision of services like banking, payments, and the issuance of currency– due largely to high barriers to entry and a stringent regulatory environment. Newer entrants are blurring the boundaries of service provision (Pollari 2016, He et al. 2017). WeChatPay and AliPay in China paved the way in the early 2000s for tech companies entering financial services (Cao and Niu 2019, Lu 2018, Guo and Bouwman 2016; Mu and Lee 2017, Klein 2020). Interestingly, this pattern echoes that seen in alternative financial services. For instance, microfinance institutions have often expanded beyond loans to other financial products like insurance (Banerjee et al. 2014, Churchill 2003). Extending into adjacent services that use some of the same technological infrastructure to reach customers is found in other digital markets, often labelled 'envelopment'.

Evolving landscape of providers

The literature has characterised existing and emerging business models in different ways, but distinctions generally revolve around: (1) Regulatory regimes – including the types of licenses and charters that a service falls under; (2) Operational models – including the extent to which operations are focused on technology; and (3) Consumer bases – including the size of the customer base and level of specialisation. Additional factors may include trust and establishment of the brand, jurisdictional boundaries (or lack thereof), and product and offering cross-over.

There has also been a new suite of players looking to provide infrastructure for the emergent FinTech space. Companies such as Stripe, Shopify, and Plaid have seen tremendous growth in the last five years. Areas such as e-commerce, open banking, and mobile money all rely on straightforward connections to the existing financial rails. Importantly, the relationship is bi-directional – with traditional financial infrastructure informing FinTech evolution and vice versa (Phan et al. 2020, Hornuf et al. 2021).

One area where traditional financial services companies have increasingly been using data is insurance, with insurers steadily moving toward individualised pricing of risk, at least where use of individual characteristics (such as gender in the EU) is not prohibited. Data collection on individual characteristics and behaviour appears to give insurers the ability to price discriminate in far greater detail and limit adverse selection. On the other hand, it also reduces mutuality and risk-pooling or risk-spreading. Some observers consider the trend could undermine certain insurance markets (eg Cevolini and Esposito 2020) by making it preferable for a growing number of individuals to self-insure as premiums rise.

"Historically, information asymmetries have been built into the intermediated model. This may be shifting, leading to changes in business and operational models. Technological progress in financial services involves a trade-off between lower costs from public availability of data as well as lower-cost of provision; and the competitive edge that comes with proprietary information and private accumulation of data."
(Hauswald and Marquez 2003).

Table 1 summarises some key aspects of data use in fin tech models.

Compliance and RegTech

The increased use of technology in financial services has started a conversation about re-thinking regulation of the sector, especially through integrated regulatory technology, or "RegTech." Under a RegTech model, data produced in the provision of financial services could be used for supervisory functions (also called SupTech). In fact, some argue that to keep pace with financial innovation, governments will need to increase the use and reliance of RegTech. As Arner et al. argue, "The emergence of RegTech is attributable to: (1) post-crisis regulation changes requiring massive additional data disclosure from supervised entities; (2) development in data science (for instance AI and deep learning) that allow the structuring of unstructured data; (3) economic incentives for participants to minimise rapidly

Table 1: Data model comparison – traditional finance and FinTech startups

	Traditional Finance	FinTech Startups
Background	Data capture originally for compliance, screening, and monitoring; extended into marketing and customer segmentation	Business models generally technology and data-first; sophisticated personalisation
Site of Data Capture	Integrated data capture across single financial service provider – can include physical and digital components	Digital-first experience; reliance on mobile devices (may or may not be a smartphone); movement towards "digital footprint" – integrated data capture across different services
Data Aggregation	Horizontal integration to consolidate data on a single customer with the goal of providing a "personalised" experience	Distribution of individual data; aggregation and mining of trends; In some cases, shift to "personal ownership" of data
Business Models	Customer account-based; emphasis on repeated interactions with the customers for collection, processing, and re-use of information (Boot et al., 2001); Cross-selling of financial services (Puri and Rocholl, 2008); Proprietary model and safely-guarded information	Rise of business-to-business service models; diversification of service provision beyond individual accounts; leveraging public infrastructure and regulatory developments
Systemic Risks	"Too big to fail"	"Too integrated to fail"; or, no single points of failure

rising compliance costs; and (4) regulators' efforts to enhance the efficiency of supervisory tools to foster competition and uphold their mandates of financial stability (both macro and micro) and market integrity." (2017, p. 383). At best, they argue, this will enable a "real-time and proportionate regulatory regime." This holds especial promise for real-time assessment of macro risks, illicit activity, and distributional effects.

Measuring progress

When considering progress in the financial sector, the unit of interest varies. Traditional measurements of financial inclusion and access have included measurements at the individual, household, or account (which could be individual, household, or other). Many have hailed FinTech as a potential key to unlocking greater financial inclusion, but it is widely recognised that technology alone cannot be considered a panacea (Gabor and Brooks 2017). Still, research has supported the hypothesis that FinTech may support greater financial inclusion. Multi-country studies have found a positive relationship between technology and inclusion (Demirgüç-Kunt et al. 2021, Sahay et al. 2015; Mookerjee and Kalipioni 2010). However, these projects also emphasise differences in outcomes between countries and regions.

There are entirely different measurements on the business side. For example, Brown and Eisenhardt (1995) offer a three-tiered measurement scheme for companies: at the product level (profitability, market share, and revenue), project level (time, cost, and function), and company level (excess returns). Other models emphasise function. For example, inputs (financial resources, human capital, idea generation), processes (cycle time and resources expended per project, and outputs (new products or services launched, revenue and profit gains) (Boston Consulting Group 2006).

Underlying assumptions

Though based on quantitative assessments, there are values embedded in what and how we choose to measure in terms of inclusion.

Perhaps most fundamentally, there is the assumption that financial health can be reasonably standardised and quantified. For the most part, measurement of individual and household economic wellbeing is conducted through detailed surveys, such as the World Bank Findex, the Federal Reserve Economic Wellbeing Survey, or the Personal and Economic Well-Being in Great Britain series. While these are very detailed efforts, they are inherently constrained by the standard questions and nature of administration. In contrast, sociological explorations have painted a richer picture of the use of financial tools and how they are pieced together (Collins et al 2009, Morduch 2017).

Until recently, most measurements of financial inclusion focused predominantly on an individual or household's relationship with the formal financial sector. This implies that inclusion in the formal financial sector is a valuable goal because historically, financial intermediaries have been viewed as valuable facilitators of trust and the efficient allocation of capital. The presumption is that, in theory, the services the formal financial sector offers are meeting the needs of the customer.

Moreover, each measurement typically has a reference population. These can vary from country to country or based on the data collected. There are categories constructed in these measurements – for example, through age cut-offs or orientation around heads of household. While this is not unique to measuring financial wellbeing, it is important to note in a system so related to trust, literacy, and power. The desire for a nuanced picture has led to recent shifts to disaggregate data along the lines of gender, race, education level, and more.

Measurement models

As with transport, financial services touch upon a complex web of actors and entities. Measurement models tend to vary greatly depending on what entity is doing the measuring – and for what purpose. Measurement models in the public sector aim to create pictures of the economic wellbeing of individuals and households, the business and competitive environment, and the overall risk present in the system. Private sector models are, necessarily, more focused on growth, business opportunities, and more tailored pictures of risk. Finally, academic models take alternative approaches to tracking growth and progress over time.

At the same time, the purpose dictates the unit of interest, which varies across measurement types. Historically, measurements focused on the individual and/or household level, aggregate locality-level (city, country, etc), business level, or another specific unit.

Finally, there is a temporal aspect. While economic measurements may provide a picture of relative wellbeing for a particular moment, an understanding of *progress* includes a comparison over time. As discussed, there is typically a hypothesis surrounding a desirable outcome that underpins these measurements – though the hypothesis may shift over time.

Some examples of models used to measure financial wellbeing are collected in Table 2.

Challenges in measuring progress

Measurements like availability and use provide only one part of the picture. It is important to consider to what extent these factors meaningfully impact *outcomes*. Importantly, the World Bank found that even though there was growth in account ownership and use, "only 55 percent of adults in developing economies could access extra funds within 30 days if faced with an unexpected expense, and about two-thirds of adults were very worried about at least one area of financial stress," (p. 3). Similarly, those who do not have prior experience with formal financial institutions may need additional support. Inexperienced customers, the survey found, may be more vulnerable to fraud – and may not understand how to optimise benefits and minimise risks within formal financial services. This vulnerability applies equally to people in high-income countries such as the US, where the proportion of households reporting they could readily find $400 for an emergency has climbed steadily but stands at just 68%, and where uncertainty and variability of incomes is a challenge for many households (Morduch & Schneider 2017, US Federal Reserve 2022). Lower income or otherwise disadvantaged people pay higher fees or interest rates, on services ranging from sub-prime mortgages to the purchase of crypto assets (JP Morgan Chase 2022).

Table 2: Example financial measurements

	Public Sector	Private Sector	Academic & Third Party
Individual/ Household	• Penetration: Access, use, and quality of financial services and alternative financial services (G20 Financial Inclusion Indicators[36]; World Bank Findex[37]; National surveys[38]) • Economic activity: income, consumption, wealth (System of National Accounts[39]) • Financial control: Dispute resolution capabilities (World Bank Consumer Protection survey[40]); Credit outcomes (National surveys) • Financial stability (micro): Dealing with unexpected expense (World Bank Findex, National surveys); Retirement savings (National surveys)	• Customer base: Number of customers, value per customer • Transaction types and volume: Transactions per day, digital versus cash	• Wellbeing and progress (OECD41) • Subjective happiness (UN World Happiness Report42)
Business	• Growth: Sector growth, value created (National measurements43) • Enterprise: Formally banked enterprises (IMF Financial Access surveys44); SME capital accessibility (World Bank Business Enabling Environment45)	• Customer base: Number of customers, value per customer, monthly active users • Economic activity: Cross-business line performance; annual profit and revenue • Valuation: Amount of capital raised, publicly-traded value; mergers and acquisitions • Return on Assets (RoA), total client assets, net new money loans, and cost-income ratio (Fasnacht, 2018)	• FinTech value-added: Stock price changes based on FinTech patent filings (Kabulova and Stankevičienė, 2020)
Aggregate or System-Level	• Resources and inclusion: GDP per capita (National measurements); Un- and under-banked population (World Bank Findex, National surveys) • Economic inequality: Gini coefficient (Standardised World Income Inequality Database46); Indices of Deprivation (National surveys47) • Points of service: Bank branches, ATMs, mobile agent outlets, PoS terminals (IMF Financial Access surveys)	• Service provision: Average loan size, • Product and pipeline performance: Acquisition, activation, retention, referrals, revenue • Cost models: Customer acquisition cost • Ease of doing business: Startup costs, barriers to entry	• Unit cost of financial intermediation (Philippon, 2015; Philippon, 2019) • SDG Measurements48 • CGAP Holistic inclusion framework: Cost, Access, Fit, Experience49

Table 2 indicates how complicated the question of understanding financial wellbeing can be. In fact, the literature aiming to quantify financial progress reports mixed results. Though overall measured trends are positive for access, use, and quality of financial services, this picture is incomplete.

This raises a related question around equity. On average, does technology facilitate a more even playing field and reduce discrimination seen in the system to date? The answers in the literature are mixed, and complicated by the fact that important elements of value in financial services are intangible.

For instance, there has been little work done to measure the value of trust in a system or aspects like privacy and security. Other elements such as independence, autonomy, and flexibility are rarely considered in models of "progress," though they are often considered as aspects of added value from technology (Gai et al. 2018). Fasnacht asserts: "Examining the extent to which the delivered service meets the client's expectation is finally the only meaningfully way to measure innovation," (2018, p. 128). While this may be, it is difficult to assign metrics, especially as expectations change. Companies have used measurements such as speed, cost and efficiency, and responsiveness. They are now turning to customer data to provide a clearer picture of preferences. Over time and across geographies, there have been shifts in preferences around community-based models, intermediated models, and "trustless" models. There is also a body of literature focused on measuring the size of the informal economy (Hussmanns 2004, Vuletin 2008, Losby et al. 2002).

Thinking of progress in terms of access to traditional formal financial services has recently shifted with the advent of alternative financial services such as mobile money and cryptocurrency. For example, the World Bank's Findex database distinguishes mobile money accounts from accounts at a formal financial institution. The U.S. Federal Reserve began including cryptocurrency use in its survey of the Economic Well-Being of U.S. Households in 2021. Data suggests that those who are un- or under-served by formal financial services may be turning to such alternatives. While those who held crypto for investment purposes were largely high-income, those who used crypto for transactions were generally low-income and less likely to have a bank account. Nearly 60 percent of adults who used crypto for transactions had an income of less than $50,000, 13 percent of those who used crypto for transactions did not have a bank account and 27 percent did not have a credit card. By comparison, just 6 percent of adults who did not use crypto lacked a bank account and 17 percent lacked a credit card (US Federal Reserve 2022). This is consistent with marketing claims by players such as crypto but, as noted above, even in such new services or assets the usual gradients of disadvantage apply.

Since FinTech firms represent a new business model, scholars have grappled with how to effectively assess the valuation of FinTech companies. Some argue that current valuation models are of limited applicability (Saeterboe 2019). Other research supports the hypothesis that FinTech companies follow a technology model but argue that they may eventually converge and engage in co-opetition with traditional banks (Moro-Visconti et al. 2020).

Looking beyond traditional financial metrics, emphasis on Environmental, Social, and Governance (ESG) factors in finance has led to a greater emphasis on sustainability implications. As Arner et al. (2020) summarise, approaches to climate change and the SDGs fall into three broad categories:

- Emphasising traditional financial services' focus on risk and related disclosure
  - Example: Financial Stability Board climate change-related disclosures
- Viewing SDGs as related to new sources of potential risk that must be addressed
  - Example: InsureTech; Involvement of International Association of Insurance Supervisors
- Thinking about how to re-structure or re-design the financial system to support the SDGs
  - Example: Provision of underlying infrastructure for digital transformation.

Overall, measurement of progress needs to account for trade-offs among various aspects of financial services – for instance, trust, privacy, convenience, efficiency, personalisation, etc. Additionally, it will be important to recognise that individual, financial provider, and social value may all diverge, as we explore below.

"This raises a related question around equity. On average, does technology facilitate a more even playing field and reduce discrimination seen in the system to date? The answers in the literature are mixed, and complicated by the fact that important elements of value in financial services are intangible."

Governance models for using data in financial services

Governance of data in financial services sits at the intersection of several risk areas and associated regulatory perimeters. For example, as financial services become increasingly interconnected governments will need to grapple with third party risks, concentration risk, accountability and oversight, due diligence and compliance, solvency and financial stability, and consumer protection (Zetterli 2021). Furthermore, "as FinTech gradually moves from digitisation of money to embrace the monetisation of data, the regulatory framework for finance will need to be rethought as to cover notions previously unnecessary such as data sovereignty and algorithmic supervision," (Arner et al. 2017, p. 403).

Governance principles

Principles for data governance in financial services closely echo those related to general data protections, though acknowledging that this data is particularly sensitive. Important aspects of data policy involve setting the rules around who will have access to data and under what conditions. These parameters will ultimately have implications for competition, market structure, and equity in the digital economy (Carriere-Swallow and Haksar 2022).

For example, Jeng (2022:3) raises multiple questions around financial data:

"How much we spend, on what and on whom and at what time—these granular pieces of transactional data are very sensitive and also commercially very valuable. Do we as individuals own these pieces of our personal data? Or is the bank that spends money maintaining its customers' data the real data owner? If we do not own our data, can we at least control what personal data is shared, with whom, and how the data is used? Is it necessary to have informed consent in open data activities? And what counts as informed consent? When customers give fintechs permission to collect their private financial data held at banks, do customers fully understand that they are handing over the keys to their banking kingdom when they click "Continue" after downloading the smartphone app, handing their bank account login credentials to fourth-party data aggregators? Do customers know that they have consented to data aggregators signing on to their bank accounts multiple times a day and night to harvest their personal data?"

Asrow (2022) offers a general framework for data protection applied to financial services: "Passive" rights are actions taken by entities that provide protection to individuals without requiring direct action. These include data management, cybersecurity, appropriate use, and data quality. "Active" rights, on the other hand are actions taken by individuals via avenues and tools provided by entities. These include portability and exportability, ability to give and revoke consent, and deletion and correction. Service provider transparency is the layer that connects both. These fundamental concepts are echoed in more formalised attempts at principles-building. For example, the CFPB "Principles for Consumer-Authorised Financial Data Sharing and Aggregation,"[29] and the FDX principles of user-permissioned data.[30]

Regulation

There have been several regulatory approaches to FinTech around the world. Omarova (2020) provides a taxonomy, while observing that, "Despite the wide variety of specific policy choices and legislative developments around the world, the overall process appears to rely primarily on the existing regulatory tools and techniques as the means of accommodating and absorbing new entities and activities into the established regulatory schemes," (p. 52):

- **Experimentation –** setting up programs, such as sandboxes, so that private firms can test innovative financial services in a controlled environment. This approach was pioneered by the United Kingdom's FCA and has since been picked up by over 50 jurisdictions around the world (World Bank 2020).

- **Incorporation –** special licensing or chartering of fintech firms. For example, in 2018, the United States banking regulator began accepting applications for a special purpose fintech charter. These entities would be subject to bank-like prudential requirements that were adjusted to individual risk profiles and would be exempt from money transmitter laws. At the state level, the New York Department of

Financial Services' BitLicense provides another example, tailored to cryptocurrency.

- **Accommodation –** taking a wide range of regulatory efforts to accommodate and adjust to tech-driven market developments. These include RegTech and investment in infrastructure like digital identity systems and market infrastructure investments.

Business models

Open banking has created new opportunities for data sharing and integration (Omarini 2018; Gozman et al. 2018). There has been a growing number of infrastructure "as a service" start-ups and new players. "Banking as a Service" – or BaaS – is an emerging trend involving the "Provision of complete banking processes, such as loans, payments, or deposit accounts, as a service using an existing licensed bank's secure and regulated infrastructure with modern API driven platforms from a specialist provider."[31] BaaS allows for the disaggregation of service provision and the aggregation of data. Because companies do not have to build these products in-house, they are able to open new avenues of service provision that are complementary to their core business models. Those outside of the financial services realm have also been integrating financial products via "embedded finance." These services include payments, wallets, payments, and lending (Townsend 2021). Providing financial services can provide new information about customers risk appetite, preferences, and even trustworthiness. Marketplaces and platforms are particularly well-poised to take advantage of this new influx of data because they have information about both the businesses and the large consumer base.

Following the adoption of new open standards, a new group of players emerged capitalising on API connections. Operating via a business-to-business model, companies like Plaid and TrueLayer created trusted access for open banking. In essence, these companies have capitalised on providing a user-friendly layer on this open banking technical standard (Awrey and Macey 2022). The open banking service providers may provide a proxy for the value of a public good like open data standards. As of April 2021, Plaid had a $13.4 billion valuation[32] and TrueLayer boasted a $1+ billion valuation[33] as of September 2021. Because of the modularisation of financial services, on-ramps and off-ramps to financial accounts remain critical. So, while there is increased competition for service provision in some arenas, there still may be a role for traditional services – especially as facilitated by these API operators (Gozman et al. 2018).

Many of the newer FinTech companies have yet to turn a profit. In these cases, operations have been sustained by investments – for instance, through venture capital or capital markets. However, others are profitable, and many others have what are in fact quite conventional finance business models such as fees and commissions, interest spreads, underwriting margins and annual management charges. For this latter category, the challenge is to grow to adequate scale, or to reduce customer acquisition costs.

It is not yet clear, amid the variety of new services, what types of business models will succeed. Will it be ecosystems or central platforms? Will there be dis- or re-intermediation, fragmentation or consolidation, and decentralisation or centralisation? (Knight and Wojick 2020) It is equally unclear what kinds of outcomes and broader progress there will be: will the technology enable greater access, equality and democratisation of finance – or on the contrary will models of predatory innovation deliver the reverse?

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Table 3: Comparison of data approaches – United States and United Kingdom

	United States	**United Kingdom**
Primary Users	Large financial institutions Banks were early adopters, looking to create consolidated picture of service provision	FinTechs Consumer-side data aggregation growth came from propositions offered by firms without a banking license
Mechanisms	Allowed for "screen-scraping"[50]	UK banks educating customers not to share their passwords; market players opted for secure password sharing
Regulatory Scheme	Market-Led	Mandatory
Regulatory Landscape	No overarching legislation; assortment of federal and state laws that touch on data privacy; complicated web of financial regulators[51]	Most formalized open banking system in the world via the Open Banking Implementation Entity (OBIE); established certification program
Regulatory Targets	Frameworks based on function and jurisdiction; no mandatory impositions	General-purpose framework; imposition of open banking standard on the nine largest banks in the UK (CMA9)
Data Protection Laws	Data rights for individuals in the data economy assigned under the rubric of Fair Information Practices (FIPs). Partially adopted into law via Fair Credit Reporting Act (FCRA) of 1970, Privacy Act of 1974, and Gramm-Leach-Bliley Act of 1999 (sector-specific approach) Modern era sector- and state-specific approach: • Section 1033 of Dodd-Frank established right to access digital financial records (2010) • California Consumer Privacy Act (CCPA) is biggest state-level package (2018)	Data Protection Act (2018)[52] passed as UK's implementation of GDPR; covers companies within and outside of the open banking system OBIE introduced the concept of "consent codification"[53] Underpinning philosophy "consumers own their data and grant explicit consent for other parties to access that data."

Comparison of consumer FinTech in the United States & United Kingdom

Both the United States and the United Kingdom have seen significant shifts towards a digital financial environment over the past decade. Enabled by high levels of broadband and mobile penetration, as well as relatively high levels of literacy, these countries were natural environments to lead in financial technology. At the same time, there was a proactive strategy from governments to attract innovation in the financial sector, though the two countries are structurally different. In both countries, data aggregation developed with minimal regulation, though they took different paths over time (Table 3).

The United States, on one hand, took a technology-first approaches to customer "pain points." However, financial regulation in the United States is complicated given the myriad actors that touch on banking, payments, and other financial service provision, and in contrast to the transportation sector, innovation in finance has lagged in some areas (such as absence of contactless payments, continuing use of checks), while proliferating the use of data in some other ways, particularly marketing. US customers sharing their financial data with third parties is roughly ten times more than those in the UK and, "the United States has been typically more than two years ahead of the United Kingdom in transformational technology platform availability simply because the United States is the home market for these BigTechs," (Littlejohn et al., 2021, p. 177-8).

The United Kingdom, on the other hand, has a simpler regulatory regime and has made concerted efforts to attract and innovate in financial services, building on the traditional on the success of its finance sector. However, the political complexities of Brexit have created considerable uncertainty, with (among other things) continuing debate about the regulatory framework.

Even so, FinTech has been a notable trend in both countries, as the use of cash and number of bank branches declines, and the use of digital-first services rises. This raises several questions, including:

- Who is this shift serving and who is being left behind? What are the intersecting inequalities that may come into play here?
- Is FinTech a new way of doing old business, or something entirely different? Are alternative financial products substitutes or complements to traditional financial services?
- What are the new operational, business, and regulatory models needed to enable digital financial services?

There are several trends to note. First, there are several emerging business models. Broadly, there are three categories of firms involved in FinTech: (1) traditional financial institutions making significant technology investments; (2) specialised new entrants with a technology-first business model; and (3) non-financial companies newly entering the financial sector – also loosely termed "TechFins" (Zetsche et al., 2018).

Here we focus on the latter two categories, specifically, digital banks and Big Tech financial services.

Digital banking

Digital and challenger banking has represented a high-growth area of FinTech for both the United Kingdom and United States. Challenger banks take a remote-first approach as mobile-only, branchless banks (Cavaglieri 2019).[34] As of 2021, North America was home to 44 "neobanks", while the United Kingdom was home to 37 (Exton Research 2021).

Despite their large and growing user base, few of these banks have yet to achieve sustainable profits. Recent announcements have indicted shifting strategies, with companies moving from customer deposit accounts to SME services, trading services, and beyond. One challenge in both the US and UK is the unassailable profits traditional banks make from their large, inert deposit books and other sources such as eyewatering unauthorised overdraft fees, charges on overseas transactions and so on. To date, the lower cost base of digital-first challengers has not proved sufficient to offset such structural challenges.

Indeed, scholars have been critical of the potential for hype. Johnson (2021) identifies six axes of the banking business: onboarding, payments, savings, investing, lending and support, asserting that challenger banks is superior only in the first three. She posits that taking advantage of data-driven insights will be the key battleground between incumbents and challenger banks, and asserts that incumbents have a head start in this arena. Schepinin and Bataev (2019) estimate that a challenger bank's operations will be efficient if it can exceed 200,000 customers in one year.

Evaluations of challenger banks tend to focus on the business upside – or potential upside – with little consideration of the potential broader consequences – particularly the distributional implications. For instance, there is little consideration of the fact that physical location may play a key role in determining poverty or inequality. How does digitised banking relate to the geography of poverty and opportunity? Interestingly, microfinance research has emphasised community proximity and physicality as core tenets affecting success.

Case Study: Starling Bank

Starling Bank is a UK-based and branchless digital challenger bank, founded in 2014. In July 2022, it became one of the first to turn a profit, ahead of competitors Revolut and Monzo. This came following two critical pivots in its business model. First, the bank turned to mortgage lending. Over £2 billion of its £4 billion in gross lending was mortgage-driven as of June 2022. Second, Starling moved away from retail customers to targeting business customers. CEO Anne Boden has publicly stated that she sees the future of Starling as a technology, BaaS company. That is, the company aims to move its business model from solely direct to consumer services to servicing both non-banks and existing banks. This will also include international expansion.

However, the bank came under fire because of its "Bounce Back" lending during the pandemic. Representing 40 percent of Starling's lending book, the bounce back loans drove a large amount of the challenger bank's growth. Starling has already claimed £61mn from the support scheme to cover defaults. This has been contentious because the loans were 100 percent guaranteed by taxpayers.

Compounding inequalities: the UK example

As discussed, those who are financially excluded often sit at an intersection of inequalities.

For example, these has been a recent trend of bank branch closures. Almost 50 percent of the UK's bank branches have closed since 2015. Data gathered by cash machine network LINK has found closures of more than 440 bank branches announced in 2022 alone.

Figure 2 maps these bank branch closures against the UK indices of deprivation, which measures deprivation across multiple domains, including income, employment, education, health, crime, housing, and living environment (UK Ministry of Housing, Communities & Local Government 2019). The Index of Multiple Deprivation (IMD) is a composite score of these factors. The map suggests that there may be several areas that see both high IMD scores and a concentration of bank branch closures. This could have implications for already vulnerable population – research has shown that financial deepening and physical access is important in reducing poverty (Rewilak 2017, Mookerjee and Kalipioni 2010).

For instance, the UK Finance Access to Cash Action Group is working to identify cash "cold spots," with an emphasis on examining distances to banking facilities, levels of financial and digital vulnerability, and the proportion of individuals over 65 in each community.

Looking more specifically at the intersection of transportation and financial access, Figure 3 maps bank branch closures on Public Transport Accessibility Levels (PTAL).[35] This demonstrates where there might be compounding inequalities. For the most part, bank branch closures in London seem to correspond with areas of connectivity to public transport. However, in the areas that this is not the case, access to financial services might become costlier in terms of time and money spent in transit to access financial services. We see this particularly in the outskirts of the city. Financial service providers should carefully evaluate other factors – such as mobile phone penetration, age makeup, etc. – in addition to accessibility to mitigate any risk of financial exclusion.

Big tech financial services

Almost every major technology company is making investments and announcements in financial services. These actors are fundamentally different from FinTech start-ups in that they begin with their customer base and build products from there. This contrasts with companies that build and evolve business models around acquisition. So-called "TechFin" companies are introducing standard business lines – such as credit cards, Buy Now, Pay Later services, lending, and payments – but using customer data from other services they already provide. Other technology companies have ventured into financial services as well. For instance, Uber and Lyft have created financial offerings for drivers, with the aim of attracting and retaining more.

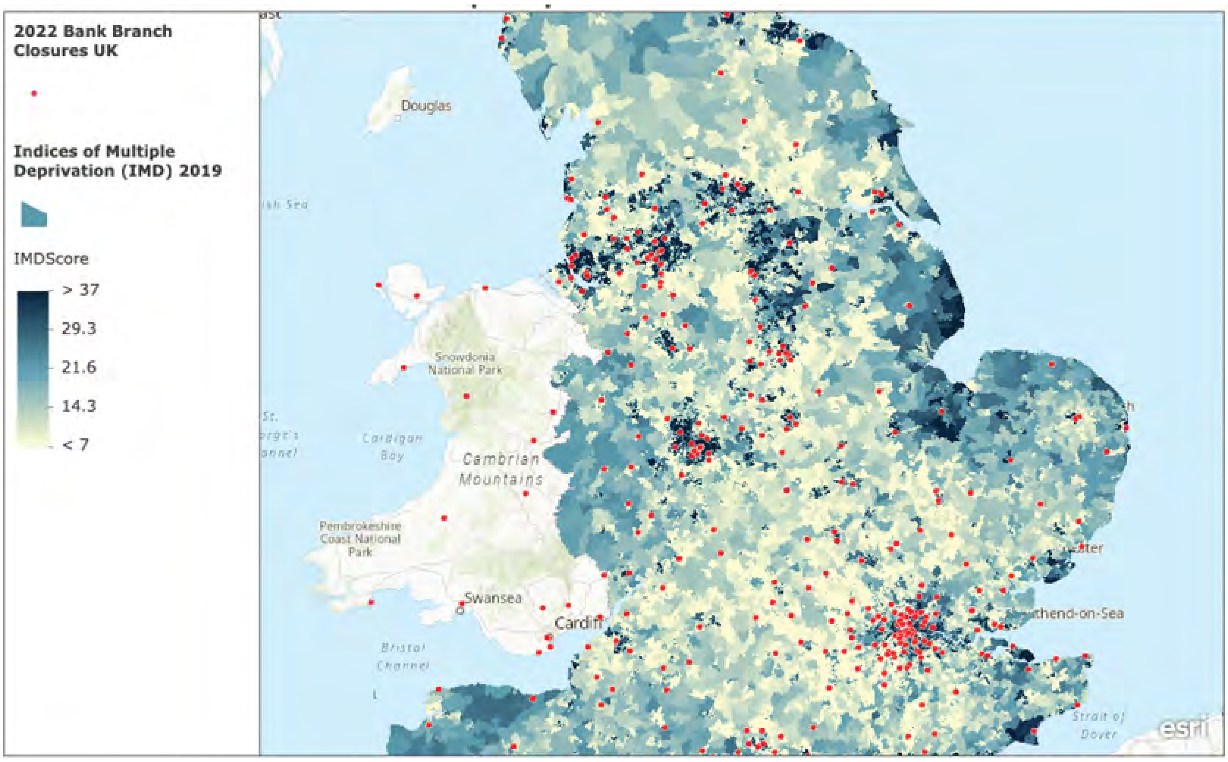

Figure 2: Bank branch closures (2022) mapped on indices of multiple deprivation (2019), United Kingdom *Source: Authors' creation*

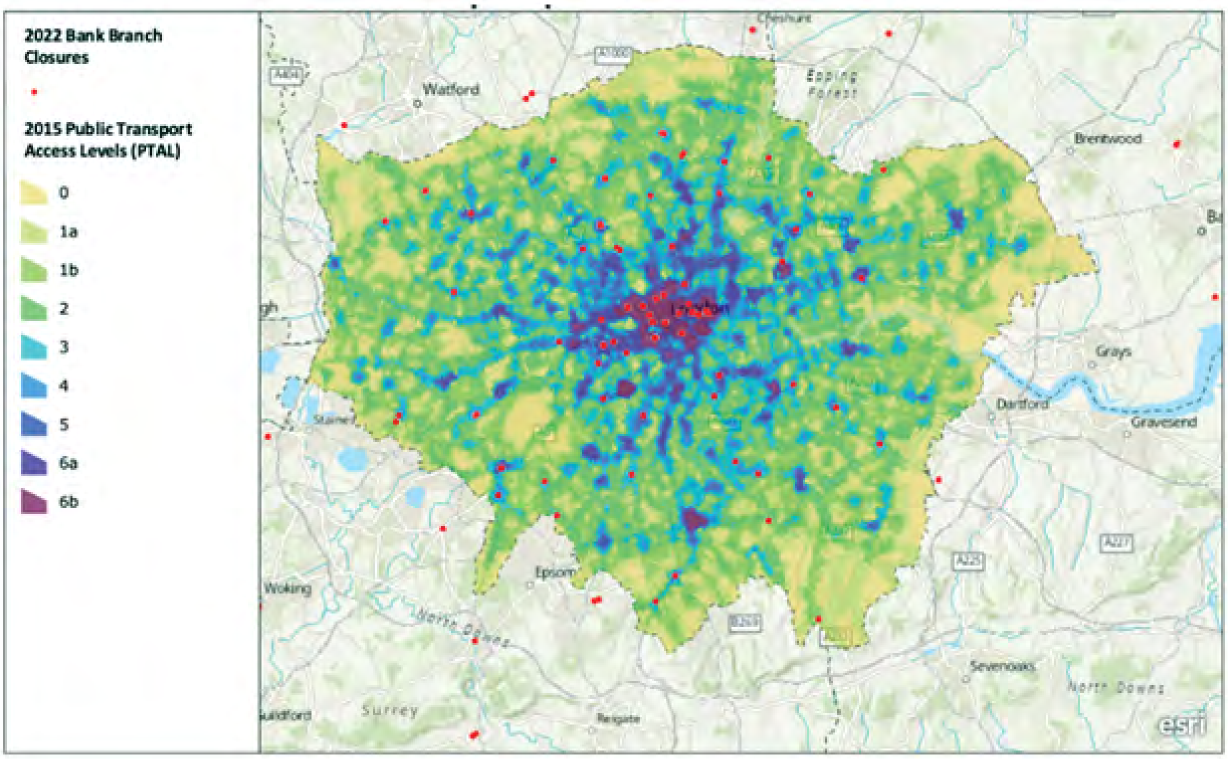

Figure 3: Bank branch closures (2022) mapped on public transport accessibility levels (2015), London *Source: Authors' creation*

Table 4: Mapping big tech financial services

	Credit Card	BNPL	Lending	Payments	P2P Transfers
Alphabet		■	■	■	■
Apple	■	■		■	■
Amazon	■	■	■	■	■
Meta				■	■

Source: Authors' creation based on public announcements

Table 4 shows the publicly announced projects.

The literature highlights several potential benefits from the entry of Big Tech companies into financial services, including reducing transaction costs, improved business and risk management, and financial inclusion – benefits that could apply as much to developing countries as to SMEs (McQuinn et al. 2016, Buckley 2015, Sheng 2021, Rewilak 2017). Zetzche et al. (2018) identified three phases of development for "TechFin": (1) Data Broker, (2) Vertical Integration, and (3) Horizontal Diversification — wherein companies move from low complexity to high complexity, with new business models.

At the same time, the entry of this type of player raises new challenges and concerns. These include systemic risk issues, the potential for data misuse, and the potential for unintended consequences, given the unprecedented integration of data. Big Tech financial services has been an area that governments have paid close attention to, with a particular eye towards competition effects, financial stability, and sovereignty issues. Unlike both traditional financial services and FinTech startups, this is an area where governments have moved quickly to address concerns. For example, governments quickly mobilised to regulate stablecoins following Facebook's announcement of the Libra project (Taskinsoy 2019).

Big Tech's entry represents the extended integration of financial data with data far beyond the scope of financial services. This raises several questions:

- How is the data being integrated across service verticals?
- What are the implications?
- What does this mean for competition policy in both technology and finance markets?

It is important to note that, to-date, a large swathe of Big Tech financial services is enabled by partnerships with established financial sector players. For instance, Apple's credit card is underwritten by Goldman Sachs, while BBVA supports the Uber Money product. In addition to providing the underlying platform, the partner bank may also be providing customer service and regulatory compliance (Arkadan 2022). What the Big Tech company brings is powerful network effects and scale.

Whether companies reach the point of horizontal diversification will depend largely on the regulatory environment – especially considerations around data use and protection, competition, and compliance requirements. For instance, there has been research into using mobile data for assessing creditworthiness. Could this be a part of future regulatory disclosure requirements for Big Tech firms participating in financial services?

Case study: Apple Financial Services

Apple was a pioneer in digital payments. The company announced Apple Pay on September 9, 2014 – seven years after the release of the first iPhone. While uptake was slow at first, it has experienced rapid growth. Though usage data is not publicly available, it is estimated that In September 2016, the product had approximately 67 million users and grew to nearly 507 million users by September 2020. According to one global survey, Apple Pay usage is highest in the United Kingdom (63% of respondents used Apple Pay), followed by the United States (56% of respondents used Apple Pay). Apple is reportedly collecting transaction fees from financial institutions. Generating almost $70 billion in revenue a year, Apply Pay has become an important part of the business model. In fact, Apple's category of "Services" – which includes the Apple Pay product – generated $19.8 billion in net sales in Q1 of 2022. This was preceded in value only by iPhone sales. As discussed in the transport section, digital and contactless payments have enabled rapid growth in other sectors. Since then, Apple has expanded into other areas of financial services. Apple Card, a credit card produced by Apple and issued by Goldman Sachs and supported by Mastercard, launched in 2019. Apple Card has approximately 6.7 million users in the United States. Apple has also announced "buy now, pay later" product.

For now, Apple relies on partners to provide the financial services. However, its intention to move these operations in-house was reported in early 2022. Dubbed "Breakout," the multiyear plan would involve building the infrastructure for payment processing, risk assessment for lending, fraud analysis, credit checks, and other customer services. The company has also been making acquisitions in the space. For example, Apple acquired UK-based Credit Kudos, a company that uses bank data to make lending decisions, in early 2022.

Information about Apple's use of data has been closely guarded. It is unclear how financial information is being used within and across services. Moreover, it is not clear whether this information has been re-packaged for third parties.

Conclusions

This section reflects on insights about the governance and business models for data use in FinTech that emerge from the case studies, within the context of wider scholarship on the nature and measurement of progress through financial services. It points to key questions that remain for policymakers seeking to promote and support data use in ways that further wellbeing, economic growth and sustainability in financial services.

Governance arrangements

Policymakers and regulators are tasked with delineating what counts as financial data – and what unique properties this type of information might have. There is certainly potential from new uses and applications of data, but emergent risks as well.

One issue needing careful consideration is consumer protection. For instance, Wolberg-Stok (2021:24) highlights that: "Consumers generally take for granted that anything that has the ability to plug into their bank is going to be up to standard and will be operating at bank-grade levels of security, privacy, and data stewardship." However, third-party connections raise new questions around the frequency, duration, and breadth of data access. This includes when and how it is stored, if and how it is aggregated, by whom it is harvested, and more. It will be up to policymakers and regulators to decide what the standards are for products, practices, and disclosures.

As financial services turn increasingly digital, it will also be up to governments to ensure that the building blocks for *digital* financial inclusion are in place. This includes infrastructure enablers, such as affordable access to smartphones and internet. It also involves investments in and deliberate efforts around literacy and education. Proactive efforts are critical to not exacerbating existing inequalities or creating new forms of exclusion.

Business models

Questions about business models for the wide array of providers include considerations around competition, data use, monetisation, and more. Emerging business models are taking different approaches – both slicing and aggregating data in new ways.

The questions raised by financial services largely mirror those raised in transport. Do services mirror existing forms of exclusion, exacerbate them or even create new ones? Do they reach the more marginalised and/or lower income users? Is there an argument for direct policy interventions from an economic welfare and equality perspective, given the importance of financial services to achieving other economic and social ends?

There are some questions specific to financial services. For instance, how should the evolution of intangible and systemic components such as privacy and trust be evaluated, if at all? Who is (or should be) the ultimate controller of financial data? What does this mean for business use and how we value financial data? Are the models of the past – including potentially predatory overdraft fees and charges on overseas transactions – ones that should continue into the future? What do the avenues for potential harm look like – and who is ultimately responsible?

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Similarities and differences in transport and financial services

Evolving regulatory models and lowering barriers to entry

Both transport and financial services are highly regulated industries due to their importance in individuals' lives. Digital business models may start with an opportunity created by regulatory arbitrage but regulators respond, reactively or – increasingly – proactively. Policy and regulation approaches focus on evaluating and mitigating risk, while allowing for consumer choice, including recognising a potential trade-off between regulation and competition. This is especially the case in moves towards open data models, which are designed to lower barriers to entry and bring new players into these incumbent-dominated industries. In fact, McKinsey analysis estimates that economic impact of broad adoption of open-data ecosystems could range from about 1 to 1.5 percent of GDP in 2030 in the European Union, the United Kingdom, and the United States.[54]

Valuing data integration

In both transport and financial services, the value of a platform or company's data is potentially expanded when it is integrated with other sources of data. This is especially true of data from another source or activity – for example, food purchases and ride sharing or social media and financial services. However, whether this value is captured and by whom depends on the structure of the businesses and the markets in which they operate. As these business models expand, it is worth investigating what affects the opportunity of different players to use data, and who benefits.

Importance of place

Digital activities are tied to place. The connection in transport is immediately obvious, but it remains important in access to finance. Data-driven services could either mitigate or reinforce existing place-based inequalities, depending on the access, costs and potential added value of services to people in different areas.

Relationship between public and private sector

There are critical connections between services provided by the public sector and the private sector in both domains. However, in the case of transport, public sector involvement is essential in both co-ordinating and providing transport services. Private transport options often face tensions between ensuring profits, covering the costs of providing and maintaining a physical service, and affordability and wide access. The positive network externalities may not be able to be captured by private businesses.

Though there are public good elements of financial services, private providers have been better able to capture value within the financial network, but there is essential publicly-provided infrastructure – including trust in the system thanks to regulation and supervision. There has been tension with regard to products that purport to be substitutes for government financial services like cash provision because of concerns about financial stability, consumer protection and sovereign authority.

Trust

When it comes to sensitive information like mobility and financial data, maintenance of trust in digital-first models in the long run will be critical. Yet policy and regulatory regimes are evolving, as are business models, and the ultimate impact on trust is unclear.

A core trust issue, wholly unresolved, concerns data. First how is data generated and by whom? Unlike official statistics, which have regard to representativeness, the kinds of data discussed in this report are generated for specific functional and often commercial purposes. "Missing data" is one issue we have highlighted throughout, but it should stand perhaps as shorthand for wider participation in the data-generating decision process. And once data exist, who can access what and on what terms; and when, how and for what purposes can data be combined? In the pre-digital world, strong regulations and norms covered these questions, ensuring what is known as "privacy in public," (Coyle 2022). These have not yet evolved in our digital world.

(Re-considering) conditions of progress

1. **Progress is multi-dimensional, and requires intervention to balance gains for individual users, service providers and society.**

When it comes to the central question of this exploration – what difference digital has made to people's life experiences – the picture is mixed. First, there are grounds for concern over distribution and those who are un- or under-served by the emerging digital economy. In the areas of transport and finance, the fact that there are important network externalities and public goods leads to some questions about the distribution of services and benefits.

In financial services, we see a wide range of measurements of progress, each defined by very different areas of interest. For instance, metrics of access to formal financial services may provide an incomplete picture where consumers are not actually using these services and/or are better served by other mechanisms. The public sector underpins private activity and innovation by providing trust in the system via regulation, and some public goods, but (some) private providers can capture much of the network value. Digital technology has also enabled some extractive or predatory practices, exacerbating existing inequalities. The potential of the technology is evident in some ways but there are also missed opportunities to deliver broad-based benefits from digital finance.

The case of London reveals the key role of TfL as a regulator, co-ordinator and service provider in balancing value creation for individuals, the city and businesses. For payments, TfL coordinated with private providers and helped to ensure interoperability, thereby setting up a more accessible payment system. For data, TfL, using Amazon Web Services, has maintained and expanded open data access. With private ride-sourcing platforms, regulation has been important in prioritising individual safety, environmental impacts, driver conditions, and fair competition.

2. **Progress and profits**

Whether within traditional finance, start-ups, or Big Tech, the growth of technology in the financial sector has introduced both new operational models and business models that have yet to scale. Many of the startup models have thus far been supported by venture capital money. As a result, it remains to be seen whether they will be able to foster sustainable growth. Big Tech models, on the other hand, have the advantage of established customer bases and diversified product strategies – but are subject to increasing competition scrutiny.

Have these new data-based services generated sufficient demand to become 'too useful or too integrated to fail'? Free information apps are widely used, even without secure revenue streams. Digital payment systems, once set up, become integral to the operation of the wider transit system, including revenue collection, decision making, user access, making it difficult to move away from their operation. As transport services using data struggle to realise sustainable profits, questions emerge about what will sustain these different applications of data use, meeting their demand and integration. Can they become profitable, while also ensuring equitable access and use, given their strong public good characteristics?

3. **Progress in some areas can generate new forms of exclusion and omission for those who are not represented in data and not able to use digital services**

People who are digitally connected, particularly through multiple applications, may be "too visible." That is, financial information may be connected to other information in a way that is not necessary or intentional. It is unclear whether or how this benefits those customers. This is closely tied to the emerging idea of the "digital footprint" and its role in financial services (Mogaji, Soetan, and Kieu 2020). On the other hand, those who are not digitally connected may be invisible in the data. These individuals may not be counted when it comes to making decisions around financial services. For instance, it is difficult to approximate cash flow volumes relative to digital transactions. This is already a feature of financial provision – for example, the 'thin file' problem is when people cannot access credit because no data is available about them on which a scoring / lending decision can be made. Models have been built using data sources such as social media as an alternative to credit bureau data. While not deployed, initiatives like this offer a more valuable model of financial inclusion than existing, potentially predatory, services such as crypto or Buy Now-Pay Later schemes.

Areas of omission are built into transport data and its use. Data is generated from people's realised behaviours and activities; therefore, it reflects existing physical and service investment, and the resulting existing patterns of travel. These existing behaviours have associated forms of social privilege and values (Kitchin 2013). Therefore, the data itself, and decisions made using this data, are not neutral. They make visible information on people who are able to use transport services, and make invisible those who cannot. Depending on the importance given to social welfare and equality in measuring progress, this question of who is not represented in data, and what data we *don't* have, is critical. It suggests the need for some caution in using transport data to inform decision making, even as it is more granular and extensive, and greater attention to looking for and seeking to evidence behaviours, preferences and individuals who are less easily seen in the data.

4. Spatial distribution and place remain important when considering value creation through data use

Even if the future of transport might be assumed to be increasingly digitalised, transport services are by nature concerned with place. Where someone lives, and features of their physical existence, even affect people's experiences of and ability to use new data-based services (Durand et al. 2022). Data use can mitigate some inequalities, e.g., through better information on transport services. However, it can also reinforce inequalities, depending on the distribution of value creation and if services are developed in relation to realised behaviours as opposed to missed opportunities. Similarly, in finance, as physical bank branches are closed and as data use links location to other personal data, the importance of place and mobility will be amplified. A key area of study, then, is how the application of data use in different sectors will, affects spatial inequalities; will digital, ironically, reinforce place-based inequalities rather than alleviating them?

5. Greater coordination is needed in policymaking

FinTech touches on a wide range of policy and regulatory considerations. These include, but are not limited to prudential policy, monetary policy, competition law and policy, technical standardisation, and data guardrails (Vezzoso, 2018). Consequently, coordination (at a minimum) is needed, though a holistic strategy for a country may be preferred.

Data-use in transport also remains concerned with longstanding challengers in transportation around the tragedy of the commons, as individual and businesses act within a finite place and infrastructure. Coordination of competing data-driven providers has been found to improve the efficiency of the transport system (Ratti 2022), and is important to recognising and balancing interrelated individual and aggregate outcomes.

Conclusions

This exploration of whether digital technology is improving daily life in two essential areas for quality of life and economic opportunity – transport and finance – has highlighted several unknowns or unanswered questions.

A key area needing more focus is measuring the value created through data-use and its distributional effects. Who can access and use the vast amounts of data being collected, and who benefits from the resulting services? While there has been some attention to measuring the aggregate value created through data use in transport across individuals, businesses and governments, such top-down measures do not account for trade-offs and interdependencies between aggregate and individual outcomes. Little attention has been paid to missed opportunities and forms of exclusion in measures of progress – to those who are digitally less visible. Is the technology in some cases affording predatory innovation and if so how might this be addressed? Yet these insights are crucial for informing decision making about how to ensure progress is widely shared, and to address overlapping inequalities.

A second challenge is the need to think in terms of network models, and the resulting wedge between private and social value. How are external benefits from network effects captured and distributed? Some of the network externalities are positive, and may or may not be captured by private providers – transport and finance differ in this respect. Crystallising them, and ensuring all parties benefit to some extent, points to a key co-ordinating role for public bodies. Digital markets, left to themselves, are less likely than non-digital ones to deliver socially desirable outcomes because they have such strong public good characteristics. Other network externalities are negative, and more demanding of public oversight. For example, many FinTech projects are connected to large commercial banks and/or infrastructure service providers. This creates a new manifestation of systemic risk. The new interconnections within and outside of the industry remain under-studied. To understand the full range of systemic and consumer protection risks – and the ways they are related to data capture and use – crafting a network model for a specific country and/or FinTech vertical may prove useful. Similar models have been employed in international relations to outline hierarchies, dependencies, and power dynamics (Oatley et al., 2013; Farrell and Newman, 2019). Conducting such an analysis for FinTech could help to identify significant players, whether on the financial side or the technology side. This could also contribute to understanding where FinTech may be reaching a "too integrated to fail" situation.

Finally, geographic considerations are important when looking to understand the distributional effects of digital services. The technology clearly offers the potential to reduce place-based inequalities but may in fact be reinforcing them. Localised research is important to better understand the needs of a community and ensure that those who may not be captured – or who are under-indexed – in emerging data models, are represented in decision-making around the future of transport and financial services.

In sum, is digital innovation driving progress? As with all important technologies there are pluses and minuses. In these two areas that underpin the convenience and affordability (or otherwise) of people's lives and opportunities, there are some evident benefits from innovations – such as time saving in travel or improved user experience and convenience in finance – but also some important doubts about whether the benefits are appropriately widely shared. Against a background of the cost of living crisis and a decade of rumbling doubts about how well the market model is functioning, there is also reason to believe digital and the use of data are exacerbating some inequalities. This is a failure when the technology holds so much potential to do the opposite.

There are some early-stage examples of fintech companies aiming to allow individuals to control & monetise financial data (such as Unbanx[55]). The Data for Good Foundation has a technical solution and governance model for user-centric financial data sharing consistent with GDPR requirements. Similarly, there is some evidence (although contested) in transport that ride-hailing apps provide a pathway to earnings for some drivers and will go to areas that incumbent taxi firms would not.

However, inspiring examples do not address the underlying unease about the network, be it transport or finance, as a whole. This systemic impact is the principal unanswered question about digital innovation and progress. It concerns the fundamental relationship between private and public aims and incentives, a constant question in market economies, and one that has re-emerged in the digital world. Progress requires a balance between individual and community interests, and we have not found it yet in the fundamental domains of life explored in this report.

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Endnotes

1 https://apnorc.org/projects/bipartisan-dissatisfaction-with-the-direction-of-the-country-and-the-economy/

2 https://www.ipsos.com/en-uk/half-public-think-britain-heading-wrong-direction

3 This Coordinated Adaptive Traffic System operates in at least 37,000 intersections across 27 countries.

4 For more on Mobility as a Service and its potential impact on passenger transport see: (International Transport Forum 2021)

5 There is some variation in studies about the degree to which social exclusion is linked to transport disadvantage (Lucas 2019)

6 For example, it is estimated that the cost of avoidable congestion in Australian cities was $12.8 billion in 2015. This is expected to continue to rise, alongside city expansion (p. 4)

7 In this section, data governance is considered in line with Micheli et al (2020) as: "as the power relations between all the actors affected by, or having an effect on, the way data is accessed, controlled, shared and used, the various socio-technical arrangements set in place to generate value from data, and how such value is redistributed between actors" (Micheli et al. 2020).

8 Also, outside of transport, different governance models for data sharing have been put forward, including data sharing pools, data cooperatives, data trusts and personal data sovereignty models. These have different approaches to responsibility and valuing the data (Micheli et al. 2020)

9 For example, the UK Department for Transport actively pushed for transport providers to open access to data alongside contract renewals.

10 For a discussion of resistance to open data linked to this see discussion of the Ordnance Survey in the UK in (Coyle and Diepeveen 2021).

11 The City of Portland's public transport operator and Google collaborated in developing the General Transit Feed Specification (Pettit et al. 2022).

12 See https://www.statista.com/topics/4826/uber-technologies/#dossierKeyfigures accessed 24 September 2022

13 This contrasts with some studies of traditional bus services that have been found to have minor, often negative, impacts on property values and rent (Acton, Le, and Miller 2022).

14 Companies also lobbied for their drivers to be exempt, with Uber and Lyft estimated to have spent $200 million (Scheiber 2021).

15 The code was identified as being used in Boston, Paris and Las Vegas, as well as Australia, China and South Korea.

16 There are also more examples. Another is known as the 'kill switch', where Uber deactivated computers during office raids (Anon 2022a)

17 See https://www.statista.com/topics/4826/uber-technologies/#dossierKeyfigures accessed 24 September 2022

18 See https://www.statista.com/topics/4826/uber-technologies/#dossierKeyfigures accessed 24 September 2022

19 This includes bus, the London Underground, DLR, Overground, TfL Rail, London trams, London River Services, London Dial-a-Ride, Victoria Coach Station, Santander cycles, and Emirates air line

20 https://tfl.gov.uk/info-for/media/press-releases/2017/july/one-billion-journeys-made-by-contactless-payment-on-london-s-transport-network

21 TfL was part of a wider move in the UK public sector to open access to public data, spearheaded by Transport Direct at a national level (Coyle and Diepeveen 2021).

22 See crowdsourcing campaign website: https://www.crowdcube.com/companies/citymapper/pitches/bvLyxl accessed 28 September 2022.

23 In the US, within the two years following Uber's launch (2009-2011), there were at least 638 ride-hailing companies in North America (Kondor et al. 2022b).

24 At the time, there were approximately 88,000 minicab drivers in London, with estimates this would increase by 40,000 in the next two years. By 2016, the Office of the Mayor estimated there were 110,000 Private Hire drivers and over 80,000 Private Hire Vehicles operating in London (Mayor of London, Transport for London 2016).

25 There was pressure from the London Assembly around introducing the possibility for the mayor to cap private hire licenses (Greater London Authority 2017c; London Assembly 2017) and by the mayor about cross-boundary private hires (Greater London Authority 2017c).

26 For example, in March 2017, the High Court passed a Judgement that upheld the Mayor's plans to heighten standards for private hire, adding driver language and licensing requirements (Greater London Authority 2017d).

27 Non-fare related revenue sources include landholding and housing, commercial estate and advertising estate.

28 Denmark is a good example of providing all four: NemID / MitID Home - MitID (identity - single credential to log on securely to all public & private sector services), MobilePay Betal nemt med mobilen - få MobilePay privat eller til din virksomhed - MobilePay.dk (payments - send / receive money to / from any person / organization instantly using mobile numbers linked to bank accounts)

29 https://www.consumerfinance.gov/about-us/newsroom/cfpb-outlines-principles-consumer-authorized-financial-data-sharing-and-aggregation/

30 https://www.financialdataexchange.org/FDX/FDX/About/About-FDX.aspx

31 https://content.11fs.com/reports/banking-as-a-service

32 https://www.cnbc.com/2021/04/07/plaid-hits-13point4-billion-valuation-in-the-wake-of-scrapped-visa-deal.html

33 https://techcrunch.com/2021/09/20/truelayer-nabs-130m-at-a-1b-valuation-as-open-banking-rises-as-a-viable-option-to-card-networks/

34 Okeke, 2019 notes that this leads to an unclear boundary with certain services such as Tesco Bank and Sainsbury's Banks though they are mobile first and do not have physical branches.

35 The most recent release of the PTAL was in 2015.

36 https://www.gpfi.org/sites/gpfi/files/Indicators%20note_formatted.pdf

37 https://www.worldbank.org/en/publication/globalfindex

38 https://www.federalreserve.gov/consumerscommunities/shed.htm; https://www.ons.gov.uk/peoplepopulationandcommunity/wellbeing/bulletins/personalandeconomicwellbeingintheuk/may2021

39 https://unstats.un.org/unsd/nationalaccount/sna.asp

40 https://www.worldbank.org/en/topic/financialinclusion/brief/ficpsurvey

41 https://www.oecd.org/wise/measuring-well-being-and-progress.htm

42 https://worldhappiness.report/ed/2022/

43 https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

44 https://data.imf.org/?sk=E5DCAB7E-A5CA-4892-A6EA-598B5463A34C

45 https://www.worldbank.org/en/programs/business-enabling-environment

46 https://fsolt.org/swiid/

47 https://www.gov.uk/government/statistics/english-indices-of-deprivation-2019

48 https://sdg-tracker.org

49 https://www.cgap.org/blog/banking-becoming-modular-glimpse-future-finance

50 "At its simplest, screen-scraping involves asking bank customers to hand over their user ID and password for their bank's website or app, and then utilizing these credentials to sign on to the bank, impersonating the user."

51 See "Financial Regulation: Complex and Fragmented Structure Could Be Streamlined to Improve Effectiveness," Government Accountability Office, 2016 for a graphical representation of the complex and fragmented US landscape

52 The Data Protection Act, Government of the United Kingdom (May, 23, 2018). https://www.legislation. gov.uk/ukpga/2018/12/contents/enacted .

53 "Open Banking, Preparing for Lift Off," United Kingdom Open Banking Implementation Entity (July 2019). https://www.openbanking.org.uk/wp-content/uploads/open-banking-report-150719.pdf.

54 https://www.mckinsey.com/industries/financial-services/our-insights/financial-data-unbound-the-value-of-open-data-for-individuals-and-institutions

55 https://www.unbanx.me

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