What characterises a sustainable MaaS business model?

STEVEN SARASINI* *RISE Viktoria, Sweden // steven.sarasini@ri.se*
JANA SOCHOR *RISE Viktoria, Sweden, Chalmers Univ. of Tech., Sweden // jana.sochor@ri.se*
jana.sochor@chalmers.se
HANS ARBY *UbiGo Innovation, Sweden // hans.arby@ubigo.me*

Abstract

This paper examines the ways in which business models for MaaS can generate sustainable value, that is, value that extends beyond the traditional 'profit norm' embedded in business models, and belongs to the economic, environmental and social dimensions of sustainability. We draw on the growing literature on sustainable business models to explicate a set of principles and guidelines for generating sustainable value, and address one key function of a business model that is often overlooked in this field – value capture. We then identify different ways in which MaaS business models can generate sustainable value, linked to mobility services, data-based services, environmental technology and material recirculation. We identify potential mechanisms for value capture, and discuss the implications of our findings for practitioners and future research.

KEYWORDS *Mobility services, business models, value capture, sustainable development*

1. Introduction

Generally, business models are increasingly recognised as a vital component of transitions towards sustainability (Bocken et al., 2014; Bocken and Short, 2016; Boons and Lüdeke-Freund, 2013a; Schaltegger et al., 2016, 2012; Stubbs and Cocklin, 2008). For example, several works have noted that new business models may unlock the economic potential of electric vehicle technology and assist in its adoption (e.g. Budde Christensen et al., 2012; Costain et al., 2012; Weiller et al., 2015), but there exists no such work on Mobility as a Service (MaaS), although it can, in principal, revolutionise the way we travel and has a huge potential to improve the sustainability of the transport system. Whilst is not presently clear which business model/s will underpin the development and adoption of Mobility as a Service, it is possible to outline the characteristics of a sustainable MaaS business model. This paper aims to address the following research question:

> "What characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions?

In order to address this question, we must first tackle the sticky problem of understanding how to treat MaaS as a concept that currently lacks a formal and robust definition. MaaS is often described as an alternative to private vehicle ownership that combines different types of mobility services as part of a single, seamless offering made available to users via subscription-based smartphone applications (Beutel et al., 2014; Goldman and Gorham, 2006; Sochor et al., 2015), and is also referred to using the rubrics 'combined' or 'integrated' mobility services. However, the MaaS concept can refer to different types of services, and there are several 'things' that can be integrated within any MaaS initiative. Also, at the current, pre-commercial phase, it makes little sense to attempt to define MaaS as the field is in a state of fluidity, with several innovative concepts being tested. Hence any pre-emptive definition would run the risk of quickly becoming redundant, especially given the current level of hype around the MaaS concept. Instead, it is better to treat MaaS in

topological terms by classifying different elements in terms of what may be integrated in a single service (Table 1).

A business model is commonly referred to as a device for creating, delivering and capturing value (Chesbrough, 2010; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Teece, 2010; Zott et al., 2011; Zott and Amit, 2010). Hence in order to examine what characterises sustainable MaaS business models, it is important to consider: 1) the concept of sustainable value; and 2) the ways in which MaaS, as a topological phenomenon, can be translated into a set of business models that create, deliver and capture sustainable value. These two points underpin the structure of this paper, which consists of four sections, of which this is the first. The next section outlines the methods deployed, focusing on an integrative literature review. Section three presents our main findings, outlining a set of principled arguments regarding sustainable MaaS business models, supported by practical examples. The last section concludes with a set of implications for practitioners and further research.

Level of integration	Characterisation
4	Integration of societal goals
3	Integration of the service offer
2	Integration of booking and payment
1	Integration of information
0	Single, separate services

Table 1: Different levels of integration within MaaS and value generated. Source: Sochor et al. (2017).

2. Methodology

MaaS has been described as a concept that can deliver sustainability gains in terms of reduced congestion and transport emissions and improved accessibility. MaaS is also billed as an innovation opportunity, underpinned by the development of new business models in transport, such that it can deliver economic benefits. Until now, however, little has been done to examine how business model innovations in the MaaS field can generate sustainable value. To address this shortcoming, we performed an integrative literature review, which is defined as "a form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated" (Torraco, 2005, p. 356). Here the topic in question is related to the way in which different MaaS business models can generate sustainable value. Given that this topic is not addressed by any single literature, we elected to focus on existing literatures on business models and the related subfield of sustainable business models, together with the more general literature on mobility services. In perusing these literatures, we sought to identify and synthesise a set of key ideas, concepts and principles that can be used to address our research question (What characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions?). The overall aim was to deliver a fresh and consolidated perspective on how MaaS can generate sustainable value that is useful for MaaS practitioners when designing and further refining MaaS services, and a basis for further research on this topic.

3. Sustainable business models for MaaS

Many practitioners argue that MaaS comprises a user-centric approach, suggesting that creating user value is the main aim. However, MaaS can and should aim higher than this by contributing to the development of a more sustainable transport system. Generally, mobility services such as car sharing are recognised for their sustainability attributes, in terms of better urban management; improvements in energy efficiency and urban air quality; greater use of renewable fuels; reduced congestion and improved accessibility (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015; Rydén and Morin, 2005). The limited evidence available suggests that MaaS can bring about more sustainable forms of travel behaviour (Karlsson et al., 2017; Karlsson et al., 2016; König et al., 2016b; Sochor et al., 2016a, 2016b, 2015a, 2015b, 2015c, 2014; Strömberg et al., 2016). Taken together, these studies indicate that MaaS has the potential to generate sustainable value that benefits more than just individual users.

Considering the ways in which MaaS can generate different types of value brings us squarely to a discussion on business models. What types of value does MaaS generate? For whom? Which actor/s are able to capture and distribute different types of value? And what characterises MaaS business models that generate *sustainable* value? These issues are discussed in the following sections.

3.1. What is a business model?

Generally, a business model is regarded as a device for *creating* and *capturing* value, and for *delivering* that value to customers (Chesbrough, 2010; Johnson et al., 2008; Osterwalder and Pigneur, 2010; Teece, 2010; Zott et al., 2011; Zott and Amit, 2010). The concept of a business model is rather new and is thus not robustly defined. However, one oft-cited definition is provided by Teece, (2010, p.179):

> "A business model describes the design or architecture of the value creation, delivery and capture mechanisms employed. The essence of a business model is that it crystallizes customer needs and ability to pay, defines the manner by which the business enterprise responds to and delivers value to customers, entices customers to pay for value, and converts those payments to profit through the proper design and operation of the various elements of the value chain".

The above definition makes it clear that traditional conceptualisations of business models consider how value is created for and delivered to customers, and how value is captured by firms. Other conceptualisations share this idea. The Osterwalder (2004) 'canvas', for instance, can be used to categorise different business model types, and describes nine constituent 'building blocks'. These include: a value proposition (i.e. a product or service that is offered to *customers*), a *customer* interface, supply chain relationships, a financial model (i.e. a cost and revenue structure that distributes benefits across business model stakeholders), partners, distribution channels and other key resources and processes (Osterwalder, 2004; see also: Bocken et al., 2014; Johnson et al., 2008; Zott et al., 2011b). A broader conceptualisation, which focuses on the "total value creation for all parties involved" (i.e. suppliers, partners and customers) is offered by Zott and Amit (2010, p. 218). The latter characterise business models as 'activity systems', describing content (what is done), structure (how it is done) and governance (who does it).

Both the activity system approach and the Osterwalder ontology can be used to explore the network of contracts and agreements within different MaaS services, in other words how value is created, delivered and captured via value chain collaborations. Uber, for instance, relies on privately-owned assets (vehicles) that are made accessible to users via multi-sided platforms. Uber captures the value generated via provisional

fees on each transaction made via the platform. By contrast, MaaS Global and UbiGo creates value via a set of contractual arrangements with different service providers and by repackaging and bundling these services into a single offer. This value is captured via a subscription-based payment model. Yet neither the Osterwalder ontology nor the activity systems approach consider the ways in which business models generate sustainable value, that is, value for stakeholders other than the end-users of a product or service. In order to examine the way in which MaaS can generate sustainable value, we turn to the field of sustainable business models.

3.2. What is a sustainable business model?

The development of new business models is increasingly linked to sustainability (Bocken et al., 2014; Bocken and Short, 2016; Boons and Lüdeke-Freund, 2013a; Schaltegger et al., 2016, 2012; Stubbs and Cocklin, 2008). As a consequence, a body of literature on sustainable business models[1] (SBMs) has emerged in the past decade. Similar to the work on corporate social responsibility, much work in this field has taken issue with the 'profit normative' orientation of business (Upward and Jones, 2016). The latter is critiqued for measuring firm success in terms of economic performance, serving a narrow set of stakeholders (i.e. shareholders). By contrast, SBMs aim to broaden the definition of value creation by integrating social and environmental performance into the fabric of business. SBMs are thus defined in terms of their ability to internalise the three sustainability dimensions into the core of business:

> "A business model for sustainability helps [in] describing, analyzing, managing, and communicating (i) a company's sustainable value proposition to its customers, and all other stakeholders, (ii) how it creates and delivers this value, (iii) and how it captures economic value while maintaining or regenerating natural, social, and economic capital beyond its organizational boundaries" (Schaltegger et al., 2016, p.4).

And:

> "…a sustainable business model is one which is both sufficiently profitable and that results in a process of comparative absolute or relative reductions in environmental and socioeconomic burdens through the delivery of socially relevant products and services. Sustainability is not an absolute end-point, but rather an improvement process whereby future generations are progressively less prejudiced by contemporary practices" (Wells, 2016, p.3)

These definitions are successful in acknowledging the negative social, economic and environmental externalities of business, and note that SBMs are those which either reduce existing burdens (make things less bad) or have positive impacts (make things good). SBMs can thus be viewed as a subgroup of normative business models, referring to the set of norms that become embedded in business models through a process of institutionalisation (Randles and Laasch, 2016). A narrow view of shareholders, as profit maximisers, is what lies behind the critique of (unsustainable) business models as 'profit normative', as noted above. Here sustainability can be regarded as one set of norms and values among many, such that business models are pitched as capable of resolving a variety of societal issues (Randles and Laasch, 2016).

Related to the topic of sustainability norms embedded within business models, scholars have outlined a set of principles upon which to base SBMs. These include things like: resource efficiency, social relevance, longevity, localisation and engagement, ethical sourcing and work enrichment (Wells, 2016); sustainable supply chain management, the management of production and consumption phases, the equitable distribution

1 Sometimes referred to as 'Sustainability Business Models' (e.g. Wells, 2016), or 'Business Models for Sustainability' (e.g. Abdelkafi and Täuscher, 2016).

of financial costs and revenues among involved stakeholders (Boons and Lüdeke-Freund, 2013); using a triple bottom line metric to assess performance, stakeholder engagement, environmental stewardship, and systems thinking (Stubbs and Cocklin, 2008; see also: Upward and Jones, 2016). This broad set of principles reflects the prescriptive tone taken within the SBM literature, which seeks to radically transform and reform societal structures and institutions in a broader process of transformation (Randles and Laasch, 2016).

One aspect that is overlooked in some studies from this field is that a business model is a mechanism for creating and capturing value. SBM scholars that do acknowledge the importance of value argue for a broad definition of it, as reflected in the following statement:

> "…a business that contributes to sustainable development needs to create value to the whole range of stakeholders and the natural environment, beyond customers and shareholders" (Schaltegger et al., 2016, p.4).

Whilst the creation of social and environmental value is undoubtedly desirable from a sustainability perspective, the question of how firms can capture these types of value is largely left unanswered by the SBM literature. Traditionally, business models allow firms to *directly* capture value via sales of products or services, whose utility fulfils a customer need or want. Value capture is conducted through the market, where business models serve to assign prices to goods (products or services). Capturing value becomes much more complex when a market does not exist, rendering such goods uncommodifiable. This is arguably the case for many goods with social and environmental value, hence the economic terms 'market failure' and 'externality'. Even in cases where public sector organisations create mechanisms to internalise externalities, such as subsidies for public transport, one can argue that a market exists. Hence public transport, which typically captures the social and environmental value inherent in its offering[2] via ticket sales and subsidies, can be seen to have a financially viable business model. Where markets do not exist (e.g. creating social value for future generations) due to a lack of paying customers, designing financially viable SBMs becomes much more challenging.

The main challenge in capturing sustainable value is related to the concept of merit goods. A merit good is defined in terms of the private and public benefits inherent in its consumption, where the latter outweighs the former (Musgrave, 1957). In other words, the consumption of a merit good generates positive externalities (or less bad negative externalities) that are greater than private benefits perceived the individual consuming the good. An example may be the treatment of a contagious (yet not life-threatening) disease via medication, where the benefits of vaccination may be of greater benefit to the public than to the individual that is inoculated. The fact that the public benefit is greater than the private means that individuals under-consume merit goods in a free market, warranting state (or other third party) intervention. The importance of merit goods has been noted in studies on business models for shared mobility (Cohen and Kietzmann, 2014). Further, the public good aspect of public transport is what in many cases warrants support from the state coffers.

This reasoning can be used to understand the inability of firms in capturing sustainable value, due to the fact that the public benefits often outweigh those which are private. Hence we posit that *for a MaaS business model to be sustainable, one cannot ignore the function of value capture*. It is unlikely that any organisation (public or private) will aim to generate sustainable value if they cannot appropriate revenues directly or

2 Public transport generates both social and environmental value, i.e. value for the collective, in terms of reduced emissions and congestion that would probably arise if it did not exist and travellers instead utilised private modes such as cars.

benefit via some other form of indirect returns (e.g. competitive advantage, market position, brands). How can firms capture such value?

There is evidence to show that environmental value can be captured *indirectly*. In a review of the literature on corporate environmentalism, Abdelkafi et al. (2013) argue that SBMs with environmental value propositions allow firms to enhance their brands; boost their image and reputation; attract and retain talented workers; improve resource efficiency; support higher sales volumes; reduce investment risks; attract financial capital; build trusting relationships with stakeholders; attract new customers; and promote customer loyalty. However, firms can experience difficulties in capturing environmental value, as in some cases environmentally-oriented firms demonstrate lower economic performance in comparison to firms that are not environmentally oriented (Linder et al., 2014).

There are some cases where environmental value can be captured *directly* as a result of paying customers that are willing to express their environmental concerns with their wallets, such as the growing market for premium electric vehicles (e.g. Tesla, Prius). However, the consumption of such goods is often also linked to individuals' willingness to pay for products that confer a certain status or identity (e.g. the wealthy, environmentally conscious consumer). Firms can also capture the value of environmental value propositions directly by minimising waste (i.e. becoming more resource efficient), allowing for cost savings (Porter and van der Linde, 1995). Regardless of whether the value of an environmental value proposition is captured directly or indirectly, the ability to capture value is arguably dependent on the salience of environmental issues in the external business environment.

3.3. How can MaaS business models create, deliver and capture sustainable value?

In order to examine the potential for MaaS business models to generate sustainable outcomes, it is important to consider different types of MaaS services, the value they may generate, and ways in which that value may be captured. To reiterate, *for a MaaS business model to be sustainable, one cannot ignore the function of value capture*. Hence we now investigate ways in which MaaS business models can create, deliver and capture sustainable value.

Customer segments

Although MaaS currently lacks a robust definition, existing attempts to characterise the concept highlight some of its potential sustainability attributes. As noted in the introduction, Sochor et al. (2017) characterise MaaS in 'topological' terms, i.e. with reference to mobility-related services that exist at different levels of integration. Seen this way, MaaS comprises a set of different mobility-related services that can potentially generate different types of value, for private individuals and for broader publics. For example, there is evidence to suggest that a level 3 MaaS service, entailing the integration of different mobility services into a single offer: 1) is attractive to customers in terms of flexibility, convenience and cost; 2) may be a viable alternative to private car ownership; and 3) may encourage a shift towards more sustainable modes of travel such as public transport, walking and cycling (Karlsson et al., 2016; Sochor et al., 2016b, 2015b). Hence the value created by such services is delivered to:

1. Customers, who gain access to an attractive, cost effective and convenient mobility service;
2. The environment, via lower transport emissions);
3. Society, which benefits from lower congestion and improved accessibility.

Each type of value listed above can be captured by a level 3 MaaS operator via sales of the service to users. Note that the value captured by operators is redistributed to partners in the value chain. Partners must be alerted to the opportunities of collaborating in a MaaS ecosystem to overcome the tendency towards protectionism and risk aversion. That is, MaaS operators, acting as the focal organisations which capture the value generated by MaaS business models, must create an offer which allows partners (e.g. upstream transport service providers such as public transport operators and taxi firms) to *expand* their existing customer base. Further, MaaS operators must ensure that the value captured is distributed within the ecosystem in a manner that is just and legitimate among partners. Without this, transport service providers are unlikely to enter into partnerships as they will foresee risks of other actors cannibalising their offers, which is arguably the main reason public transport operators are currently unwilling to allow MaaS operators to resell the full range of available tickets. The upshot is that the viability of level 3 MaaS business models depends on their ability to attract customers from new market segments, namely those beyond their partners' existing customer base. In practice, this refers to segments where customers either walk, cycle, or drive (or ride in) a privately-owned vehicle. For level 3 MaaS business models to be sustainable, however, they must also ensure shifts to more sustainable modes. The sum consequence is that *the viability and sustainability of level 3 MaaS business models hinges entirely on their possibility to attract customers from the private car segment*. Without this, the provision of low cost, convenient access to combined mobility services may result in shifts to modes which are less environmentally sustainable (e.g. travellers from the public transport segment may increasingly travel by car).

Similar arguments can be made for level 0 MaaS services such as station-based and free-floating car sharing initiatives. If the provision of these services does not attract users from the private car segment, then these services will likely not result in environmental sustainability improvements. However, car sharing can improve accessibility, which belongs to the social sustainability dimension. That is, users can gain access to a flexible alternative to taxis/public transport that grants better accessibility in towns and cities. Hence car sharing represents a potential trade-off between environmental sustainability and accessibility (note that this also applies to car sharing in level 3 MaaS). The trade-off between environmental sustainability and accessibility further accentuates the need for MaaS service providers to target existing and potential private car owners. Without this, the consumption of MaaS services will not result in the reduction of environmental burdens, and level 3 MaaS business models will not be feasible in the eyes of value chain actors. In other words, without targeting private car owners, the consumption of MaaS services will not generate sustainable value.

Travel behaviour

As noted above, while some scholars have noted that car sharing may facilitate shifts to more environmentally sustainable transport modes (e.g. Firnkorn and Müller, 2011), others have voiced concerns that modal competition may result in a shift in the opposite direction (e.g. from public transport to car sharing) (Stillwater et al., 2009). In reality, MaaS will likely facilitate modal shifts in both directions, that is, some users will shift from less-to-more environmentally sustainable modes, and others will move in the opposite direction to fulfil their accessibility needs. Hence in addition to attracting users that are currently within the private car segment, it is important that MaaS operators encourage sustainable travel behaviour by creating incentives for the utilisation of more environmentally sustainable modes and for ride sharing. In practice MaaS operators must find innovative ways to improve accessibility and promote environmentally sustainable travel behaviour, particularly in geographical contexts where public transport is sparser (e.g. rural areas). The simplest way

to create incentives is through pricing, such that more sustainable modes and ride sharing are made cheaper than less sustainable alternatives. In terms of environmental sustainability, the least pollutive mode within a level 3 MaaS service is walking, followed by cycling, public transport, car sharing and finally taxi. Pricing these modes in terms of their environmental impacts is not necessarily a challenge, as more pollutive modes are generally more expensive.

It may appear to be difficult for MaaS operators to capture the value of modes such as walking and private cycling, since they are not commodified within the business model (i.e. users do not pay to walk or use their own bicycles). However, it may be possible to increase savings if users elect to walk or cycle rather than utilise a mode that would entail a cost to MaaS operators (public transport, taxi, etc.). Similar arguments could be made for ride sharing and non-travel options such as virtual meetings. In practice, the opportunities to capture this type of value relate to the composition of payment models. Pay-as-you-go models disallow value capture, as users will only pay for their actual use, creating no incentives for MaaS operators to minimise costs. This is not the case for subscription packages, assuming users pay a lump sum for a predetermined travel allowance, and if rebates or deferrals are not provided for unused credits. In such circumstances, MaaS operators would be able to capture the value of walking and cycling in the form of cost savings. However, this type of payment model may have rebound effects if users rush to use up their credits prior to the start of a new subscription period (likely a new month). Notwithstanding, it does appear to be possible for level 3 MaaS operators to capture the value inherent in incentivising sustainable modal shifts. Aside from (or alongside) pricing, MaaS operators can create other types of incentives, through mechanisms such as nudging and gameification, that encourage sustainable travel behaviour. These types of mechanisms can be directly integrated into MaaS software applications, and value can be captured in the same manner described above.

Data-based services

One way in which to better understand modal choice in MaaS-based transport systems is to leverage the power of big data analytics. Willing et al. (2017) review the literature on multimodal platforms (MMPs), which refer to a range of information services that allow travellers: to compare different transport options; to make informed selections according to preferences (usually trip duration and cost); and to plan and re-plan trips *en route* (see also: Motta et al., 2015). Some MMPs also facilitate bookings and payments (cf. levels 1 and 2 in the Sochor et al. (2017) topology). Most MMPs provide informational services for free, and collect user data which is typically anonymised and aggregated before being put to use.

Aside from individual travellers, data analytics can be used to create value for different stakeholders in the MaaS ecosystem, including transport service providers and government or regulatory bodies. Transport service providers, for instance, can gain real-time data on customer demand, which can help to deal with tasks such as the relocation of shared cars in free-floating systems; to optimise service coverage according to geographical and temporal variations in demand; and to understand *revealed* user preferences regarding modal choices as a means to improve the service offer (Willing et al., 2017). This type of data is also of interest to governmental bodies such as city planners and municipalities, who are charged with the responsibility of minimising congestion and governing infrastructures such as roads and parking (Motta et al., 2015; Willing et al., 2017). Arguably, the value of big data analytics has network effects – as more data is generated the value becomes greater in terms of private and public benefits. Hence as (or if) MaaS services proliferate, the sustainable value that data analytics generates will increase. The value of data analytics is likely created by MaaS integrators, a role in the ecosystem which refers to ICT platform providers (i.e. actors that provide

access to and operate multimodal platforms) (Smith et al., 2017). The value can be captured, in principal at least, via sales or agreements with stakeholders such as transport service providers, MaaS operators, city planners, municipalities, and transport authorities. Integrators may also capture value via advertising revenues in a similar way as actors such as Google generate revenue streams, or via provisional fees for individual transactions (e.g. ticket sales).

Resource efficiency

Changes in travel behaviour in the form of modal shifts and ride sharing can reduce the environmental impacts of the transport system. These types of actions improve the resource efficiency of the transport system by reducing the number of material inputs (e.g. vehicles, road infrastructure) required to fulfil user needs. The resource efficiency of the transport system also depends on the technologies deployed within vehicles and is critical to the decarbonisation of the transport system. This can be realised by introducing environment friendly technologies such as electric vehicles into MaaS fleets. Autonomous vehicles may also have a role to play in reducing transport emissions (Greenblatt and Saxena, 2015; Greenblatt and Shaheen, 2015). Can MaaS business models generate sustainable value via the deployment of environment friendly vehicle technologies?

Generally, it is widely understood that there is a link between business models and technology. Although the two are distinctly separate concepts (Baden-Fuller and Mangematin, 2013), business models are mediating devices that capture the value of technology and deliver it to customers (e.g. Chesbrough, 2010; Chesbrough and Rosenbloom, 2002). That is, without a functioning business model, new technologies are merely inventions in need of commercialisation. A new technology is seen as useless without a complementary business model: “the inherent value of a technology is latent until it is commercialized” (Björkdahl, 2009, p. 1470). The often cited case to highlight this point is that of Xerox Corporation, whereby a new, technologically superior photocopier was developed but could not be commercialised without a radically new business model (Chesbrough and Rosenbloom, 2002). In line with this thinking, several scholars have noted that new business models can unlock the potential of electric vehicle technology and assist in its adoption (e.g. Weiller et al., 2015; Budde Christensen et al., 2012; Costain et al., 2012).

It may be possible for MaaS business models to capture the sustainable value inherent in technologies such as electric and autonomous vehicles, resulting in a more environmentally friendly, sustainable transport system. If vehicles (particularly cars) are utilised more frequently as a result of being utilised within a MaaS service, then their operational costs take a more accentuated role in determining the types of technologies deployed. In cases where market competition exists between different MaaS operators, fleet owners will be forced to compete on cost. This has two principal implications for the environmental sustainability of the vehicle fleet. The first is in the vehicles’ use phase, where incentives will exist for fleet owners to deploy vehicles with low running costs. If electric vehicles have lower running costs than fossil fuel vehicles, then fleet owners will, in principal at least, be able to capture the sustainable value inherent in electric vehicle technology in the form of cost savings. In practice, the deployment of electric vehicles depends on other factors, such as the costs of installing recharging infrastructure and the range of electric vehicles, which influences their availability. Notwithstanding, the fact that electricity is generally a lower cost fuel than petrol and diesel means that value capture may be possible. Similarly, if it can be shown that autonomous vehicles lower costs for fleet owners, then a viable business case can be put forward. In both cases, value may be captured by both fleet owners and MaaS operators, assuming the two are different actors. In addition, MaaS operators may be able

to capture the value of this type of environmental offering through indirect channels, as described in section 3.2. Further, higher utilisation rates mean that the vehicles in a MaaS system will be renewed more frequently than privately-owned vehicles, allowing for more rapid technological substitution.

In cases where it is not possible to capture value directly via cost savings, it may be possible to collect revenues via public policies that create incentives for the deployment of environmentally friendly vehicle technologies. Given their climatic benefits, several governments have created subsidies and tax exemptions for electric vehicles, for instance, and decarbonisation is increasingly enshrined as a transport policy goal. Hence in the future one may reasonable assume that governments will increasingly support environment friendly vehicle technologies via supportive and/or punitive measures (i.e. those which make the consumption of fossil fuels more expensive, such as carbon taxes).

The second implication is that cost competition between MaaS operators may result in attempts to find cost savings further upstream in the value chain. One way to achieve these types of cost savings is to prolong product (i.e. vehicle) lifespans by recirculating physical materials, akin to the principles of a circular economy. This is especially pertinent given that vehicles in a MaaS system will be utilised more than privately-owned vehicles, and thus wear out more rapidly. In a circular economy, material can be recirculated via different cycles, such as reuse, remanufacturing and recycling. Remanufacturing, for example, has been shown to simultaneously generate environmental benefits and cost savings by minimising waste in manufacturing processes (e.g. Amaya et al., 2010; Guide, 1997; Ijomah, 2009; Lindahl et al., 2006; Smith and Keoleian, 2008). The main reason that MaaS creates incentives for material recirculation is because of the development of product-service business models (i.e. those which give access to products as services), which have been cited as an key enabler of a transition to a circular economy (Linder and Williander, 2015; Tukker, 2015). Similar to the deployment of environment friendly technologies, the value of material recirculation can be captured through cost savings. However, the question of which actor captures this type of value is unclear, as new value chains are required to facilitate material recirculation (Ferguson, 2010). Hence gains in resource efficiency in the form of environmental technology and material recirculation are future-oriented business model activities that require new forms of cross-industry collaboration (Sarasini et al., 2016).

4. Discussion

This paper sought to examine the issue of what characterises MaaS business models that deliver improvements in the economic, environmental and social sustainability dimensions. To address this question, we examined the concept of a business model, noting that it is broadly understood to be a mechanism for creating, delivering and capturing value. The concept of a sustainable business model extends the definition of value to encompass benefits in each of the economic, environmental and sustainability dimensions. Based on this understanding, we then sought to identify ways in which MaaS business models can create and capture sustainable value, noting that value capture is a fundamental element of business modelling that is often overlooked in the SBM literature. We identified three types of sustainable value that MaaS business models can generate, and outlined potential mechanisms for capturing this value. Our findings are summarised in Table 2.

Classification	Private value	Public value	Potential mechanisms for value capture
Mobility services	Affordability, flexibility and convenience	Reduced congestion and emissions following sustainable modal shifts Improved accessibility	Bundled mobility services, available to individual customers
Data-based services	Trip planning, booking and payment Mobility service optimisation Travel time savings and lower mobility costs	Real-time traffic management Urban planning	Sales of data analytics to MaaS operators, transport service providers and public sector organisations Provisional/brokerage fees for individual transactions Advertising
Resource efficiency I: Environment friendly vehicle technologies	Lower mobility costs	Reduced congestion and emissions in vehicles' use phase	Cost savings due to lower operational costs
Resource efficiency II: Material recirculation	Lower mobility costs	Reduced environmental impacts in vehicles' production phase	Cost savings due to lower cost of vehicle production

Table 2: Potential ways in which MaaS business models can create and capture sustainable value.

4.1. Implications for MaaS practitioners

Our findings have some practical implications. One major implication is that for MaaS business models to be truly sustainable, MaaS operators must consider the different elements of sustainable value when designing new business models and when refining existing ones. In many instances, generating sustainable value is linked to details within the business model, such as targeted customer segments, the pricing of different transport modes, and the way in which different payment models influence travel behaviour. A more nuanced understanding of these factors and the way in which they influence sustainable outcomes is needed as a basis for MaaS business modelling. Also, our findings sought to outline a set of future oriented opportunities for sustainable value generation via resource efficiency gains. Realising these potentials in practice means that practitioners from different sectors must establish new forms of collaboration to facilitate the deployment of environment friendly vehicle technologies and material recirculation. These are intended more as medium- to long-term aims rather than immediate objectives. In the short term, practitioners should focus on developing business models that generate sustainable value by 1) identifying the different ways in which MaaS business models can create different types of sustainable value; 2) finding ways to capture that value, either directly in the form of revenues or indirectly in the form of other types of economic benefit; and 3) understanding potential trade-offs between, for instance, environmental sustainability and accessibility. We contend that a more nuanced understanding of how business models can generate sustainable value will not only benefit the sustainability of the transport system – it will also allow practitioners to act as advocates of MaaS in broader settings, creating legitimacy for the concept and serving to create a set of enabling conditions to allow it to flourish.

4.2. Implications for future research

The three types of sustainable value outlined in this paper are linked to the mobility and data service elements of MaaS business models, and the resource efficiency of the transport system. This is not an exhaustive list, but an initial set that may be expanded on in future studies. Further, we focused on the ways in which MaaS business models can create and capture sustainable value, obscuring other elements of business models that may potentially influence sustainability outcomes. One such function of a business model is its scalability, which can be defined as the capacity or potential for a particular business model to expand effectively and efficiently by reaching larger numbers of customers and new markets (Jolly et al., 2012). Scalability is central to the 'innovativeness' of MaaS business models, and may thus fall under the economic sustainability dimension. Examining scalability as a potential enabler of sustainable value delivery is an interesting way of building on this study, and may be used to compare different types of MaaS business models, according to the roles taken by private and public actors in the business ecosystem (e.g. König et al., 2016a). Finally, while the literature provides some useful guidance in terms of principles that should be embedded in sustainable business models, a more nuanced set of tailored guidelines is needed for developing and assessing the sustainability of MaaS.

5. References

Abdelkafi, N., Makhotin, S., Posselt, T., 2013. Business Model Innovations for Electric Mobility — What Can Be Learned From Existing Business Model Patterns? Int. J. Innov. Manag. 17, 1–41. doi:10.1142/S1363919613400033

Abdelkafi, N., Täuscher, K., 2016. Business Models for Sustainability From a System Dynamics Perspective. Organ. Environ. 29, 74–96. doi:10.1177/1086026615592930

Amaya, J., Zwolinski, P., Brissaud, D., 2010. Environmental benefits of parts remanufacturing: the truck injector case. 17th CIRP Int. Conf. Life Cycle Eng. 159–172.

Baden-Fuller, C., Mangematin, V., 2013. Business models : A challenging agenda. Strateg. Organ. 11, 418–427. doi:10.1177/1476127013510112

Beutel, M.C., Gokay, S., Kluth, W., Krempels, K.-H., Samsel, C., Terwelp, C., 2014. Product oriented integration of heterogeneous mobility services. 2014 17th IEEE Int. Conf. Intell. Transp. Syst. ITSC 2014 1529–1534. doi:10.1109/ITSC.2014.6957650

Björkdahl, J., 2009. Technology cross-fertilization and the business model: The case of integrating ICTs in mechanical engineering products. Res. Policy 38, 1468–1477. doi:10.1016/j.respol.2009.07.006

Bocken, N.M.P., Short, S.W., 2016. Towards a sufficiency-driven business model: Experiences and opportunities. Environ. Innov. Soc. Transitions 18, 41–61. doi:10.1016/j.eist.2015.07.010

Bocken, N.M.P., Short, S.W., Rana, P., Evans, S., 2014. A literature and practice review to develop sustainable business model archetypes. J. Clean. Prod. 65, 42–56. doi:10.1016/j.jclepro.2013.11.039

Boons, F., Lüdeke-Freund, F., 2013a. Business models for sustainable innovation: state-of-the-art and steps towards a research agenda. J. Clean. Prod. 45, 9–19. doi:10.1016/j.jclepro.2012.07.007

Boons, F., Lüdeke-Freund, F., 2013b. Business models for sustainable innovation: State-of-the-art and steps towards a research agenda. J. Clean. Prod. 45, 9–19. doi:10.1016/j.jclepro.2012.07.007

Budde Christensen, T., Wells, P., Cipcigan, L., 2012. Can innovative business models overcome resistance to electric vehicles? Better Place and battery electric cars in Denmark. Energy Policy 48, 498–505. doi:10.1016/j.enpol.2012.05.054

Chesbrough, H., 2010. Business model innovation: Opportunities and barriers. Long Range Plann. 43, 354–363. doi:10.1016/j.lrp.2009.07.010

Chesbrough, H., Rosenbloom, R.S., 2002. The role of the business model in capturing value from innovation: evidence from Xerox Corporation's technology spin-off companies. Ind. Corp. Chang. 11, 529–555. doi:10.1093/icc/11.3.529

Cohen, B., Kietzmann, J., 2014. Ride On! Mobility Business Models for the Sharing Economy. Organ. Environ. 27, 279– 296. doi:10.1177/1086026614546199

Costain, C., Ardron, C., Habib, K.N., 2012. Synopsis of users' behaviour of a carsharing program: A case study in Toronto. Transp. Res. Part A Policy Pract. 46, 421–434. doi:10.1016/j.tra.2011.11.005

Ferguson, M., 2010. Strategic issues in closed-loop supply chains with remanufacturing, in: M. Ferguson, Souza, G. (Eds.), Closed-Loop Supply Chains: New Developments to Improve the Sustainability of Business Practices. CRC Press, Boca Raton, FL, pp. 1–12.

Firnkorn, J., Müller, M., 2011. What will be the environmental effects of new free-floating car-sharing systems? The case of car2go in Ulm. Ecol. Econ. 70, 1519–1528. doi:10.1016/j.ecolecon.2011.03.014

Goldman, T., Gorham, R., 2006. Sustainable urban transport: Four innovative directions. Technol. Soc. 28, 261–273. doi:10.1016/j.techsoc.2005.10.007

Greenblatt, J.B., Saxena, S., 2015. Autonomous taxis could greatly reduce greenhouse-gas emissions of US light-duty vehicles. Nat. Clim. Chang. 5. doi:10.1038/nclimate2685

Greenblatt, J.B., Shaheen, S., 2015. Automated Vehicles, On-Demand Mobility, and Environmental Impacts. Curr. Sustain. Energy Reports 2, 74–81. doi:10.1007/s40518-015-0038-5

Guide, V.D.R., 1997. Scheduling with priority dispatching rules and drum-buffer-rope in a recoverable manufacturing system. Int. J. Prod. Econ. 53, 101–116. doi:10.1016/S0925-5273(97)00097-2

Ijomah, W., 2009. Addressing decision making for remanufacturing operations and design-for-remanufacture. Int. J. Sustain. Eng. 2, 91–202. doi:10.1080/19397030902953080

Johnson, M.W., Christensen, C.C., Kagermann, H., 2008. Reinventing your business model. Harvard Business. Harv. Bus. Rev. 86, 50–59.

Jolly, S., Raven, R., Romijn, H., 2012. Upscaling of business model experiments in off-grid PV solar energy in India. Sustain. Sci. 7, 199–212. doi:10.1007/s11625-012-0163-7

Karlsson, I.C.M., Sochor, J., Strömberg, H., 2016. Developing the "Service" in Mobility as a Service: Experiences from a Field Trial of an Innovative Travel Brokerage. Transp. Res. Procedia 14, 3265–3273. doi:10.1016/j.trpro.2016.05.273

Karlsson, M., Sochor, J., Aapaoja, A., Eckhardt, J., König, D., 2017. Deliverable 4: Impact Assessment. MAASiFiE project funded by CEDR.

König, D., Eckhardt, J., Aapaoja, A., Sochor, J., Karlsson, M., 2016a. Deliverable 3: Business and operator models for MaaS. MAASiFiE project funded by CEDR.

König, D., Sochor, J., Eckhardt, J., Böhm, M., König, D., 2016b. State-of-the- art survey on stakeholders ' expectations for Mobility-as-a-Service (MaaS), in: 23rd ITS World Congress, Melbourne.

Lindahl, M., Sundin, E., Östlin, J., 2006. Environmental issues within the remanufacturing industry. Proc. CIRP Life Cycle Eng. 447–452.

Linder, M., Björkdahl, J., Ljungberg, D., 2014. Environmental Orientation and Economic Performance: a Quasi-experimental Study of Small Swedish Firms. Bus. Strateg. Environ. 23, 333–348. doi:10.1002/bse.1788

Linder, M., Williander, M., 2015. Circular Business Model Innovation: Inherent Uncertainties. Bus. Strateg. Environ. n/a--n/a. doi:10.1002/bse.1906

Motta, G., Sacco, D., Ma, T., You, L., Liu, K., 2015. Personal Mobility Service System in Urban Areas : the IRMA Project. IEEE Symp. Serv. Syst. Eng. 1–10. doi:10.1109/SOSE.2015.15

Musgrave, R.A., 1957. A Multiple Theory of Budget Determination. Finanz. / Public Financ. Anal. doi:10.2307/40909134

Osterwalder, A., 2004. THE BUSINESS MODEL ONTOLOGY A PROPOSITION IN A DESIGN SCIENCE APPROACH. Université de Lausanne.

Osterwalder, A., Pigneur, Y., 2010. Business Model Generation: A handbook for visionaries, game changers and challengers. John Wiley and Sons, Inc., Hoboken, New Jersey.

Porter, M.E., van der Linde, C., 1995. Toward a New Conception of the Environment-Competitiveness Relationship. J. Econ. Perspect. 9, 97–118. doi:10.2307/2138392

Randles, S., Laasch, O., 2016. Theorising the Normative Business Model. Organ. Environ. 29, 53–73. doi:10.1177/1086026615592934

Rydén, C., Morin, E., 2005. Mobility Services for Urban Sustainability: Environmental Assessment Report WP6.

Sarasini, S., Marcus, L., Karlsson, M., Strömberg, H., Friman, M., 2016. Integration as a conduit for sustainable forms of Mobility as a Service, in: 23rd ITS World Congress, Melbourne, Australia, 10–14 October 2016. pp. 1–16.

Schaltegger, S., Freund, F.L., Hansen, E.G., 2012. Business cases for sustainability: the role of business model innovation for corporate sustainability. Int. J. Innov. Sustain. Dev. 6, 95. doi:10.1504/IJISD.2012.046944

Schaltegger, S., Hansen, E.G., Lüdeke-Freund, F., 2016. Business Models for Sustainability: Origins, Present Research, and Future Avenues. Organ. Environ. 29, 3–10. doi:10.1177/1086026615599806

Smith, G., Sochor, J., Karlsson, I.M., 2017. Mobility as a Service: Implications for future mainstream public transport, in: Thredbo15 - International Conference Series on Competition and Ownership in Land Passenger Transport. Stockholm.

Smith, V.M., Keoleian, G.A., 2008. The Value of Remanufactured Engines: Life-Cycle Environmental and Economic Perspectives. J. Ind. Ecol. 8, 193–221. doi:10.1162/1088198041269463

Sochor, J., Eckhardt, J., König, D., Karlsson, I.C.M., 2016a. Future needs and visions for Mobility as a Service : Insights from European workshops, in: 23rd ITS World Congress.

Sochor, J., Karlsson, I.C.M., Strömberg, H., 2016b. Trying Out Mobility as a Service: Experiences from a Field Trial and Implications for Understanding Demand. Transp. Res. Rec. J. Transp. Res. Board 2542, 57–64. doi:10.3141/2542-07

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2015a. Implementing Mobility as a Service: Challenges in Integrating User, Commercial, and Societal Perspectives. Transp. Res. Rec. J. Transp. Res. Board 2536, 1–9. doi:10.3141/2536-01

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2015b. The Added Value of a New, Innovative Travel Service: Insights from the UbiGo Field Operational Test in Gothenburg, Sweden, in: *Internet of Things Infrastructures, IoT 2014, LNICST 151.* pp. 169-175, R. Giaffreda et al. (Eds.), New York: Springer. doi:10.1007/978-3-319-19743-2_26

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2015c. An innovative mobility service to facilitate changes in travel behavior and mode choice, in: 22nd ITS World Congress. Bordeaux, France.

Sochor, J., Strömberg, H., Karlsson, I.C.M., 2014. Travelers' Motives for Adopting a New, Innovative Travel Service: Insights from the Ubigo Field Operational Test in Gothenburg, Sweden, in: 21st World Congress on Intelligent Transportation Systems. Detroit.

Sochor, J., Arby, H., Karlsson, M., 2017. The topology of Mobility as a Service: A tool for understanding effects on business and society, user behavior, and technical requirements, in: 24th World Congress on Intelligent Transportation Systems. Montreal.

Stillwater, T., Mokhtarian, P., Shaheen, S., 2009. Carsharing and the Built Environment. Transp. Res. Rec. J. Transp. Res. Board 2110, 27–34. doi:10.3141/2110-04

Strömberg, H., Rexfelt, O., Karlsson, I.C.M.A., Sochor, J., 2016. Trying on change - Trialability as a change moderator for sustainable travel behaviour. Travel Behav. Soc. 4, 60–68. doi:10.1016/j.tbs.2016.01.002

Stubbs, W., Cocklin, C., 2008. Conceptualizing a "Sustainability Business Model." Organ. Environ. 21, 103–127. doi:10.1177/1086026608318042

Teece, D.J., 2010. Business Models, Business Strategy and Innovation. Long Range Plann. 43, 172–194. doi:10.1016/j.lrp.2009.07.003

Torraco, R.J., 2005. Writing Integrative Literature Reviews: Guidelines and Examples. Hum. Resour. Dev. Rev. 4, 356–367. doi:10.1177/1534484305278283

Tukker, A., 2015. Product services for a resource-efficient and circular economy - a review. J. Clean. Prod. 97, 76–91. doi:10.1016/j.jclepro.2013.11.049

Upward, A., Jones, P., 2016. An Ontology for Strongly Sustainable Business Models. Organ. Environ. 29, 97–123. doi:10.1177/1086026615592933

Weiller, C., Shang, A., Neely, A., Shi, Y., 2015. Competing and Co-existing Business Models for EV : Lessons from International Case Studies. Int. J. Automot. Technol. Manag. 15, 1–12. doi:10.1109/EVS.2013.6914776

Wells, P., 2016. Economies of Scale Versus Small Is Beautiful. Organ. Environ. 29, 36–52. doi:10.1177/1086026615590882

Willing, C., Brandt, T., Neumann, D., 2017. Electronic mobility market platforms – a review of the current state and applications of business analytics. Electron. Mark. 27, 267–282. doi:10.1007/s12525-017-0257-2

Zott, C., Amit, R., 2010. Business model design: An activity system perspective. Long Range Plann. 43, 216–226. doi:10.1016/j.lrp.2009.07.004

Zott, C., Amit, R., Massa, L., 2011. Journal of Management 37, 1019–1042. doi:10.1177/0149206311406265