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A Delphi study of business models for cycling urban mobility platforms

Elisabete Sá [a,*], Ana Carvalho [b], Joaquim Silva [a], Arash Rezazadeh [b,1]

[a] Interdisciplinary Centre of Social Sciences (CICS.NOVA.UMinho), School of Economics and Management, Campus de Gualtar, University of Minho, 4710-057 Braga, Portugal

[b] Centre for Research in Economics and Management (NIPE), School of Economics and Management, Campus de Gualtar, University of Minho, 4710-057 Braga, Portugal

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ABSTRACT

The movement towards sustainable and liveable cities is gaining momentum and is projected to continue to shape the future of cities. Bicycles are one of the fastest-growing transportation modes that can contribute to more sustainable and smart urban mobility. New digital service platforms will likely arise to support an enhanced cycling mobility experience while also offering value to other stakeholders of a connected urban mobility ecosystem. Exploring suitable business models is critical to sustaining digital urban mobility platforms, but approaches that consider multiple stakeholders are scarce in previous research. Aiming to reduce this gap, this Delphi research with experienced professionals and academics adopts an ecosystem approach and explores two important components of business models for future cycling urban mobility platform services and the data they would generate: value propositions and value capture models. Results show that experts participating in the study generally agree on the potential attractiveness of the services of such a platform and mobility data for the studied stakeholders. However, lower and diverging estimates regarding the expected willingness to pay suggest that a business model that combines revenues from platform services and data services may be needed and that cross-subsidisation of some stakeholders could be necessary.

1. Introduction

The pressure for smart mobility that accompanies the movement towards sustainable and liveable cities, expressed in concepts like Smart City (Ferraris, Santoro, & Papa, 2018), 15-min city (Moreno, Allam, Chabaud, Gall, & Pratlong, 2021) or City 5.0 (Rosemann, Becker, & Chasin, 2021), means that both digital systems and micromobility (especially bicycles) increasingly assume a central role in urban mobility (Abduljabbar, Liyanage, & Dia, 2021; Heiskala, Jokinen, & Tinnilä, 2016). This is manifest in the growing investment by cities in cycling programmes and infrastructure (Földes & Csiszár, 2018; Moreno et al., 2021) and the substantial growth in bike sales and bike-related businesses, intensified by the COVID-19 pandemic (Stilo, Segura-Velandia, Lugo, Conway, & West, 2021). These trends are expected to continue to shape the future of cities (Abduljabbar et al., 2021; Moreno et al., 2021).

Several stakeholders are involved in offering services in urban mobility and to urban cyclists, from bike-sharing operators, municipalities, public transport operators, and bicycle, sensor and interface original equipment manufacturers (OEMs). Most already employ digital systems. However, these systems operate in isolation, which curtails the potential for value co-creation and results in fragmented service offerings to urban cyclists (Cruz & Sarmento, 2020; Meireles & Ribeiro, 2020). A connected cycling urban mobility platform would be formed around the general value proposition of enhancing the bike-riding experience of urban cyclists in the city through digital services. For supply-side members, such a platform can create value by amplifying their market reach and especially by improving their practical and managerial decision-making based on the valuable data it can generate.

For a digital service platform to be viable, an appropriate business model must be established (Kohtamäki, Parida, Oghazi, Gebauer, & Baines, 2019; Wiener, Saunders, & Marabelli, 2020; Zolnowski, Christiansen, & Gudat, 2016). However, extant research rarely adopts an ecosystem perspective when exploring digital business models that can create and capture value from and with multiple stakeholders

* Corresponding author at: Interdisciplinary Centre of Social Sciences (CICS.NOVA.UMinho), School of Economics and Management, Campus de Gualtar, University of Minho, 4710-057 Braga, Portugal.

E-mail addresses: elisampaio@eeg.uminho.pt (E. Sá), anac@eeg.uminho.pt (A. Carvalho), josilva@eeg.uminho.pt (J. Silva), arezazadeh@ucp.pt, a.rezazadeh@eeg.uminho.pt (A. Rezazadeh).

[1] Present address: Católica Lisbon School of Business and Economics, Palma de Cima, 1649-023 Lisboa, Portugal.

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(Broekhuizen, Broekhuis, Gijsenberg, & Wieringa, 2021; Kohtamäki et al., 2019; Williamsson & Moen, 2022). The purpose of this study is to explore, through the lenses of specialists in connected urban mobility, two elements of business models, value propositions and value capture models, for a digital platform to serve the connected cycling urban mobility ecosystem.

The Delphi technique is particularly useful in forecasting exercises to explore complex phenomena for which there is no historical data (Beiderbeck, Frevel, von der Gracht, Schmidt, & Schweitzer, 2021; Linstone & Turoff, 2002; Okoli & Pawlowski, 2004). This is the case of connected cycling mobility platforms, that are mostly emergent and experimental ventures yet to develop sustainable and truly integrated stable operations.

2. Literature review

2.1. Urban micromobility and smart mobility

As cities grow and global sustainability is undermined, concepts like 15-min city (Moreno et al., 2021), Smart City (Ferraris et al., 2018) and City 5.0 (Rosemann et al., 2021) are being explored for their potential to minimise and overcome pressing urban problems and improve city sustainability and liveability. These concepts have in common the notion that digital technology can contribute to urban sustainability by improving city management effectiveness and efficiency through integrated and interconnected systems, thereby eliminating restrictions and enabling the frictionless delivery of public goods and services and contributing to the wellbeing of citizens (Ferraris et al., 2018; Moreno et al., 2021; Rosemann et al., 2021).

Smart mobility emerges in this context. It builds on several trends, including manufacturers' efforts to add a service component to their offerings (*servitisation*) based on digitisation, the transition from ownership to usership and from a modal-centric to a user-centric transport system, and the expansion of intelligent infrastructure (Arias-Molinares & García-Palomares, 2020; Athanasopoulou, de Reuver, Nikou, & Bouwman, 2019; Heiskala et al., 2016).

Digital services and digital platforms are therefore becoming central to support urban mobility (Cruz & Sarmento, 2020; Heiskala et al., 2016; Schreieck, Wiesche, & Krcmar, 2016). Mobility-as-a-Service (MaaS) platforms, for example, bundle multiple services such as journey planning, booking and payment for different transport modes in the city into tailored mobility packages to achieve door-to-door mobility (Ho, Hensher, Mulley, & Wong, 2018; Meurs, Sharmeen, Marchau, & van der Heijden, 2020). Micromobility plays an important part in smart urban mobility, especially to fulfil the first and last mile of urban journeys. It relies on privately-owned or shared light-weight vehicles like bicycles to cover short distances, which make up for 50–60% of most urban travel (Abduljabbar et al., 2021; Behrendt, 2016; Karanikola, Panagopoulos, Tampakis, & Tsantopoulos, 2018).

Bicycles, one of the fastest-growing transportation modes, constitute a low cost and flexible transport mode that contributes to reduce traffic congestion, carbon emissions, noise and air pollution, in addition to promoting health and well-being (Abduljabbar et al., 2021; Karanikola et al., 2018; Lu, Hsu, Chen, & Lee, 2018; Meireles & Ribeiro, 2020; Stilo et al., 2021). Bicycles sales have been growing steadily over the years and the global market size is predicted to reach over USD 80 billion by 2027 (Research and Markets, 2021). Public policy and investment supporting urban cycling have also been rising (Abduljabbar et al., 2021; Behrendt, 2016), accelerated by the COVID-19 pandemic (Stilo et al., 2021). Although the benefits of smart and networked cycling are acknowledged (Meireles & Ribeiro, 2020; Romanillos, Zaltz Austwick, Ettema, & De Kruijf, 2016; Turetken, Grefen, Gilsing, & Adali, 2019), bicycles are still largely neglected in smart urban mobility research (Behrendt, 2016; Földes & Csiszár, 2018) that has devoted more attention to other modes of transport like electric vehicles and public transport and to issues such as safety and efficiency (Francini, Chieffallo, Palermo, & Viapiana, 2021).

2.2. Digital service platforms

A digital service platform is an integrated digital system that congregates a variety of supply-side stakeholders to serve demand-side end-users, expediting the interactions, transactions and collaboration among diverse and dispersed actors and objects through information, communication and connectivity technologies (Gawer, 2021; Kohtamäki et al., 2019; Täuscher & Laudien, 2018). The interaction among platform participants thus facilitated allows them to combine data, resources and capabilities to generate accurate urban mobility analytics and offer innovative and complementary service solutions (Broekhuizen et al., 2021; Ferraris et al., 2018; Zolnowski et al., 2016). Transitapp, Moovit and Citymapper are good examples of privately owned digital service platforms that integrate the contribution of multiple stakeholders to offer intelligent and integrated transport systems, seamless booking, ticketing and payments solutions and real-time trip information. These digital platforms also integrate valuable real-time data and crowd-sourced inputs from end-users that are incorporated in the development of new, improved or personalised solutions, enabling true co-creation of value by all participating members (Nelson, Ferster, Laberee, Fuller, & Winters, 2021; Schreieck et al., 2016; Turetken et al., 2019). This is especially relevant in service ecosystems, where the coordinated interaction among partners is the foundation for value co-creation (Ferraris et al., 2018; Kohtamäki et al., 2019). Because single service providers cannot usually supply holistic service packages, there is advantage in having a service integrator that combines the disperse offerings of platform suppliers into bundled value propositions that are more attractive to end-users (Arias-Molinares & García-Palomares, 2020; Kohtamäki et al., 2019), thereby also empowering a more customer-centric approach (Turetken et al., 2019; Zolnowski et al., 2016).

2.3. Business models for cycling urban mobility platforms and the data they generate

Establishing a suitable business model is identified as a critical factor for digital platforms in general (Broekhuizen et al., 2021; Kuebel & Zarnekow, 2014; Täuscher & Laudien, 2018) and for urban mobility ventures in particular (Ho et al., 2018; Jittrapirom, Marchau, van der Heijden, & Meurs, 2020; Polydoropoulou et al., 2020; Williamsson & Moen, 2022). The business model describes the logic of how a business creates value for customers and for the firm itself through its offerings on the market (Heiskala et al., 2016; Schüritz, Seebacher, & Dorner, 2017; Wiener et al., 2020; Williamsson & Moen, 2022). Two central aspects of business models are therefore the value proposition and revenue models (Täuscher & Laudien, 2018; Zolnowski et al., 2016).

2.3.1. Value propositions

The literature stresses the need to develop clear and attractive value propositions for both sides of a digital platform (Kuebel & Zarnekow, 2014). Besides providing a further channel for transactions within the ecosystem, two main strengths of digital service platforms can be the basis of attractive value propositions within the urban mobility context: its service integration potential, and the integration of data generated from multiple sources and stakeholders.

Service integration is particularly valuable to urban mobility users (Arias-Molinares & García-Palomares, 2020; Meurs et al., 2020). Citizens are becoming more utility-oriented (Rosemann et al., 2021) and seek personalised (Athanasopoulou et al., 2019), simple and flexible solutions that improve their urban mobility experience (Cruz & Sarmento, 2020; Turetken et al., 2019). More integrated services reduce cognitive effort (Földes & Csiszár, 2018), increase feelings of safety and connection to the community (Heiskala et al., 2016; Romanillos et al., 2016) and encourage people to change their mobility behaviour into more sustainable alternatives (Elmashhara, Silva, Sá, Carvalho, &

Rezazadeh, 2022; Sochor, Arby, Karlsson, & Sarasini, 2018).

Collaboration among stakeholders is also key to achieving integrated urban mobility, which can be much enhanced by information exchange through digital systems (Jittrapirom et al., 2020; Kohtamäki et al., 2019; Meurs et al., 2020). And, as urban transport dynamics becomes more complex, advanced modelling techniques are required to draw value from travel behaviour data to accurately reflect the dynamics and interaction among the different agents (Franco, Johnston, & McCormick, 2020). Consequently, there is great potential for value-creation based on the data and analytics facilitated by a connected cycling urban mobility platform.

Indeed, data and associated analytics have been recognised as central to urban mobility operators (Alaimo, Kallinikos, & Valderrama, 2020; Arias-Molinares & García-Palomares, 2020; Meurs et al., 2020; Polydoropoulou et al., 2020). So, in addition to the access to a potentially large market of urban cyclists (Meurs et al., 2020; Olszak & Zurada, 2020; Ruutu, Casey, & Kotovirta, 2017; Turetken et al., 2019) and reputation for sustainability from their presence in the platform (Heiskala et al., 2016; Turetken et al., 2019), the value proposition to supply-side members revolves around the benefits they can extract from the rich generated data and derived analytics to optimize processes and improve decision-making (Broekhuizen et al., 2021; Heiskala et al., 2016; Wiener et al., 2020; Williamsson & Moen, 2022; Zolnowski et al., 2016).

For example, urban mobility data and analytics can help municipalities and local authorities define and sustain polices that contribute to environmental and societal value, like those aimed at reducing car use, accidents and carbon emissions, and thereby improve the quality of life and sustainability of cities (Heiskala et al., 2016; Ismagilova, Hughes, Dwivedi, & Raman, 2019; Janssen & Zuiderwijk, 2014; Karanikola et al., 2018; Meireles & Ribeiro, 2020; Olszak & Zurada, 2020; Sochor et al., 2018). Other members in general can benefit from the customer behaviour and profiling obtained from this data to predict demand and adapt customer services through targeted marketing, improving service quality and increasing customer satisfaction and loyalty (Abduljabbar et al., 2021; Alaoui & Tekouabou, 2021; Elmashhara et al., 2022; Heiskala et al., 2016; Huang, Henfridsson, Liu, & Newell, 2017; Zolnowski et al., 2016).

2.3.2. Revenue models

In terms of revenue models, it is often the case that one or both sides of digital platforms are subsidised to maximise traction (Gawer, 2021; Heiskala et al., 2016). In the urban mobility context, platforms are sometimes promoted and funded by public transport companies or public authorities seeking social and environmental benefits (Ferraris et al., 2018; Meurs et al., 2020; Sochor et al., 2018). Yet, for a business to be financially sustainable, it must generate income, and there are several businesses running mobility platforms for profit, such as Moovit and Waze (Heiskala et al., 2016). Typically, end-users do not expect to pay for mere information aggregation. For more integrated and differentiated bundling of service packages (e.g., provision of planning, booking and payment of alternative combinations of transport modes for complete door-to-door mobility), end-user subscriptions or pay-per-use (or "pay-as-you-go") are viable revenue streams (Ho et al., 2018; Sochor et al., 2018), especially if they are personalised and customisable (Ho et al., 2018; Meurs et al., 2020). A freemium model, where urban cyclists access the basic services for free and pay to benefit from high-end features, is a potential alternative to secure a revenue stream from the end-user side (Schüritz et al., 2017).

From the supply-side, the revenue streams associated with digital platforms include transaction fees on the purchase of products and services, periodic subscriptions to access services, commissions on vendor sales, advertising, and registration or admission fees (Schreieck et al., 2016; Täuscher & Laudien, 2018). In addition to end-users and supply-side members, revenue can also be obtained from third-parties that wish to advertise on the platform (Arias-Molinares & García-Palomares, 2020; Täuscher & Laudien, 2018). The sale of data generated from platform activity is increasingly mentioned (Heiskala et al., 2016; Janssen & Zuiderwijk, 2014; Schulz, Gewald, Böhm, & Krcmar, 2020; Täuscher & Laudien, 2018). This has been accompanied by the emergence of platform-based data-driven services that specifically generate revenue from data and analytics (Alaimo et al., 2020; Hartmann, Zaki, Feldmann, & Neely, 2016; Wiener et al., 2020; Zolnowski et al., 2016).

3. Methodology

3.1. Delphi method

The purpose of this research is to explore potential value propositions and value capture models for future cycling urban mobility platforms and the data they can generate. The Delphi method was deemed appropriate for this purpose as it provides important knowledge insights and serves as a rich data gathering tool to support effective strategic decision making in areas where there is high market uncertainty and ambiguity, by drawing on the expert judgement of knowledgeable people (Beiderbeck et al., 2021; Linstone & Turoff, 2002; Melander, 2018; Okoli & Pawlowski, 2004; Winkler, Kuklinski, & Moser, 2015). A panel of specially selected experts is presented with a number of successive rounds of the same survey where they provide their input and receive feedback with the results of previous rounds, based on which they are invited to revise their judgements, often leading to wider collective agreement (Beiderbeck et al., 2021). In addition to this iterative nature and the controlled feedback, Delphi is characterised by the anonymity and aggregation of experts' responses (Rowe, Wright, & Bolger, 1991).

The appropriate number of rounds can vary, with studies using two to ten (Goluchowicz & Blind, 2011). The objective is to reach a pattern of group convergence or response stability after a number of rounds (Belton, MacDonald, Wright, & Hamlin, 2019; Linstone & Turoff, 2002). We used a two-round process, which is typical when involving professionals (Landeta, Barrutia, & Lertxundi, 2011) and, specifically, within transport studies (Melander, 2018). The reasons for limiting the study to two rounds were, first, that research shows most opinion revisions occur after the first interaction (Goluchowicz & Blind, 2011; Woudenberg, 1991); and, second, to minimise response fatigue and drop-out rate considering the length of the questionnaire. The two rounds were considered sufficient, since the results show a fair amount of agreement among panellists and, despite some dissent, the results of the second round are stable for most projections.

3.2. Panel selection and characterisation

The selection of experts is key in Delphi studies to ensure the validity and reliability of results (Belton et al., 2019; Goluchowicz & Blind, 2011) and should consider the size, heterogeneity, and appropriate knowledge of the expert panel (Goluchowicz & Blind, 2011). Criteria for identifying suitable experts were pre-defined to ensure all relevant domains were present (Goluchowicz & Blind, 2011; Okoli & Pawlowski, 2004). To ensure heterogeneity, we considered professionals with experience and academics with publications (Belton et al., 2019) in four relevant areas: (i) the urban mobility ecosystem, (ii) the cycling world, (iii) digital platforms and (iv) data-driven businesses. We also looked for geographical heterogeneity, by considering experts from different countries and cities, where urban mobility may be different, although we favoured prospective participants with worldwide knowledge on the topic, such as leaders of international cycling communities and organizations.

To identify potential participants, we searched the websites of cycling associations and cycling-promoting organizations and projects, digital urban mobility and data analytics organizations, and professional and scientific publications. Publicly available information (websites and professional networks) was scanned for contacts and to assess the expertise of potential panellists (Goluchowicz & Blind, 2011; Rowe &

Wright, 2011). The main criteria for assessment were specific experience in one or more of the above-mentioned areas of expertise and relevant position in the organization.

Recommendations for sample size for Delphi studies vary, most ranging from 5 to 60 (Belton et al., 2019). Counting on typically low response rates (Belton et al., 2019) a group of 213 experts was selected, using purposive sampling technique, and invited to participate. Thirty-five experts accepted, representing a response rate of 16.4%. The panel size was deemed sufficient in light of the literature recommendations, considering that the participants were asked to read a summary of the other panellists' qualitative rationales as between-round feedback and a larger group would have produced information that might have increased their cognitive burden and impaired decision accuracy (Belton et al., 2021). As four experts contributed anonymously to the first round, only 31 were invited to participate in the second round. After several reminders and personal appeals made by the researchers (Belton et al., 2019) via email or LinkedIn, 21 completed the second round, corresponding to a dropout rate of 32.3%. Table 1 shows the relevant information about the panellists.

3.3. Data collection

Following recommendations from the literature, summarised by Belton et al. (2019), a survey was constructed for the first round using Qualtrics. This was pilot-tested with five experts on urban mobility known to the research team, who validated the survey design. Two business model scenarios, involving six ecosystem stakeholders and resulting in 20 total projections were assessed by the panel. The first scenario explores a service-based business model, where supply-side cycling urban mobility stakeholders offer urban cyclists their services through a multi-sided digital platform. The second one explores a data-based business model, in which the supply-side ecosystem stakeholders purchase from the platform management the behavioural and transactional data collected and derived data analytics to improve their operations. Two components were explored for each business model scenario. Regarding the service-based model, panellists were asked to provide probability estimates (on a scale of 0 to 100% likelihood) of each ecosystem stakeholders' (1) interest in the value proposition associated to services provided by such a digital platform; and (2) their willingness to pay to access the platform services. For the second scenario, estimates were solicited for ecosystem stakeholders' (3) interest in accessing data and analytics derived from the platform; and (4) their

Table 1
Sample profile.

Category	Expert *	Position	Fields of expertise **	Years of experience	Self-reported level of expertise	Gender	Country	2nd-round
Urban mobility equipment and digital service providers	1	Regional Director of Business Development	1, 3, 4	2	high	female	Sweden	
	2	Head of bike-sharing services	2, 3, 4	5	very high	male	Slovakia	Y
	3	Head of Business Development	1, 3, 4	2	high	male	Italy	Y
	4	Mobility marketing manager	2	6	high	male	Switzerland	Y
	5	Chief Technology Officer (CTO)	1, 3	5	high	male	Netherlands	Y
Municipal organizations	6	Policy Advisor on Transport & Mobility	1, 3	8	reasonable	male	Austria	Y
	7	Head of Intelligent and Information Systems	3	4	high	male	Portugal	Y
	8	Project Manager for sustainable mobility	1	10	reasonable	male	Sweden	
	9	Former CEO of Municipal transport company	1	30	very high	male	Portugal	Y
	10	Advisor for cycling mobility at inter-municipal organization	1, 2	11	high	male	Portugal	Y
	11	Advisor to the City Councillor on Mobility	1, 3	18	reasonable	male	Portugal	
	12	Director of intermodal public transport	1, 2	15	reasonable	male	Portugal	Y
Urban mobility consultancy	13	Founder and sales manager	2	6	reasonable	male	Germany	Y
	14	Transport programme coordinator	1, 2	3	reasonable	male	Bosnia and Herzegovina	Y
	15	Researcher on urban cycling	1, 2	10	high	male	Austria	
	16	Founder and Senior consultant	2	20	reasonable	male	Spain	
	17	Communication project manager	2	5	reasonable	female	Italy	
	18	Senior consultant in cycling mobility	1	8	high	male	Spain	Y
	19	Managing Partner	1	12	high	male	Spain	Y
Cycling advocacy or community organization	20	Founder and CEO	1, 2	20	very high	female	Ireland	
	21	CEO	2	10	reasonable	female	Belgium	
	22	Project manager for bicycle infrastructure	2	6	reasonable	female	Switzerland	Y
	23	Project coordinator	2	1	reasonable	female	Netherlands	
	24	Co-founder	2, 3	5	high	female	Italy	Y
	25	Founder and CEO	2	29	reasonable	male	Romania	Y
	26	Chairman	2	26	high	male	Latvia	Y
	27	President	1, 2, 3	n/a	very high	male	Portugal	Y
	28	President	1, 2	40	high	male	Serbia	
Academics	29	Professor in urban transport	1, 3	15	high	male	Portugal	Y
	30	Professor in smart and sustainable cities	1, 2, 3, 4	8	reasonable	male	Spain	Y
	31	Professor in transportation engineering	1, 3	25	high	male	Thailand	Y

Notes. *Experts 32 to 35 participated anonymously. **Fields of expertise: 1 = the urban mobility ecosystem; 2 = the urban cycling context; 3 = digital platforms; 4 = data-driven businesses.

willingness to pay for different types of data services (Table 2).

Based on the advice of the pre-test experts, the analysis was limited to six key ecosystem stakeholders to minimise the response fatigue, namely Urban Cyclists, Bike-Sharing Operators, Municipalities, Urban Logistics Operators, Public Transport Services, and OEMs (bicycle manufacturers). The questionnaire was organized in such a way that the participants rated the probable interest in the value propositions and the willingness to pay of each of these ecosystem members within the two business model scenarios. Given their specificities, only the service-based model scenario was explored relative to Urban Cyclists and the data-based model scenario relative to OEMs, while both were assessed for the remaining stakeholders. This resulted in a total number of 20 projections assessed by the panel, which is within the range of projections used in other studies (Melander, 2018).

Panellists were also asked to provide reasons for their estimates in order to obtain more reflected opinions and permit better quality and more relevant feedback (Belton et al., 2019; Bolger & Wright, 2011; Goluchowicz & Blind, 2011).

The second-round survey replicated the first one, only this time it was personalised, presenting each panellist with the mean, standard deviation and quintile distribution (presented in a histogram) of the panel aggregated estimates for the 20 projections along with their own original estimates. Additionally, the qualitative responses were content analysed to provide the panellists a summary of reasons for higher and lower estimates for each projection. Participants were then asked whether they would like to change their estimates and provide additional comments as desired.

3.4. Data analysis

Regarding the numerical probability estimates, the mean ($\bar{X}$) and standard deviation (SD), which are commonly used measures in Delphi studies (Belton et al., 2019), were calculated after each round. In addition to their numerical representation, the means of the estimates for all the projections were represented graphically to facilitate interpretation (Belton et al., 2019). Although there is a general tendency for Delphi studies to seek consensus building, our purpose was to explore both agreement and disagreement points, which can offer valuable insights for prospective studies (Beiderbeck et al., 2021). Experts with different relationships with the problem being explored often have disparate views and consensus may not be possible, appropriate or even desirable, as divergent ideas may help to shed light on a little understood issue or complex problem (Belton et al., 2019; Melander, 2018). Thus, for data interpretation purposes, consensus was deemed as important as its absence (von der Gracht, 2012). The Interquartile Range (IQR) was used to analyse the level of consensus/dissent regarding each projection after each round. This is a robust and objective measure widely used in Delphi studies (Fritschy & Spinler, 2019; Schmalz, Spinler, & Ringbeck, 2021) that measures the dispersion from the median, consisting of the middle 50% of the observations, calculated from the difference between the third and the first quartile (Birko, Dove, & Özdemir, 2015). To assess whether consensus was achieved, a maximum threshold should be established in advance (Birko et al., 2015). Although rigorous standards for consensus in Delphi research have not been established (von der Gracht, 2012), we followed the recommendations of Beiderbeck et al. (2021) who argue that a maximum of 25% of the used scale is a fit threshold. As the study used the 0 to 100% likelihood scale, we set the threshold for consensus at IQR $\leq$ 25. Outliers, which can have a significant effect on group consensus measured by the IQR (Beiderbeck et al., 2021), were identified and eliminated. In parallel, after each round, we analysed the percentage of experts that placed their likelihood estimates in a lower (0–45%), neutral (46–54%) and higher (55–100%) range, to assess not only the level of agreement but also its direction. Consistent with Fritschy and Spinler (2019), the threshold of a minimum 60% of experts placing their estimates in one of these categories was used to assume that a certain level of agreement was attained, which is above the majority (>50%) indicated in previous literature (Dajani, Sincoff, & Talley, 1979).

Table 2
Projections assessed by the panel.

	Service-based business model		Data-based business model	
Stakeholder	Interest in… (value propositions)	Willingness to pay … (revenue models)	Interest in… (value propositions)	Willingness to pay … (revenue models)
Urban Cyclists	P1. Obtaining and sharing relevant and personalised information about their bike journey and surrounding services and events.	P6. To access such a platform in a freemium model, in which only high-end features are paid.		
Bike-Sharing Operators	P2. Participating in a digital platform that allows them to contact prospective users and interact seamlessly with their current customers, through the integration of their dedicated app	P7. A subscription to integrate their dedicated apps in the connected biking platform and/or paying a commission on service booking made through the platform	P11. Accessing data analytics services, based on mobility and behavioural patterns, allowing them to improve internal operations, e.g., rebalance stations; forecast demand in some places/times of the day, week, months...	P16. A fee for on-demand analytics and/or subscribing a regular data feed.
Municipalities	P3. Participating in a digital platform that allows them to contact citizens and receive their feedback, e.g., on the state of the infrastructure.	P8. A small amount for each contact made via opt-in alerts.	P12. Accessing data analytics services, based on mobility and behavioural patterns, that can allow to improve infrastructure quality and safety and support urban planning.	P17. A fee for on-demand analytics and/or subscribing a regular data feed.
Urban Logistics Operators	P4. Participating in a digital platform that allows them to recruit riders among urban cyclists and integrate last-mile deliveries with other urban operators.	P9. A small amount for each contact made from the platform.	P13. Accessing data analytics services, based on mobility patterns, that allows them to improve internal operations, e.g., route and load factor optimisation...	P18. A fee for on-demand analytics and/or subscribing a regular data feed.
Public Transport Services	P5. Participating in a digital platform that allows them to integrate their services with first and last mile bike solutions.	P10. A service integration subscription and/or pay-per-contact with users via opt-in alerts and/or ticket purchase commission.	P14. Accessing data analytics services, based on mobility patterns, allowing them to improve internal operations, e.g., forecasting demand and adapt customer service, including scheduling.	P19. A fee for on-demand analytics and/or subscribing a regular data feed.
OEMs (bicycle manufacturers)			P15. Accessing data analytics services, based on mobility patterns, that allows them to obtain malfunction and usage patterns to base future technical developments and innovation.	P20. A fee for on-demand analytics and/or subscribing a regular data feed.

Note. P=Projections. Each projection corresponds to one statement assessed by the panel on a probability scale ranging from 0% to 100%.

Opinion stability between rounds, more than consensus, provides indications for the need of additional rounds (von der Gracht, 2012). To assess it, we calculated the Coefficient of Variation (CV) change after the second round, which is considered one of the most accurate measures for stability (Kwiatkowski & Chinowsky, 2017). The CV is a standardized measure of dispersion calculated by dividing the standard deviation of the opinions of each projection by the mean, which, ideally, should decrease between rounds, indicating wider agreement (von der Gracht, 2012). However, when this change, consisting in the absolute value of the difference in CV between Rounds 1 and 2, is higher than a certain level, it reflects opinion instability. We used the 0.1 threshold that has been considered suitable by previous research (Anderhofstadt & Spinler, 2019; Kwiatkowski & Chinowsky, 2017). The number of study rounds was communicated to the panellists upon the invitation to participate, so as to manage expectations regarding time commitment and decrease the potential for drop-out (Belton et al., 2019). However, a high level of opinion instability after the second round would indicate the need for follow-on enquiry, for instance, through an interview to gain feedback about areas of low agreement (Powell, 2003). Conversely, a low level of instability allows for a stronger confidence in the results.

As for the qualitative data obtained from the experts' explanations of their estimates, all contributions from both rounds were subject to content analysis. The main reasons supporting higher or lower estimates were summarised and organized into categories to support the interpretation of the quantitative results, particularly those that reveal dissent. A total of 113 comments were analysed and coded manually by two of the authors, following a coding scheme that included categories of reasons for the interest (attractiveness/barriers) of the value propositions (e.g., offering characteristics, user characteristics, privacy) and types of revenue models based on the willingness to pay for services (e.g., fee, freemium, subsidisation). The codes and their operational definitions were then discussed with a third author, who coded all the material separately. The comparison between the two coding rounds revealed a high level of intercoder agreement, with the differences being discussed by all authors until full convergence was achieved. Excerpts of the comments are identified with the expert (Exp) number, from 1 to 35.

4. Results

4.1. Service-based model

The descriptive analysis of the experts' estimates for the ten projections of the service-based model, along with the consensus and agreement, and stability results, are depicted in Table 3. A graphical overview of the mean likelihood estimates for both interest (value propositions) and willingness to pay (revenue models) is presented in Fig. 1. Results show that, overall, experts rate fairly highly the likelihood that the stakeholders considered in the study would be interested in the value propositions offered by the services of a digital platform focused on the Urban Cyclist (P1 to P5). After two rounds, the mean likelihood values range from 61%, in the case of Urban Logistics Operators (P4), to 79% for Bikesharing Operators (P2). As for the level of agreement among experts, for all projections related to the service-based model value propositions, the percentage of participants placing their estimates in the higher range (≥55) was above the threshold of 60%, denoting consistency in their favourable opinions. The IQR results indicate that only two projections (P2 -Bike-sharing operators and P3-Municipalities) are below the 25 threshold considered for this research (Beiderbeck et al., 2021). The stability analysis shows, however, that the CV change is always below the threshold of 0.1 (Anderhofstadt & Spinler, 2019; Kwiatkowski & Chinowsky, 2017), meeting the criterion for stability.

Thus, although there seems to be an agreement regarding the overall attractiveness of the services of such a platform for different members of the ecosystem, some level of dissent persists. The qualitative analysis of the experts' comments helps clarify this.

Table 3
Descriptive, agreement and stability results for the service-based model scenario.

	Descriptives				Agreement and consensus										Stability		
	Round 1		Round 2		Round 1					Round 2					Round 1	Round 2	
	$\bar{X}$	SD	$\bar{X}$	SD	% experts rating			Agreement	IQR	% experts rating			Agreement	IQR	CV	CV	CV change
					0–45	46–54	55–100			0–45	46–54	55–100					
Expected likelihood of the interest in participating (value propositions attractiveness) (0 to 100%)																	
P1. UC	66	22	67	20	19,0	14,3	66,7*	Yes	30	14,3	14,3	71,4*	Yes	27	0,33	0,30	0,03*
P2. BSO	78	18	79	17	5,0	10,0	85,0*	Yes	21*	4,8	9,5	85,7*	Yes	16*	0,23	0,21	0,01*
P3. MPS	74	19	73	17	11,1	5,6	83,3*	Yes	22*	4,8	14,3	81,0*	Yes	21*	0,25	0,23	0,02*
P4. ULO	61	27	61	25	35,3	0,0	64,7*	Yes	45	36,8	0,0	63,2*	Yes	39	0,44	0,41	0,02*
P5. PTS	69	27	69	28	21,1	10,5	68,4*	Yes	41	25,0	5,0	70,0*	Yes	44	0,40	0,41	0,01*
Expected likelihood of the willingness to pay (revenue models adequacy) (0 to 100%)																	
P6. UC	66	18	68	18	14,3	19,0	66,7*	Yes	30	9,5	19,0	71,4*	Yes	28	0,28	0,26	0,02*
P7. BSO	46	28	43	25	47,6	19,0	33,3	No	39	47,6	23,8	28,6	No	34	0,61	0,57	0,03*
P8. MPS	26	17	22	14	81,3*	18,8	0,0	Yes	31	88,9*	11,1	0,0	Yes	20*	0,64	0,66	0,02*
P9. ULO	44	25	44	24	60,0*	6,7	33,3	Yes	42	58,8	11,8	29,4	No	35	0,56	0,55	0,01*
P10. PTS	31	18	31	18	66,7*	27,8	5,6	Yes	33	65,0*	25,0	10,0	Yes	33	0,57	0,58	0,01*

Note. UC= Urban Cyclists; BSO = Bikesharing Operators; MPS = Municipalities and Public Services; ULO = Urban Logistics Operators; PTS = Public Transport Services; *respect the defined threshold.

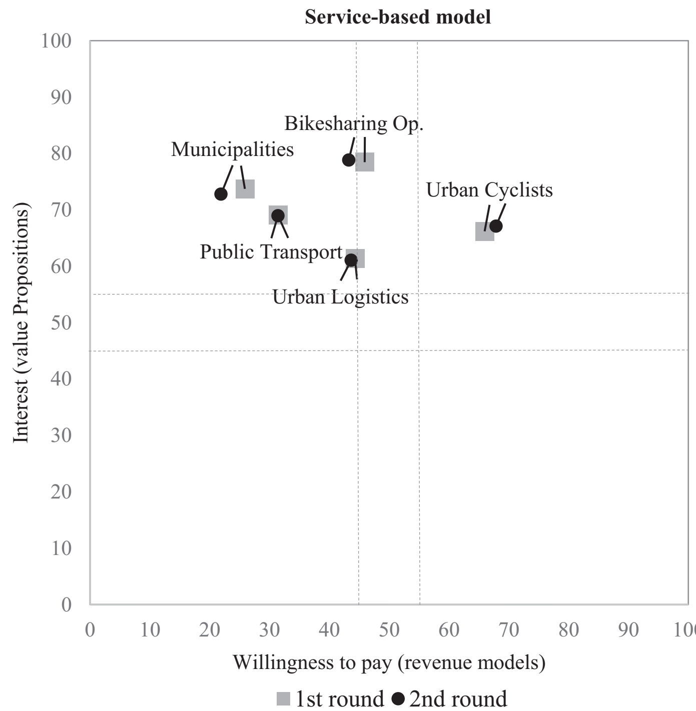

Fig. 1. Mean estimates of the stakeholders' interest and willingness to pay for services provided by a digital platform.

In general, experts support the idea that «bikers would appreciate easy access to relevant information» (Exp1), particularly if it would allow the integration «with other modes of transport and other city services» (Exp30), helping them to «plan their journey» (Exp28) and make «flexible and adjustable decisions in their everyday life» (Exp33). However, some experts believe that «mobility is a habit» (Exp20) and many cyclists «do the same journey every day» (Exp27), so they «might use it only for special occasions or circumstances» (Exp4). Additionally, the concern around «privacy» (Exp6, 10) may make users reluctant to «give their information […] as they do not want to see their journeys mapped» (Exp30).

For Bikesharing Operators, such a platform would provide an additional «communication channel» (Exp30) that grants «access to […] potential users» (Exp22) and «new customers» (Exp16). Municipalities and Public Services could find in the platform a source of «feedback from users» (Exp1) that is relevant to «identifying gaps in the network and report unsafe infrastructure» (Exp16), while also promoting «co-creation and citizens' engagement» (Exp20). Besides it would support their alignment with «green» (Exp19) and «smart» (Exp32) mobility trends.

While consensus around the high interest of both Bikesharing Operators and Municipalities and Public Services was achieved, not all the experts are fully convinced that the other supply-side stakeholders would be equally attracted to the benefits of the platform. Although Urban Logistics Operators would be able to seize the potential for «synergies among themselves» (Exp20) through this platform, experts believe that these operators could be more interested if «cargobikes are incentivised» in the future (Exp27), but «cities have not yet adapted to this reality and have not yet implemented real urban logistics policies» (Exp33).

Regarding Public Transport Services, while some believe that being part of the integrated urban «mobility solution […] that connects first and last-mile» (Exp21), would allow them to «boost demand» (Exp4) and «extend the coverage of the service to under-served areas where public transport will not be efficient» (Exp27), others argue that many operators are still «not convinced of MaaS or want to see how it works in other cities first» (Exp1). So, «it will take time for the public transportation operators to understand the value» (Exp17) of such systems. Experts also believe that «they like to create their own in-house solutions» (Exp25) and «it will be up to the bike services to join them» (Exp14) and not the other way around. One of the experts also pointed out that Public Transport Services may not see cycling as a complementary mode of transportation but rather a competitor, as «cycling can easily cover up to 10 km trips, which is way more than the average commute, in many cases» (Exp20).

The level of optimism expressed by the experts' numerical estimates regarding the attractiveness of the platform service value propositions was not mirrored by assessments about their likely willingness to pay to access those services (P6 to P10). As Fig. 1 shows, after two rounds, experts only ranked in the higher range the Urban Cyclists' ($\overline{X}$=68%) interest in accessing such a platform in a freemium model (P6). Experts attributed the lower estimates to the Municipalities and Public Services' ($\overline{X}$=22%) (P8) and to the Public Transport Services' ($\overline{X}$=31%) (P10) willingness to pay to contact users or to integrate their services. There is a certain level of agreement regarding these three stakeholders, but not towards Bikesharing (P7) and Urban Logistics Operators (P9). Consensus was achieved around the estimates for Municipalities and Public Services (IQR = 20), but not for the remaining stakeholders. The analysis of the CV change shows that it was below 0.1 for all projections, indicating that this disagreement was stable between rounds. This result suggests that experts consistently disagree regarding the monetising component of the service-based model. The analysis of the experts' comments evidence these opposing positions.

Although the majority of experts placed their estimates about the Urban Cyclists willingness to pay in a freemium model in the higher range, they note this could only be possible «if benefits covered cost» (Exp8) and if their regular use in the urban context make it worth to «pay for better features» (Exp21). Otherwise, the access to the system «should be free» (Exp28), to «encourage them to use» (Exp4). Some experts clearly expressed their doubts «as to whether [cyclists] may consider paying beyond the "minimum services"» (Exp32) as, usually, «users are very reluctant to pay for a platform» (Exp27).

As for Bikesharing Operators, despite the lack of agreement and consensus, experts tend to rank in the lower range their estimated willingness to pay to be integrated in the platform. They argue that they might be «willing to pay a small commission» (Exp1) to «have a booking service» (Exp30), which «grants that [they will] only pay when there is a direct benefit to the operator» (Exp10). However, paying a regular fee may be «complicated to understand unless they increase the number of users accordingly» (Exp21). Experts argue that Bikesharing Operators are «low margin businesses» (Exp8) and in many cases «not profitable, so everything that contributes to increase their expenses will not be seen as good» (Exp30). Also, «a good MaaS is not complete without bikesharing integration, so […] they would not be ready to pay a lot to be featured» (Exp20) in the platform.

Even though consensus was not reached, most experts also tend to moderate their estimates regarding the Urban Logistics' and the Public Transport Operators' willingness to pay. They express that it is «very unlikely that [Urban Logistics Operators] would be paying for these services» (Exp13), except in some «places where there is incentive to cargo bikes» (Exp27). In the case of Public Transport, «it will depend on the fee rate and the cost of the integration» (Exp30), but «if they want to be in a digital platform, they know that will have to pay certain commission per ticket» (Exp21). However, these services are often «subsidised to cover areas that are not profitable» (Exp8), so «paying can be difficult, for the budgets are always short» (Exp10). Additionally, according to the panel, these operators are often «(quasi-) monopolists and have a powerful position in the relevant market» (Exp16) and «still survive on captive passengers» (Exp33). So, although, they may be «always interested in increasing their client base, [they] are conservative in terms of "putting" money on new services» (Exp22).

In the case of Municipalities and Public Services, the results indicate an agreement and consensus around lower estimates, which was supported by the argument that «the willingness to pay of public entities is very, very limited, even when the perceived benefits are high» (Exp22). This could be particularly challenging for the pay-per-contact model, «due to fixed budgets» (Exp19) and the «public tendering rules» (Exp10). One of the participants does «not believe that they would be happy/ready to pay to start a conversation with their own citizens, [as] they might perceive that as their own right» (Exp20).

4.2. Data-based model

The second scenario presented to the experts was based on the mobility, transactional and behavioural data patterns drawn from the platform. Once again, the participants ranked ten projections, five regarding the attractiveness of the data-based value propositions (P11 to P15) and the remaining five about the stakeholders' willingness to pay for data and analytics in different revenue models (P16 to P20). The descriptive analysis of the results, the consensus and level of agreement, and stability measures are shown in Table 4 and a graphic summary of the mean estimates for stakeholders' interest and willingness to pay are represented in Fig. 2. In general, experts rated high the interest of the selected stakeholders in accessing data and data analytics that could support their decision-making processes. The highest likelihood estimate ($\bar{X}$=78%) was given to the Municipalities' (P12) interest in acquiring data to support decisions to improve infrastructure quality and safety, and support urban planning. The lowest mean estimate ($\bar{X}$=58%) refers to the Public Transport Services' interest in obtaining data and data analytics to improve operations, forecast demand and adapt customer service. After the second round it was possible to identify a level of agreement above 60% for the projections regarding the high interest of the data-based value propositions for all five stakeholders considered. However, only for Municipalities and Public Services (P12) did the IQR meet the threshold that determine consensus. The stability measure shows, however, that dissent was stable between rounds, with CV changes below 0.1 for all projections. The analysis of the experts' comments allows to better understand the disparate opinions.

Although consensus was not reached, experts tend to agree that Bikesharing Operators would be interested in data and analytics «for

Table 4
Descriptive, agreement and stability results for the data-based model scenario.

	Descriptives				Agreement and consensus										Stability		
	Round 1		Round 2		Round 1					Round 2					Round 1	Round 2	
	$\bar{X}$	SD	$\bar{X}$	SD	% experts rating			Agreement	IQR	% experts rating			Agreement	IQR	CV	CV	CV change
					0–45	46–54	55–100			0–45	46–54	55–100					
Expected likelihood of the interest in participating (value propositions attractiveness) (0 to 100%)																	
P11. BSO	72	31	76	27	23,8	4,8	71,4*	Yes	50	19,0	4,8	76,2*	Yes	45	0,43	0,35	0,08*
P12. MPS	75	27	78	26	16,7	11,1	72,2*	Yes	35	14,3	9,5	76,2*	Yes	20*	0,36	0,33	0,03*
P13. ULO	67	28	68	26	29,4	0,0	70,6*	Yes	57	26,3	0,0	73,7*	Yes	38	0,42	0,38	0,04*
P14. PTS	58	33	59	32	36,8	5,3	57,9	No	68	35,0	5,0	60,0*	Yes	66	0,58	0,54	0,04*
P15. OEM	63	33	64	31	33,3	5,6	61,1*	Yes	61	31,6	5,3	63,2*	Yes	57	0,52	0,49	0,04*
Expected likelihood of the willingness to pay (revenue models adequacy) (0 to 100%)																	
P16. BSO	53	28	52	25	40,0	15,0	45,0	No	38	40,0	10,0	50,0	No	34	0,54	0,48	0,05*
P17. MPS	51	28	43	30	43,8	12,5	43,8	No	42	52,6	10,5	36,8	No	58	0,55	0,70	0,15
P18. ULO	49	24	54	24	43,8	12,5	43,8	No	46	38,9	11,1	50,0	No	41	0,49	0,46	0,04*
P19. PTS	34	20	35	21	63,2*	26,3	10,5	Yes	30	60,0*	30,0	10,0	Yes	30	0,58	0,60	0,01*
P20. OEM	47	29	45	26	35,3	23,5	41,2	No	38	38,9	27,8	33,3	No	32	0,62	0,58	0,03*

Note. BSO = Bikesharing Operators; MPS = Municipalities and Public Services; ULO = Urban Logistics Operators; PTS = Public Transport Services; OEM = Bicycle Manufacturers; *respects the defined threshold.

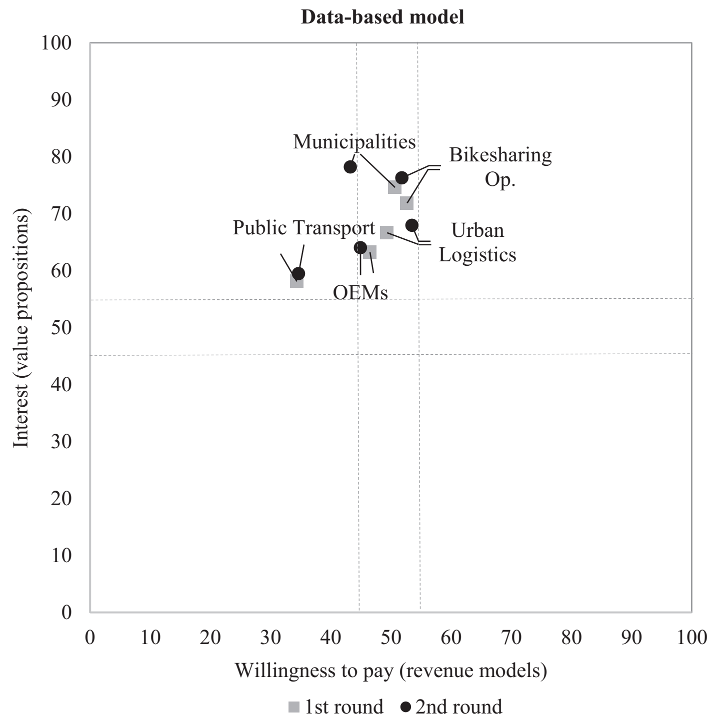

Fig. 2. Mean estimates of the stakeholders' interest and willingness to pay to access mobility, transactional and behavioural data.

improving the internal operations» (Exp27), supporting them in «increasing the user-experience and/or reducing operational costs» (Exp10), particularly those associated with «rebalancing stations» (Exp29). However, not all operators will be equally interested, as some either have the mentality «that information does not represent our city habits» (Exp8) or they focus mainly on commuters, for which «weather, topography, accessibilities represent deterministic factors that make [them] discard information» (Exp8).

Some experts think that data could be more attractive to stakeholders «if they are big» (Exp4), because «small or public projects do not have to really seek efficiency and there is no competition» (Exp7). Others believe data analytics would appeal more to «an operator that does not have a data scientist/analyst» (Exp10) but they would still «need to have technical expertise to process data and integrate it into their schedule planning and modelling» (Exp8). In any case, data services should provide them with «KPIs and analytics different from what they are [already] measuring» (Exp21).

In the case of Municipalities and Public Services, there was agreement and consensus around their interest in data services. Experts believe that «mobility and behavioural patterns are always welcome, to assist monitoring and planning» (Exp10), supporting «a better and smarter urban management and assisted decision making» (Exp31) to «execute mobility policies» (Exp30). Still, some experts note that data is «sensitive to manage» (Exp5) and some institutions may lack the resources to «make quick reactions» (Exp11) based on the available data.

Experts believe that Urban Logistics Operators would also recognise value in data and analytics considering their need to «optimize operations» (Exp20, 22, 32). The same argument supports the estimates about the interest of Public Transport Services. They would value data to «adapt their network and their itineraries accordingly and optimize ridership» (Exp16) and to «plan services and identify gaps in the network» (Exp16). On the other hand, «public transport runs on fixed routes and schedules (…), so optimizing these routes (…) only happens once in a decade or so» (Exp20). Additionally, as they tend to operate with «old systems and personnel, the tech barrier is high» (Exp8).

According to the experts, OEMs would be interested in data «for their analytics and R&D» (Exp19). Such data may assist them to «understand potential pain points that can help to improve the vehicles» (Exp21) and «give them competitive advantages» (Exp32). However, some experts disagree, arguing that as «this information [is] available for everybody, even if subject to a fee, it does not represent a competitive advantage» (Exp28). Also, they would «be more interested in such data if collected from a proprietary app based on malfunction and usage data from their own customers» (Exp24). In fact, «some bike manufactures have already some data from some technology introduced in the bicycles or from other applications/platforms (such as Strava and Strava Metro)» (Exp30).

Following the same pattern as the service-based model, the experts were much more cautious when assessing the willingness of the different stakeholders to pay for data and data analytics. The lowest likelihood ($\bar{X}$=35%) was attributed to Public Transport Services (P19) and the highest ($\bar{X}$=54%) to Urban Logistics Operators (P18), after two rounds. Results indicate, however, that there was no agreement among the experts in four out of five projections. They provided very different estimates, falling both into the lower and the higher range, resulting in mean assessments that mostly concentrate in the neutral range (Fig. 2). Thus, consensus, measured by the IQR, was not achieved for any projection. The conflicting opinions seem to be fairly stable, though. When analysing the CV change, the threshold of 0.1 was not met only in the case of Municipalities and Public Services' willingness to pay for data and data analytics (P17). This suggests that this topic is contentious, generating different reactions, or that it may not be fully understood by the experts. The qualitative comments offer some insights.

Although experts acknowledge that data and analytics are useful for Bikesharing Operators, they also believe that they «generally run on low margins» (Exp1) making it difficult for them to pay for this kind of services. Also, they assert that «such operators have access to their own data sources from existing riders» (Exp24) and that «rebalancing data and forecast demand must be pulled mainly from their own datasets, so they would not need to pay for an extra service to know where their bikes need to be» (Exp20).

Municipalities and Public Services, in turn, «are hungry for reliable mobility data and, [may be] ready to pay for it» (Exp20). However, as for them «costs are rarely welcome» (Exp5) maybe only «small charges»

(Exp13) would be possible. Even if they are willing to pay for these services, they face «too many bureaucratic obstacles» (Exp2) in terms of budget planning. For this reason, «the possibility of having a fee/subscription is higher» (Exp33) than the interest in paying for sporadic services.

As for the Urban Logistics Operators, the «majority will be willing to pay a fee for such service/data» (Exp22). Still, the fee would need to «be defined by the value that operators will expect to reap from that access» (Exp22). As «they are interested in minimizing expenses» (Exp30), a data service «should demonstrate a cost reduction» (Exp27) which could be conveyed by providing a «strong theoretical use case to show and/or a "plug-and-play" pilot demonstration in real-life conditions» (Exp27).

A similar opinion was shared regarding Public Transport Services. For these players «data analytics can be a must-have and paid data services can take place, probably in a project/pilot base first, and if value is found it can become a recurring/continuous service» (Exp10). However, those who ranked lower the Public Transport Services' willingness to pay for data, justify it by stating that «they already have access to this data» (Exp27), to «all the info they need» (Exp21).

Finally, OEMs may be willing to pay «a low-fee price (…) and optionally adding some extra features with an extra cost» (Exp21), although «on-demand analytics» (Exp33) could be more interesting for them than paying a fee for regular data. However, some experts have reservations about their willingness to pay for data in any model, since some consider that the «bicycle industry is a poor industry with a traditional mindset» (Exp17) and because they «get feedback from distributors, hardly will pay someone else» (Exp2). To pay for data they would need to «have an "assurance" of value, which needs to be previously proved» (Exp10). Fig. 3 summarises the strengths and challenges identified by the experts for each of the two business model scenarios.

5. Discussion

In general, experts predict that the value propositions associated to both models will be attractive to key members of the ecosystem. The service-based model would be able to bring together the key members of the connected cycling urban mobility ecosystem, enabling supply-side members to reach and get valuable feedback from urban cyclists, for example, through crowdsourced data (Nelson et al., 2021). It would facilitate transactions and interaction, raising stakeholders' engagement in the co-creation of integrated services (Meurs et al., 2020; Schreieck et al., 2016; Williamsson & Moen, 2022), which experts agree would be highly valued by urban cyclists. This could offer an important contribution to a more sustainable mobility in cities, extending the benefits generated for the stakeholders involved also to society and the environment (Broekhuizen et al., 2021). The synergies created would enable the more efficient management of traffic by the relevant authorities (e.g., by optimizing transportation logistics and reducing congestion) and stimulate the use of more environmentally friendly transport modes, like bicycles and public transport (Abduljabbar et al., 2021; Elmashhara et al., 2022; Sochor et al., 2018). It would also improve city liveability by increasing the convenience and ease with which places and services are reached using those greener transport modes (Elmashhara et al., 2022; Karanikola et al., 2018; Moreno et al., 2021). The growing number of private and publicly-owned MaaS platforms integrating micromobility solutions (e.g., "Whim" in Helsinki, "Move PGH" in Pittsburgh, USA, "SkedGo" in Sydney or "Willers" in Singapore), and some specifically focused on the cycling ecosystem (e.g., Bike Citizens (http://www.bikecitizens.net) or Vaimoo (https://www.vaimoo.com), illustrates the great potential of these service-based models.

Analytics on the data generated by the different members of the ecosystem reveal transactional and behavioural patterns that can be of great value to improve their operations and decision-making (Heiskala et al., 2016). A complementary data-based model would therefore be possible. Data has been considered "the new oil" for the enormous opportunities and potential for competitive advantages that it can create (Broekhuizen et al., 2021; Wiener et al., 2020). Experts agree this applies to members of the connected cycling urban mobility ecosystem, who would benefit from increased efficiency and effectiveness based on such data, allowing them to optimize operations, improve infrastructure and customer experience.

However, experts' insights call attention to the challenges some

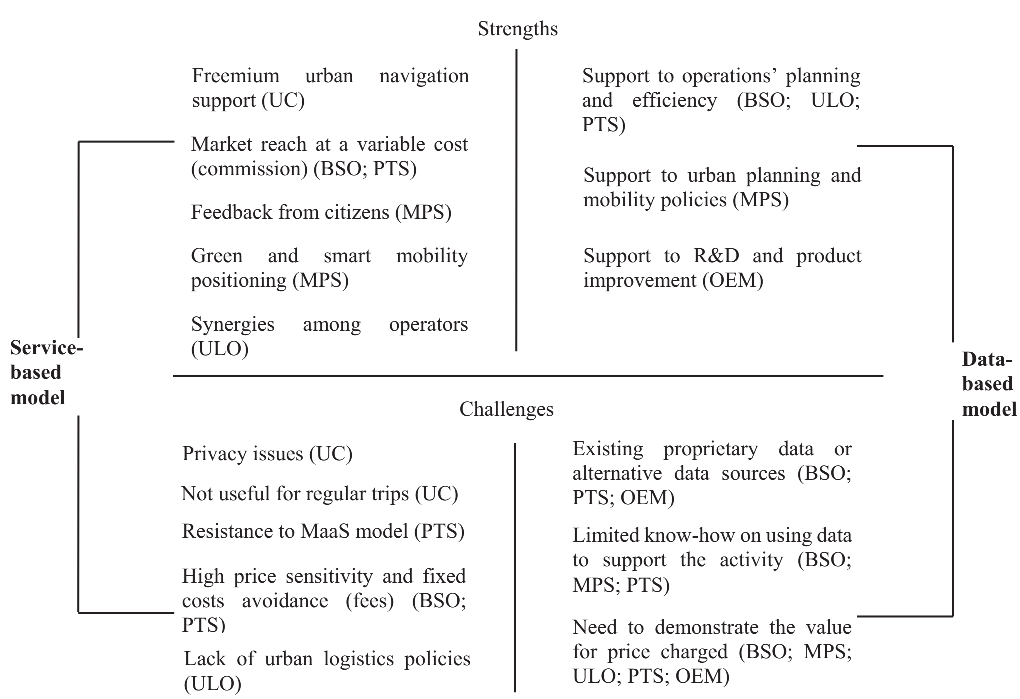

Fig. 3. Main strengths and challenges of the two assessed business model scenarios.
Note. UC= Urban Cyclists; BSO = Bikesharing Operators; MPS = Municipalities and Public Services; ULO = Urban Logistics Operators; PTS = Public Transport Services; OEM = Bicycle Manufacturers.

stakeholders would face to join such a collaborative digital platform, including the availability of resources, be they technical or financial. Specifically, in the case of the data-based model, analytics may be preferred over data packages as some stakeholders may not possess the internal capabilities to extract useful information from raw data to get the answers they need (Schroeder, 2016). This suggests that, in this context, a data service may need to integrate a strong customer support and even specific training to reach a wider market with different products.

The difficulty of public agents (like municipalities and public transport) in ensuring sufficient flexibility to adjust their operations to benefit from analytics and use their budgets in such projects is also noted (Meurs et al., 2020; Polydoropoulou et al., 2020). The challenges associated with the collaboration of public and private partners within the smart city context have been recognised (Ferraris et al., 2018; Polydoropoulou et al., 2020). So, a few notorious success cases may be needed to overcome some reluctance or hesitation.

Results also show that monetisation of both service and data-based models could be problematic. Experts' expectations about the supply-side stakeholders' willingness to pay are not altogether concurring and tend to be low, despite the appeal of their value propositions. Particularly in the case of the data-based model, lower agreement and stability could suggest that this model is still challenging or not fully understood. The issue of monetisation in data-driven business models has been previously identified as important, but research on this topic is notably lacking (Hartmann et al., 2016). The results of our study add to previous knowledge by suggesting a preference for low commitment and low risk payment schemes like small commissions or pay-per-use, and highlight the need to demonstrate the benefits of data and analytics to convince some of the stakeholders of the urban mobility ecosystem. Models such as gainsharing, which is a commission charged over the gains (or savings) realized by the customer from using the supplied data or analytics (Schüritz et al., 2017) would possibly need to be considered.

Given the uncertainty about the financial sustainability of a cycling urban mobility connected system suggested in the study, a combination of the two business models (service and data-based) may be needed to ensure diversification of the expectedly thin revenue streams. Making the data-based model more attractive will likely involve offering a more comprehensive portfolio of data services, tailored to the needs of each stakeholder. As suggested by the experts, free pilot trials may have to be granted to stakeholders so they can assess the value they can accrue to their businesses from the data and analytics. Also, as different cost sensitivities were inferred from the experts' opinions regarding different stakeholders, an integrated urban cycling ecosystem would require the cross-subsidisation of some of them to ensure the participation of key players (Gawer, 2021; Heiskala et al., 2016).

6. Conclusion

The role of technology and bicycles in urban mobility have been growing and they are expected to feature prominently in the future of cities for their potential to improve sustainability and liveability (Abduljabbar et al., 2021; Meireles & Ribeiro, 2020). It is therefore essential to establish viable business models for the connected cycling urban mobility ecosystem (Athanasopoulou et al., 2019; Kohtamäki et al., 2019). This study uses the Delphi technique to explore experts' projections regarding the value propositions and revenue models of a digital service-based and a data-based business model for connected cycling urban mobility. We contribute by considering multiple stakeholders, including the demand-side urban cyclists and several key supply-side stakeholders of a digital platform for the connected cycling urban mobility ecosystem. This allows us to ascertain the attractiveness of the value propositions of such a platform. On the other hand, we also find that its monetisation would be a challenge, which could jeopardise the platform's long-term sustainability. Although financial viability is a basic business concern, this tends to be overlooked in much of the literature on data-driven businesses (Hartmann et al., 2016) and especially within micromobility, where attention in concentrated on operational matters and environmental sustainability (Abduljabbar et al., 2021; Elmashhara et al., 2022). By highlighting this issue, and proposing the combination of the service-based and the data-based business models as a potential way to mitigate it, we also contribute to addressing the role of sustainability in service platform-based business models (Kohtamäki et al., 2019). Although we specifically studied the urban cycling context, these business models for digital platforms may be relevant for other mobility modes. Future studies should therefore examine other smart mobility contexts, assessing the applicability of value propositions and revenue models to the members of those different ecosystems. The data-based model also deserves further future study, overcoming some limitations of this study, which was restricted to two rounds and may have not fully explored the unstable divergent opinions found. Moreover, future studies should explore suitable governance structures that accommodate the idiosyncrasies of all partners and ensure the necessary trust (Meurs et al., 2020; Schreieck et al., 2016; Williamson & Moen, 2022).

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Author statement

All authors have seen and approved the final version of the manuscript being submitted. They warrant that the article is the authors' original work, has not received prior publication and is not under consideration for publication elsewhere.

Declaration of Competing Interest

The authors have no conflicts of interest to declare.

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