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Preliminary communication

Business Model for Shared Autonomous Vehicles Mobility Services

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Abstract: We propose a business model (BM) for mobility services based on shared autonomous vehicles (SAVs) anticipating the changes and opportunities for the current shared mobility service companies in updating their BMs to consider the AV technology. We have analysed the service characteristics of the current shared mobility services-taxi, ride-sourcing, ride-sharing, car rental, peer-to-peer car-sharing, and business-to-consumers car-sharing–and accordingly we determined how they would change when AVs are implemented into these services. The Lean Canvas is used to prepare the new BM, assuming the convergence of the current shared mobility services' BMs. We found that a customized travel fee and involvement of private AV owners in the service will alter revenue streams and customer segments, but modifications of key metrics and channels are not needed. According to the elaborated results, shared mobility companies can determine alterations in their BMs, strategy, and targets.

Keywords: business model; lean canvas; mobility service; shared autonomous vehicles

1 INTRODUCTION

Shared mobility services are potential solutions to decrease private car ownership, improve air quality, fill gaps in public transportation, and free up parking spaces [1] due to higher utilization of vehicles. Besides these benefits, Shared Autonomous Vehicles (SAVs) will reduce traffic accidents and road space demand. Also, they will be accessible to people without driving abilities and reduce personnel costs for shared mobility service operators [2]. The implementation of autonomous vehicles (AVs) into shared mobility services will impact service characteristics and, consequently, the business models. Business model and service characteristics have a mutual relationship, thus, changes in one impact another. A business model (BM) is a framework in which the necessary elements such as value proposition, customer, and resources for a new product or service are identified to enter the market successfully, attract investors, and anticipate expenses. Additionally, elements that create value for the company itself such as revenue streams and costs are also included. BM is a starting point to define the strategy, organizational structure, and business planning to overcome the competitors [3]. Curtis (2021) [4] classified the BMs applied to current shared mobility services into three types, focusing on the relationship between the business and the consumer. We considered the Business-to-consumer type in our SAV mobility service as it will be the most characteristic.

- Business-to-consumer (B2C) BMs are commercially oriented and tend to operate internationally. The price is set by the mobility-sharing platform, usually applying location-based and access-based prices. The revenue streams contain transaction fees, subscription fees, usage fees, and fines; it is applicable for car-sharing, ride-sharing, taxi, ride-sourcing and car rental.
- Peer-to-peer (P2P) BMs present a review system for users; resource owners are service providers instead of a company. The price is determined by the resource owner and features used, and a subscription fee is not common; it is usually applied by car-sharing and ride-sharing services.
- Business-to-business (B2B) BMs have the exchange of goods and services between two or more companies; it can be used by taxi, car rental, and car-sharing services.

In 2040, about 55% of total passenger kilometres will be covered by AV-based services [5]; thus, our objective was to forecast the changes and opportunities for the current shared mobility service companies in updating their BMs to consider the AV technology. Although changes in the BMs of shared mobility services with the implementation of AVs into the service have been speculated [1, 2], a BM for SAVs mobility services has not been proposed yet. Raudaschl (2020) [6] only analysed the BM of an autonomous Tesla taxi using the Lean Canvas (LC). Our research aims to fill this gap by proposing a BM for mobility services based on SAVs using the LC. We have identified service characteristics and compared the current shared mobility services; then, based on the literature and experts' opinions, we have foreseen the new BM. We used the LC to elaborate our new BM because it is more efficient for innovative solutions and not yet well-established businesses [7]. Our research questions are:

1) How to alter the BM of current shared mobility service companies to those applying AVs?
2) What are the customer segments and revenue streams when AVs are implemented into the current shared mobility services?

We considered the SAV mobility service characterized as follows:

- vehicle capacity is 4 - 9 persons,
- vehicles are owned by either operators or private owners,
- vehicles and rides are shared in the urban door-to-door service,
- B2C service is provided,
- the service provider operates with its own fleet and AV from private owners,
- the service provider and vehicle operator are considered as only one company.

The paper is structured as follows. The literature is reviewed in Section 2. We presented our created methodology to foresee the new BM in Section 3. Our proposed BM is presented in Section 4 and discussed in Section 5 where the implications for travellers, companies, and the environment are highlighted. Conclusions are drawn in Section 6.

2 LITERATURE REVIEW

In our study, we considered the current most typical shared mobility services:
1) taxi,
2) ride-sourcing,
3) ride-sharing,
4) car rental,
5) P2P car-sharing, and
6) B2C car-sharing.

We performed the following steps:
1) we elaborated a central source of information about the service characteristics of the current shared mobility services to fill the gap in the literature;
2) we reviewed the BM trends as changes in the service characteristics and BMs of the current shared mobility services after the implementation of AVs into these services are expected;
3) we explained the templates available to build our proposed BM and justify the use of LC.

2.1 Service Characteristics of the Current Shared Mobility Services

We created a central source of information with a summary of the main service characteristics of the current shared mobility services; this central source was missing in the literature. Taxi is provided by self-employees, cooperative members, or fleet companies. The vehicles are regulated by license, and a certified taximeter shows the fee according to traveling time, distance and time of the day [8]. People take the taxi on the street or at pre-determined locations; investments in information services occurred after ride-sourcing services [9]. Car owners provide ride-sourcing and a company operates the sharing platform; it is known as a Uber-like service. Riders and nearby drivers are matched, providing lower waiting times and fares than taxi rides. Wei et al. (2020) [10] proposed three types of BMs for ride-sourcing considering vehicle ownership and occupancy:
1) Premier offers personalized service to a passenger. Drivers can be hired. Cooperatives or platforms have their fleets.
2) Pooling allows the sharing of travel expenses among users. Drivers are car owners who are responsible for operational costs; the platforms provide mainly insurance and technology.
3) Hybrid combines premier and pooling.

In ride-sharing, the driver stipulates the schedule, origin, and destination, allowing the travellers to join the trip. The BMs of ride-sharing and ride-sourcing are similar regarding costs and revenue. Travellers want to travel long distances which are not worth using ride-sourcing or taxi and drivers want to share trip costs instead of aiming for profit. Namely, BlaBlaCar operates via a website; it sets a price limit to ensure drivers do not have any profit [11]. However, profit-oriented drivers are allowed on Oszkár's platform [12, 13]. Car rental is offered by fleet companies. The daily price, availability, and pick-up locations are pre-defined. Round-trip is common but one-way is allowed paying an additional fee. The BM of Avis Budget presents special discounts [14]. Car owners provide P2P car-sharing and a company operates the sharing platform. Different from car rental services as much as P2P platforms may not ask for a deposit [15]. A commission is kept by the platform as revenue and there are insurance costs. For example, Turo keeps around 25% instead of the 13% applied by Getaround [16, 17].

The service providers of B2C car-sharing are:
- designated car-sharing companies,
- traditional car renters,
- vehicle manufacturers, and
- public actors, such as public transport operators and local authorities [1]. Unlike car rental, B2C car-sharing provides no working hours restriction.

The user must possess a driving license. Drivers are charged for the vehicle usage time, distance covered, or a combination while costs related to ownership (e.g., purchase) and operation (e.g., maintenance) are not paid directly [18]. In some cities, users have to pay a deposit [15]. Free-floating (e.g., MOL Limo, Share Now companies) or round-trip, and zone-based or station-based are the most common BMs. They usually offer less spatial flexibility than car rental and P2P car-sharing.

2.2 BM Trends

We summarized the BM trends from the literature. The implementation of AV-based services may cause a convergence of current shared mobility services' BMs; for example, car-sharing and ride-sourcing will be very similar services as AVs pick users up [2, 20]. Moreover, it is foreseen that two BMs types based on vehicle ownership will be applied in the future of transportation:
- Private ownership model - companies offer on-demand mobility services [19].
- Sharing model - private AV owners offer the free capacity of their vehicles to mobility service companies [6].

Operators can decide to own a fleet or establish partnerships with vehicle owners; this partnership is advantageous for both stakeholders regarding reduction of costs and revenue. To create a mass market of SAV services and attract investors, there is a need to design a dominant BM [20] in which novel and altering features are capitalized [19]. Typical types of BM changes are as follows [21]:
1) BM aligned with the regime (i.e., a particular way of operating or organizing a business) and not changing it. The value proposition is aligned with the existing regime; for example, changes in the sources of revenue for car-sharing services do not affect their operation or value proposition.
2) Adapted BM, the value proposition of the BM is realigned with the regime, overcoming barriers to the business. Thus, this change might result in innovation; for example, when a station-based car-sharing is changed to a free-floating type, the operation and the value proposition should be altered.
3) Amplified BM which targets collaboration with key partners, opening new business opportunities; for example, partnerships between car-sharing and micro-mobility companies result in mobility packages.

Hence, adapting affects only the company, while amplification affects the whole market. Moreover, a diversified BM enhances competitiveness by increasing

the diversity and availability of the service [22]. To sum up, it is necessary to create a dominant BM reflecting the service characteristics resulting from the convergence of current shared mobility services' BMs; thus, our proposed BM serves as a starting point for filling this gap in literature. Also, our proposed BM is a mix of amplification and diversification due to the convergence of BMs and the offer of customized service.

2.3 Types of Canvas

We explained the differences between BM Canvas and LC, how to use these templates, and justified the use of LC in our study. The BM Canvas [23] and the LC [24] are examples of visual templates to support entrepreneurs in the creation or modification of a BM. Both have nine blocks. Fig. 1 shows the blocks used in the BM Canvas. The grey blocks (key partners, key activities, key resources, and customer relationships) will be replaced in the LC because the LC is focused on solving a problem and the new blocks are aligned with this aim. Alternatively, five blocks are in common with the BM Canvas and the LC [23] (Fig. 2):
1) unique value proposition - why the product/service is different and worth paying attention;
2) customer segments - target customers;
3) channels - how to communicate with customers;
4) cost structure - fixed and variable costs;
5) revenue streams - sources of revenue.

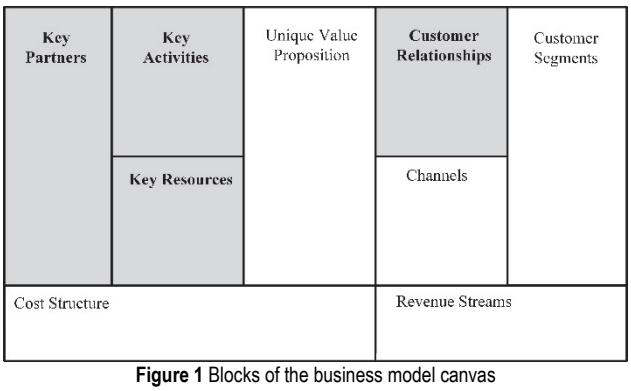

Figure 1 Blocks of the business model canvas

Fig. 2 illustrates the extended version of the LC. The greyblocks in the LC are:
- problem - identified problems to be solved;
- solution - options to solve the problems;
- key metrics - performance indicators;
- unfair advantage - unique strengths difficult to copy by competitors.

The extended version of the LC has two additional blocks to include sustainability aspects:
- Sustainability benefits, to capture both the environmental and the social benefits.
- Beneficiaries, to capture the stakeholders who benefitted from the service/product.

The extended LC facilitates the long-term prosperity of the future organization [25] and is easier than a triple-layered BM canvas created by [26].

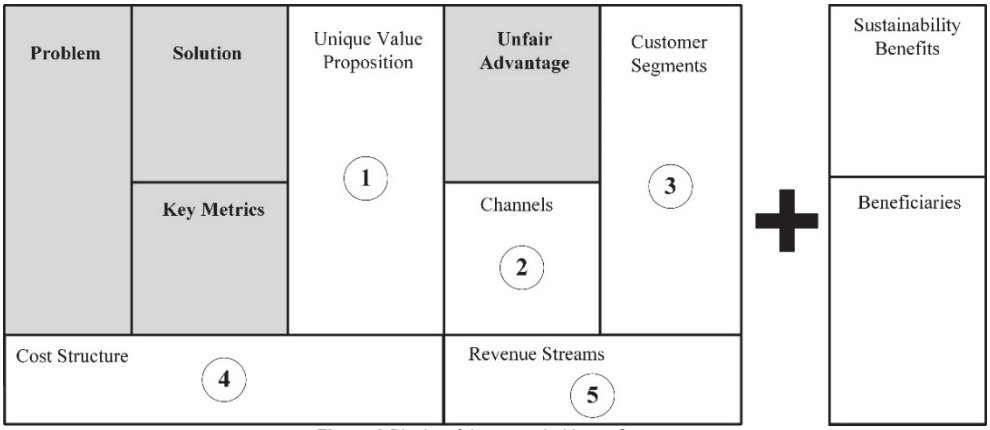

Figure 2 Blocks of the extended Lean Canvas

3 METHODOLOGY

We have created a methodology to elaborate our proposed BM. Previous studies as well as the gaps in the literature served as a starting point for the elaboration of our methodology. Tart et al. (2018) [15] characterized and compared the BMs of fifteen car-sharing service providers using the BM Canvas. Raudaschl (2020) [6] used the LC to analyse the service of an autonomous Tesla taxi. To understand the possible BMs for SAV services, Stocker and Shaheen (2017) [2] discussed the BMs of current shared mobility services and explored the potential impacts of SAVs. Based on the literature review and knowledge of seven transportation experts from the Transport Systems and Mobility Services Research Group at the Budapest University of Technology and Economics, in our methodology we have:

1) Identified more than 80 service characteristics for the blocks of the LC.
2) Examined the service characteristics of the current shared mobility services according to the blocks of the extended LC and, after that, we have compared the BMs.
3) Determined which service characteristics are to be incorporated into our proposed BM.

Traffic consisting of just AVs with the highest automation level (level 5) is considered [27].

3.1 Service Characteristics

We identified the service characteristics for all blocks of the LC; they are numbered from 1 to 91. In Tab. 1, we indicated each block of the extended LC by a letter between parenthesis:
(a) Problem.

(b) Solution.
(c) Key Metrics.
(d) Unique Value Proposition.
(e) Unfair Advantage.
(f) Channels.
(g) Customer Segments.
(h) Cost Structure.
(i) Revenue Streams.
(j) Sustainability Benefits.
(k) Beneficiaries.

3.2 Current Shared Mobility Services

We examined the service characteristics of the current shared mobility services according to the blocks of the extended LC and, after that, we compared the BMs. In Tab. 1, the sign "✓" indicates that a service characteristic is present in the corresponding mobility service. Alternatively, the sign "✓*" (with asterisk) indicates the presence of characteristics with limitation (s). For instance, all six shared mobility services present "1. Travel whenever and wherever by accessing an app" with spatial or temporal limitations (i.e., opening hours, availability of the driver, one-way or round-trip). We compared the shared mobility services according to their characteristics. The relevant results of the comparison for each block of the LC are described as follows. Drivers' related elements are not depicted as drivers will be eliminated in the future. Our results (Tab. 1) are novel as similar analysis and comparison are not available in the literature. We split Tab. 1 showing its content according to the text.

(a) Problem - Shared mobility services eliminate problems related to car ownership and operation. For example, traffic jams, parking problem /a5/, and environmental pollution /a6/ in cities. Travelers without the driving ability /a3/can use taxi, ride-sourcing, and ride-sharing.

Table 1 Comparison of shared mobility services

Lean Canvas Block	N.	Service Characteristics	(b) Solution							In the SAV BM?	SAV Business Model Item
			Current Shared Mobility Services						SAV		
			Taxi	Ride-sourcing	Ride-sharing	Car rental	P2Pcar-sharing	B2Ccar-sharing			
(a) Problem-Traveller	1	Travel whenever and wherever by accessing an app	✓*	✓*	✓*	✓*	✓*	✓*	✓	*	
	2	Expensive and unsustainable car ownership/operation	✓	✓	✓	✓	✓	✓	✓	+	/a1/
	3	Limitations of transitional services (spatial/temporal)							✓	Δ	/a2/
	4	Not everyone can drive	✓	✓	✓				✓	Δ	/a3/
	5	Unreliable/unsafe travels							✓	Δ	/a4/
	6	Traffic jam, parking problem	✓	✓	✓	✓	✓	✓	✓	+	/a5/
	7	Environmental pollution	✓	✓	✓	✓	✓	✓	✓	+	/a6/
(a) Problem - Driver/Car owner	8	Underutilized private car		✓			✓		✓	*	
	9	Willingness to earn money		✓			✓		✓	*	
	10	Underutilized seats		✓	✓				✓	*	
	11	Willing to abate trip costs			✓				✓	*	
Existing alternatives	12	Taxi		✓				✓*	✓	+	/a7/
	13	Ride-sourcing	✓					✓*	✓	+	/a8/
	14	Ride-sharing				✓*	✓*	✓*	✓	+	/a9/
	15	Car rental			✓*		✓		✓	+	/a10/
	16	P2P car-sharing			✓*	✓		✓*	✓	+	/a11/
	17	B2C car-sharing	✓*	✓*	✓*		✓*		✓	+	/a12/
	18	Private car	✓	✓	✓	✓	✓	✓	✓	+	/a13/
(c)Key Metrics	19	Number of drivers/peers	✓	✓	✓					-	
	20	Number of days for rent				✓	✓			-	
	21	Daily trips	✓	✓	✓			✓	✓	+	/c1/
	22	Daily covered distance	✓	✓	✓			✓	✓	+	/c2/
	23	Number of active users	✓	✓	✓		✓	✓	✓	+	/c3/
	24	Fleet/capita	✓	✓	✓	✓	✓	✓	✓	+	/c4/
	25	Daily empty-run distance	✓					✓	✓	+	/c5/
	26	Service rating by users	✓	✓	✓	✓	✓	✓	✓	+	/c6/
(d) Unique value proposition - Traveller	27	Enhanced privacy						✓	✓	*	
	28	Easy to book, pay, cancel	✓	✓	✓	✓	✓	✓	✓	*	
	29	On-demand service	✓	✓	✓				✓	*	
	30	Access to driver/peer's contact details	✓	✓	✓		✓		✓	*	
	31	Trip cost is shared		✓	✓				✓	*	
	32	No need of chauffeur				✓	✓	✓	✓	*	
	33	Longer trips				✓	✓		✓	*	
	34	No working hours				✓			✓	*	
	35	One-way trips	✓	✓	✓			✓	✓	*	
	36	Userhip values more than ownership	✓	✓	✓	✓	✓	✓	✓	+	/d1/
	37	Affordable, sustainable	✓	✓	✓	✓	✓	✓	✓	+	/d2/

Table 1 Comparison of shared mobility services - Continuation

Lean Canvas Block	N.	Service Characteristics	Solution (b)							In the SAV BM?	SAV Business Model Item
			Current Shared Mobility Services						SAV		
			Taxi	Ride-sourcing	Ride-sharing	Car rental	P2P car-sharing	B2Ccar-sharing			
(d) Unique value proposition - Traveller	38	Variety of the fleet	✓	✓	✓	✓	✓	✓*	✓	*	
	39	Travel whenever and wherever	✓*	✓*	✓*	✓*	✓*	✓*	✓	Δ	/d3/
	40	Integrated operational and traffic control							✓	Δ	/d4/
	41	Sharing cars and seats without owning them	✓	✓	✓	✓	✓	✓	✓	+	/d5/
Unique value proposition (d) - Driver/Car owner	42	Flexible working hours		✓	✓		✓		✓	*	
	43	Extra income		✓	✓		✓		✓	*	
	44	Easy payment	✓	✓	✓		✓	✓	✓	*	
	45	Reliable users			✓		✓		✓	*	
	46	Efficient usage of resources	✓	✓	✓	✓	✓	✓	✓	Δ	/d6/
	47	Merge shared services							✓	Δ	/d7/
(e)Unfair advantage	48	High brand awareness		✓	✓			✓	✓	+	/e1/
	49	Enhance traveller's independence	✓	✓	✓	✓	✓	✓	✓	+	/e2/
	50	Strong partnerships	✓	✓		✓		✓	✓	Δ	/e3/
	51	High capacity utilization of vehicles	✓	✓	✓	✓	✓	✓	✓	Δ	/e4/
(f)Channels	52	Word of mouth, user referrals	✓	✓	✓	✓	✓	✓	✓	+	/f1/
	53	Social media, website, mobile app	✓	✓	✓	✓	✓	✓	✓	+	/f2/
	54	Advertisement	✓	✓	✓	✓	✓	✓	✓	+	/f3/
(g) Customer segments - Traveller	55	Not smartphone user	✓			✓				*	
	56	Smartphone user	✓	✓	✓	✓	✓	✓	✓	+	/g1/
	57	Urban traveller	✓	✓	✓	✓	✓	✓	✓	+	/g2/
	58	Current shared mobility users	✓	✓	✓	✓	✓	✓	✓	+	/g3/
	59	Travellers with high-value travel time	✓*	✓*		✓*	✓*	✓*	✓	+	/g5/
Early adopters	60	Young people		✓	✓		✓	✓	✓	+	/g6/
	61	People with sharing economy, sustainability awareness		✓	✓		✓	✓	✓	+	/g7/
	62	People with AV technology awareness							✓	+	/g8/
	63	Tech-savvy people			✓			✓	✓	+	/g9/
(g) Customer segments - Driver/Car owner	64	People who own a car and want an extra income		✓	✓		✓		✓	Δ	/g4/
	65	People who love to drive	✓	✓	✓					-	
(h) Cost structure	66	IT platform development and operation	✓	✓	✓	✓	✓	✓	✓	+	/h1/
	67	Fleet purchase - insurance, taxes	✓			✓		✓	✓	+	/h2/
	68	Fleet operation - Drivers	✓							-	
	69	Fleet operation - personnel costs reallocation				✓		✓		-	
	70	Fleet operation - fuel/charging, maintenance, cleaning	✓			✓		✓	✓	+	/h3/
	71	Infrastructure usage costs - parking, pick-up point, depot	✓			✓		✓	✓	+	/h4/
	72	Personnel costs (customer service)	✓	✓	✓	✓	✓	✓	✓	Δ	/h5/
	73	Marketing	✓	✓	✓	✓	✓	✓	✓	+	/h6/
	74	Legal costs	✓	✓	✓	✓	✓	✓	✓	Δ	/h7/
(i) Revenue streams	75	Subscription fee						✓	✓	+	/i1/
	76	Service fee/Commission on transactions	✓	✓	✓	✓	✓	✓		-	
	77	Deposit				✓				-	
	78	Additional service				✓				-	
	79	Customized fee							✓	Δ	/i2/
	80	Fine				✓	✓	✓	✓	+	/i3/
(j) Sustainability Benefits	81	Boost sharing economy	✓	✓	✓	✓	✓	✓	✓	+	/j1/
	82	Enhance energy efficiency	✓	✓	✓	✓	✓	✓	✓	+	/j2/
	83	Mitigate job losses		✓			✓		✓	+	/j3/
	84	Improve service availability and vehicle occupancy			✓				✓	+	/j4/
	85	Reduction in parking demand	✓	✓	✓	✓	✓	✓	✓	Δ	/j5/
(k) Beneficiaries	86	Individuals with transport issues	✓	✓	✓	✓	✓	✓	✓	+	/k1/
	87	Cities promoting better quality of life	✓	✓	✓	✓	✓	✓	✓	+	/k2/
	88	Cities struggling with parking, traffic management	✓	✓	✓	✓	✓	✓	✓	+	/k3/
	89	Operators willing to improve sustainability in business			✓				✓	+	/k4/
	90	Operators looking for cost reduction	✓	✓	✓				✓	+	/k5/
	91	Car owners with underutilized vehicles		✓	✓		✓		✓	+	/k6/

(c) Key metrics - The number of drivers or peers is a key metric for all types except car-sharing and car rental. Daily trips /c1/ and covered distance /c2/ can be useful for B2C car-sharing, but usage time is also relevant. For P2P car-sharing and car rental, the number of days for rent is a more appropriate indicator. Moreover, the number of active users /c3/, the fleet per capita /c4/, and the service rating by users /c6/ are useful for all service types.

(d) Unique Value Proposition - Compared to car ownership, all services are more affordable and sustainable /d2/, and offer a variety of vehicle types in the fleet.

(e) Unfair Advantage - The high brand awareness /e1/ may increase possible customer groups and chances of profitability [28]. Additionally, traveller's independence /e2/, and traveller's privacy are achieved as the service is available through a platform.

(f) Channels - All mobility services use traditional (e.g., word of mouth) and internet-based channels (e.g., social media) /f1/, /f2/, and /f3/.

(g) Customer segments - Customer groups are overlapping; travellers and drivers/car owners are distinguished. Customers of the shared services may be smartphone users /g1/ and urban travellers /g2/, but traditional taxi and car rental services are used by travellers who are not smartphone users as well. For drivers/car owners, having extra income with flexible working hours is the main motivation to be part of ride-sharing, ride-sourcing and P2P car-sharing. Moreover, travellers with high-value travel time /g5/ are benefitted.

(h) Cost structure - Costs for the development and operation of the info-communication platform /h1/ must be considered. In fleet operation /h3/, costs with drivers /h5/ are applicable to taxi (when fleet companies operate the service) whereas costs with reallocation apply to car rental and B2C car-sharing in one-way trips. Other fleet operational costs are delegated to car owners in ride-sharing, ride-sourcing, and P2P car-sharing. Fleet purchase /h2/ and infrastructure usage costs /h4/ (e.g., parking) affect services with own fleet (e.g., taxi, B2C).

(i) Revenue streams - Revenue is mainly generated by a service fee. A subscription fee /i1/ in B2C car-sharing and a fee due to rule-breaking fines /i3/ in car rental, P2P, and B2C car-sharing are added.

(j) Sustainability Benefits - current shared mobility services are great examples of the sharing economy /j1/ as they exploit sharing over owning. Being a driver in ride-sourcing and offering the private car in a P2P car-sharing are often temporarily options of income for unemployed people, mitigating the job losses /j3/. Offering available seats in ride-sharing improves service availability of shared services and vehicle occupancy /j4/.

(k) Beneficiaries - in general, shared mobility services benefit individuals with transport issues /k1/, cities /k2/-/k3/, operators /k4/-/k5/, and car owners /k6/

3.3 Service Characteristics in the Proposed BM

We have determined which service characteristics are part of our proposed BM. We have summarized the transition between the current and the future shared mobility services (Fig. 3); meanwhile, the SAV service was also inserted. The main changes in service characteristics due to the elimination of the driver are the following:

- The shared mobility services become part of SAV-based service.
- Ride-sharing exists when the ride is shared with the car owner.
- P2P car-sharing exists when the service negotiation is done with the peer.

Considering the service changes when AVs are implemented into the current shared mobility services and the elaboration of a BM for SAV services, we deliberated which service characteristics listed in Tab. 1 should be incorporated into our proposed BM. The results in column "In the SAV BM?" represent:

- minus sign (-) - If the service characteristic is not present in the SAV service, we did not incorporate into our BM either.
- asterisk sign (*) - we concluded that the service characteristic is present in the SAV service intrinsically, thus, we did not show it in our proposed BM to avoid repetition.

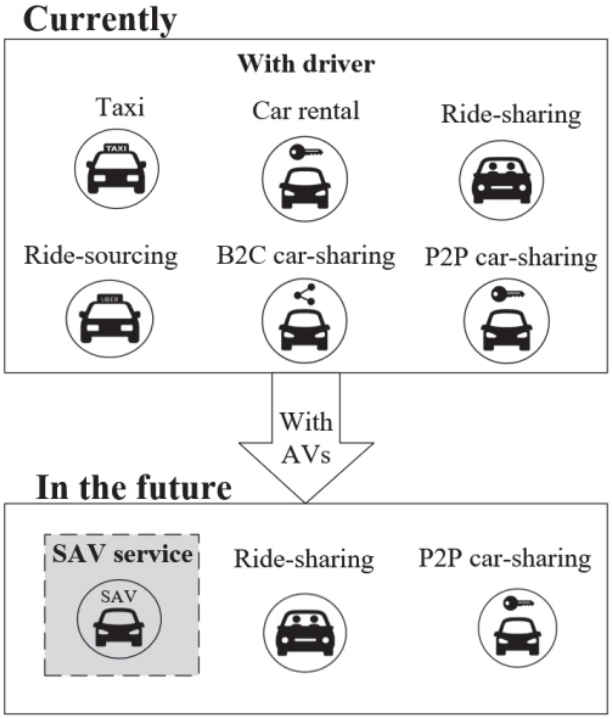

Figure 3 Transition of shared mobility services

- plus sign (+) - Otherwise, we incorporated it in our proposed BM.
- delta sign (*Δ*) - we concluded that the service characteristic changes from the current shared mobility services to the SAV service, thus, we indicated it in bold in Tab. 1 and in grey box in our proposed BM.

Hence, only service characteristics that are kept or changed are presented in our proposed BM. To indicate them, we created the column SAV Business Model Item. In SAV BM Item, the service characteristics of SAV services presented in our proposed BM in Section 4 are indicated by the letter of the corresponding LC block and its number, both between slashes. For example, /a1/ refers to the block (a) Problem and service characteristic Expensive and unsustainable car ownership/operation which is the item 1. in this block (Section 4, Fig. 4); therefore, we use the reference /a1/ throughout the text. We

proposed our BM according to the general service characteristics. We built our new BM considering the main results from our analysis in Tab. 1 and the literature review. We proposed the novel BM as a convergence of the current shared mobility services' BMs; we considered companies offering SAV mobility services and private AV owners offering the free seats to these companies. The key findings from Tab. 1 are the following:

- SAV service is a solution for the limitations of transitional services /a2/, for people without driving ability /a3/, and for the unreliable and unsafe travels /a4/.
- in the SAV service, 10% of service characteristics from the current shared mobility services are not incorporated (9 items) and 21% become intrinsic to the SAV service (19 items); 69% is incorporated into the SAV BM (63 items) - 54% of service characteristics from the current shared mobility services is kept (49 items), and 15% has been changed (14 items).

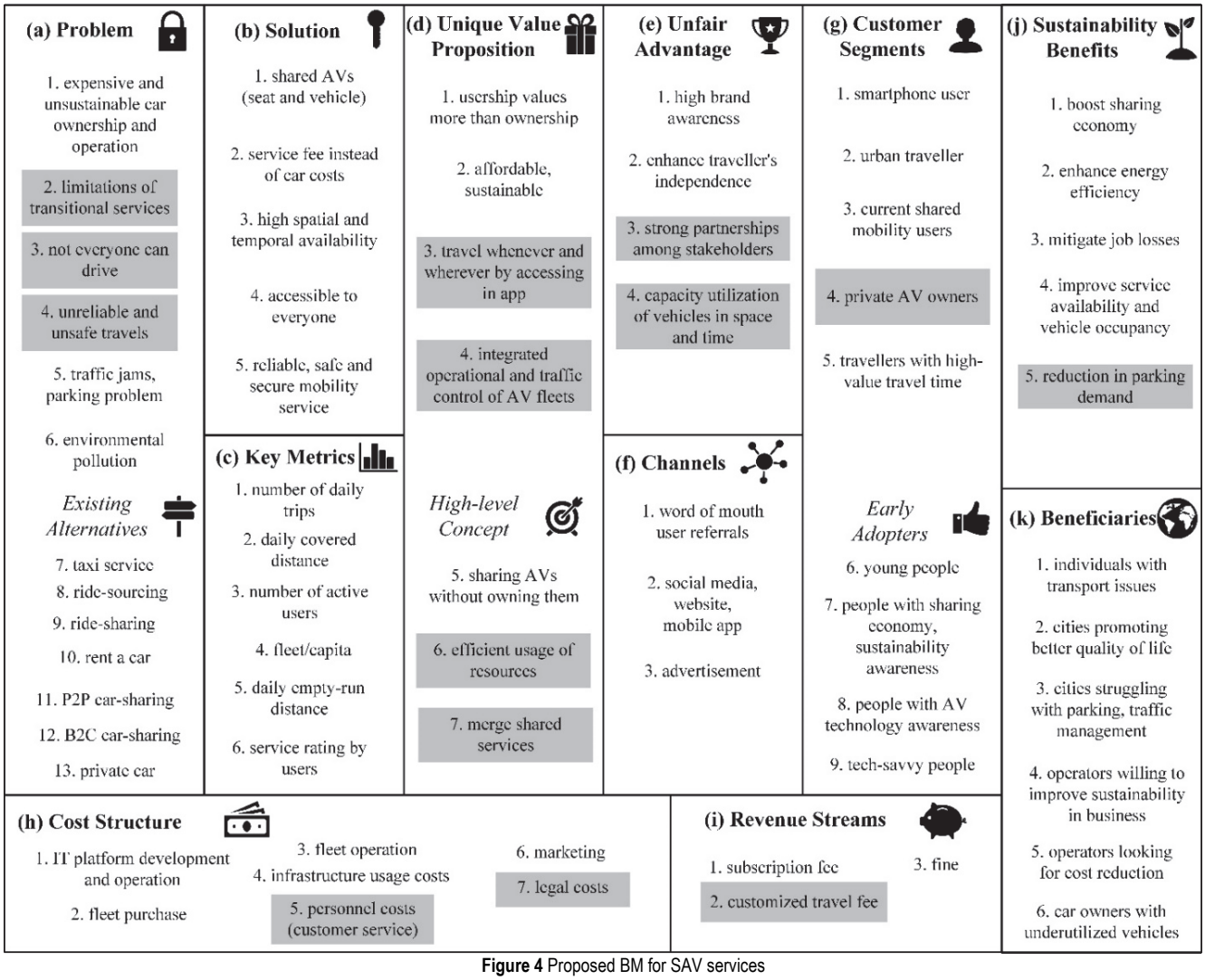

Figure 4 Proposed BM for SAV services

4 THE PROPOSED BM

The proposed BM using LC is presented in Fig. 4; it illustrates the 63 items from Tab. 1 that we incorporated into the SAV BM. The changes in the BM of shared mobility services are highlighted in grey boxes. To answer our first research question "How to alter the BM of the current shared mobility service companies to those applying AVs?", we propose that current shared mobility services:

- neglect the service characteristics related to drivers - they are presented in key metrics, customer segments, cost and revenue blocks;
- neglect not smartphone users as a customer segment;
- to substitute the key metrics number of peers and number of days for rent by fleet per capita and number of daily trips in the SAV service, respectively.
- establish strong partnerships with private AV owners and high capacity utilization of vehicles, thus, sustainability benefits are achieved;
- seek knowledge about integrated traffic control and legal requirements to the service as AV technology is developing, so companies are prepared in advance for IT development and additional costs;
- do not implement spatial and temporal limitations as AV technology brings this value proposition;
- implement a customized travel fee that substitutes the service fee and additional service fee applied in the current shared mobility services.

Moreover, we propose that:

- taxi companies must implement technology to share trip costs and a customized service as well as examine the new early adopters and customer segments to increase market share;
- ride-sourcing, ride-sharing, and P2P car-sharing companies must investigate the cost-benefit of purchasing an AV fleet because the number of private AVs may not be enough to supply the demand and reach a profitable service;
- car rental and B2C car-sharing companies must be aware of personnel costs with vehicle reallocation may be substituted by costs with daily empty-run distance.

The answer to our second research question "What are the customer segments and revenue streams when AVs are implemented into the current shared mobility services?" is:
- the *customer segments (g)* are smartphone users /g1/, urban travellers /g2/, current shared mobility users /g3/, private AV owners /g4/, and travellers with high value travel time /g5/;
- the *revenue streams (i)* are subscription fee /i1/, a customized travel fee /i2/ according to selected service options, spatial and temporal availability, as well as higher service quality, and fines /i3/.

The results supplement existing literature.

5 DISCUSSION

In this section, the main changes in the BM blocks are discussed focusing on the traveller, service, and environment.

(a) Problem - Travellers face some temporal and spatial limitations of the shared services /a2/. Some services such as car-sharing and car rental do not fit customers who cannot drive (e.g.,) /a3/.Travels are unsafe /a4/ due to many car accidents.

(b) Solution - The service is accessible to everyone /b4/. The SAV service offers higher spatial and temporal availability /b3/ than the current shared mobility services:
- availability of a driver limits taxi and ride-sourcing with pooling option while the availability of the peer limits P2P service;
- car rental has working hours;
- service area, parking, and round-trip limit B2C service.

The high service availability and accessibility are beneficial not only for the users but also for the companies. Diversified services enhance competitiveness too [22].

Also, safety and reliability /b5/ are provided as technology and connectivity will improve traffic conditions, make trips predictable, and promote a safe environment. Safety in AV-based services is the most important requirement regardless of age [29].

(c) Key Metrics - They are the same used for the current mobility services from /c1/ to /c6/. The fleet size and fleet per capita are key indicators since different BMs can serve cities of different sizes [20]; hence, they will influence competitiveness. The daily empty-run distance /c5/ should be monitored regarding impacts on operational costs and the environment (e.g., energy waste) due to the high spatial availability. Reduction in environmental impacts is a strong argument when asking for a reduction in taxes and free parking spaces from the local government.

The service rating options /c6/ enhance service quality indirectly. The waiting time may increase due to pooling [30].

(d) Unique Value Proposition - The same vehicle is used more; thus, the efficient use of a resource is achieved /d6/. The shared services are merged /d7/ into the SAV service. AVs communicate with each other [31, 32] and the mobility management center /d4/; the service is predictable and reliable which may enhance the willingness to use the service and profitability [33].

(e) Unfair advantage - Strong partnerships /e3/ among stakeholders imply a competitive advantage in the mobility market as the development of an AV fleet may be cost-prohibitive [21, 34]; small fleets might rise profitability by reaching high turnover and cheaper operational assets [33]. Fewer vehicles are enough to supply the same demand if barriers to pooling are overcome [35, 36]. The capacity utilization of vehicles in space and time /e4/generates fewer empty travelled kilometres when serving demand with the pooling option [33].

(f) Channels - The way of communicating with possible customers is not expected to change significantly [37] from the current ones /f1/, /f2/, and /f3/. However, companies may be prepared for higher usage of the internet- and app-based channels. Therefore, more attention to the user experience is recommended; accessibility to all customers will play a key role in the usability of the service.

(g) Customer Segments - A new customer segment is the private AV owners /g4/ who want to earn money making their vehicles available for public use. Customer segments are broadened, which may increase usability and market share. On the other hand, the wide range of customer segments might complicate their management and customization. Hence, operational changes in some departments such as marketing, customer experience, and finance are required.

(h) Cost Structure - Costs with platform development and operation /h1/ will remain and an increase in costs generated by the development of an info-communication system and its operation is foreseen. Intensive cooperation between operational and traffic control centers is required, demanding more complex operational functions. Alternatively, costs with personnel for customer service /h5/, marketing /h6/, cleaning, and maintenance are to be reduced with automation [38] and brand awareness. A rise in legal costs /h7/ is expected to cope with regulations and establish fruitful partnerships.

(i) Revenue Streams - Current shared mobility service companies already diversify service fees. More consumers can be attracted by an innovative pricing strategy bridging different service types; this can help overcome competitiveness as the proposed BM will be used by all shared mobility services resulting in very similar services. Besides subscription fee /i1/ and fines /i3/, the service fee is incorporated in the customized travel fee /i2/ which is a combination of service options:
- Spatial flexibility - total walking distance (access/egress distances), waiting (dedicated stop point).
- Temporal flexibility - service time, conditions of pre-ordering, reliability (delays, service disruptions, etc.),

and waiting option as subsequent travels by the same vehicle can be a choice.
- Ride-sharing option - sharing the ride with unknown people, selection of travel.
- Performance-related usage fee - time- and/or distance-based fee, tolerated detour distance/time.
- Vehicle type.
- Special care - accompanying person, notifications to responsible people about the status of the journey, child seat, onboard catering.
- Advertisement and/or onboard infotainment - providing audio and visual content.

The fee can be optimized by service packages created according to the frequency of use and trip length [21]. Additionally, expanding the service may increase revenues (e.g., providing on-demand services via a Maa S. [39]).

(j) Sustainability Benefits - With shorter headways and smoother acceleration, energy efficiency is enhanced /j2/[40]. It is predicted that AVs adoption will generate considerable job losses (e.g., drivers) which produces an expressive social cost burden [38]. Hence, the offer of an accompanying person might mitigate this damage /j3/. A smoother transition to AV use is recommended; the displaced workers need time to develop new skills and find new jobs [41]. The partnerships with private AV owners can boost benefits brought by the use of SAVs such as a reduction in parking demand /j5/[42]. It is considered that private AVs park themselves in a private garage. SAV mobility service companies may use these benefits to attract new customers or increase the number of loyal customers through marketing sustainability as one of the company's pillars.

(k) Beneficiaries - Shared mobility services with pooling should be incentivized in cities interested in promoting a better quality of life /k2/, and struggling with resources for solving parking and traffic management /k3/. SAV can serve 30 person-trips per day and 13% of vehicle miles travelled are reduced when the pooling option is used [43].

6 CONCLUSIONS

The implementation of Autonomous Vehicles (AVs) into shared mobility services will impact service characteristics and, consequently, the business models (BMs) because BM and service characteristics have a mutual relationship. Therefore, we aimed to support current shared mobility service companies in updating their BMs to move towards AV-based services. The main theoretical contribution is the proposed BM using the extended Lean Canvas. Our proposed BM is a mix of amplification and diversification due to the convergence of BMs and the offer of customized service. The limitation of the study is that AVs are not a fully developed technology, hindering conclusions only to a theoretical extent. Our key findings are:
- 69% of service characteristics is incorporated into the SAV BM - 54% from the current shared mobility services is kept and, and 15% has been changed,
- customized travel fee in SAV service substitutes the service fee and additional service fee applied in the current shared mobility services,
- accompanying personnel can be offered as an additional service,
- key metrics and channels are not to be altered,
- customer segments include private AV owners.

In the future, we are going to investigate the following topics:
- organizational structure improvements necessary for service providers as changes in the BMs may affect the functions, information flows and share of responsibilities;
- revenue model and tariff to be adopted due to the variety of service options in the customized fee;
- cost-benefit analysis of partnerships with AV owners;
- BM alteration in the case of feeder service, mainly customer segments, cost structure, and revenue streams.

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