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## ► To cite this version:

Fabio Antonialli, Bruna Habib Cavazza, Rodrigo Gandia, Isabelle Nicolai, Arthur de Miranda Neto, et al.. Human or machine driving? Comparing autonomous with traditional vehicles value curves and motives to use a car. World Review of Intermodal Transportation Research, 2020, 10.1504/WRITR.2020.106918 . halshs-03687616

**HAL Id: halshs-03687616**

**<https://shs.hal.science/halshs-03687616v1>**

Submitted on 3 Jun 2022

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## Human or machine driving? Comparing autonomous with traditional vehicles value curves and motives to use a car.

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**Abstract:** This study aims at drawing new value curves for Autonomous Vehicles (AVs) over Traditional Vehicles when considering AVs as a Product-Service System (PSS) as well as discussing the main reasons to use an AV over a traditional car. Data were collected based on secondary (academic and grey literature) and validated with AVs experts on France, Belgium, and Brazil. The results show the arrival of AVs would include different ownership forms; free time for users (no driving required); ‘infotainment’; social integration of elders and handicapped people. We realize that AVs have in their business model several attributes that fit them into a new market perspective compared to the current mobility scenario. Also, we observed that as automation levels increase, machine driving components of the vehicle also increase. As conclusions, the reasons to use a car are likely to change with a decrease in symbolic and affective attributes and increase instrumental ones.

**Keywords:** Autonomous Vehicles; Automated Driving Systems; Value Curve; Four Action Framework; Car-use motives.

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### 1 Introduction

Autonomous Vehicles (AVs), better known as Automated Driving Systems (ADS) are cars with motion and action capabilities that don’t require any sort of conductor (driver) or teleoperation control (Frazzoli, Dahleh & Feron, 2002).

According to Mutz et al. (2016) there is a strong expectation that, in the future, AVs could be used to provide accessibility for people in need, reducing costs and time in transportation systems, and offering comfort for people who do not (or cannot) drive. Although the reality of AVs may seem distant, it is increasingly evident its advances and imminent arrival (Attias, 2017).

Autonomous driving technology is advancing rapidly due to road safety concerns, potential cost savings, and technology innovations (McKinsey & Company, 2016). The current state of technology along with expected improvements and the already-announced plans of several large OEMs and others, make it likely that fully self-driving vehicles (level 4 autonomous driving capability) will be available by the mid-2020s.

It’s important to highlight that, even before the ultimate arrival of AVs, many radical changes have been occurring in the automotive industry. For a long time, such industry was predominately explained by a unique business model: the sale of a car as a privately-owned asset. When we think about the car within this perspective, we must consider that besides its instrumental’s configurations, there are important symbolic and affective aspects related to the car and its owner that must be discussed (Steg, 2005).

On the other hand, with the widespread adoption of shared mobility services enabled by two-sided platforms business models (e.g., Uber, Lyft and Didi Chuxing), the traditional business model of selling cars is being disrupted in a sense that manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer more profitable business relationships. (Antonialli et al., 2018; Johnson & Mena, 2008).

These new AVs trends are concomitant with the generalization of the service economy in which owning a car will no longer be seen as a priority for users, particularly for urban citizens. Innovations like these lead to imagining mobility in new ways and can be "freshly" interpreted as a combination of two parameters: personal and shared vehicle and personal and shared trips. Such evolution goes beyond seeing an AV simply as a new product, but rather to consider mobility as a Product-Service System (Tukker, 2004).

By considering the "servitization" of mobility, AVs can play a fundamental role within the multimodal urban system of many cities worldwide. Being either on-demand or as regular-line services, autonomous cars and autonomous shuttles could serve as first- and last-mile solutions to public transport, therefore, acting as feeders in the mobility network (Scheltes & Correia, 2017).

Even though there has been an establishment of a theoretical field regarding AVs, it is not yet evident the main aspects that permeate the thematic, as well as its conceptual base, tendencies, and characteristics. In the scope of business and management, this lack of studies is even more pronounced (Gandia, et al., 2019). Little has been discussed about the real managerial implications regarding the arrival of AVs in the market (Cavazza et al., 2017). Several authors consider the arrival of these vehicles as one of the biggest disruptive innovations in the automotive market (Attias, 2017; Enoch, 2015).

Considering the main idea of understanding what are the reasons to use and Autonomous Vehicle over a traditional car, our research problem is given by the following question: What are the value propositions of Autonomous Vehicles as a product and as service over traditional vehicles?

Based on such a question, this study aims at drawing new value curves for AVs over traditional vehicles when considering AVs as a service and as a product and to discuss the main reasons to use an Autonomous Vehicle over a traditional car.

Considering that AVs are embedded in the most significant historical change to automobile industry and transportation (Attias, 2017; Enoch, 2015), the motivation of this paper is to broaden the understating of AVs' insertion in the market for both the academia and practitioners, in a sense that governments, universities and car-manufacturers worldwide identify AVs as key-research factor, therefore, such imminent arrival includes impacts on several spheres, being important to consider the impacts of such disruptive innovation not only in cities and society but on structure and functioning of companies as well.

## **2. Theoretical Background**

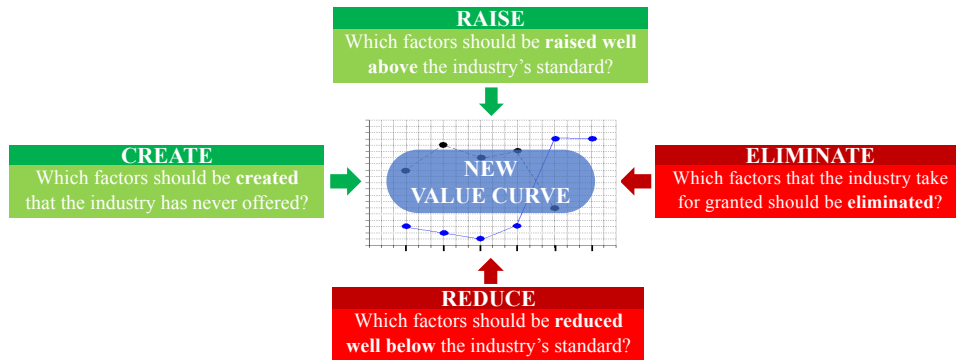
### *2.1 Value Curves and the Four Action Framework*

Kim and Mauborgne (2005) question the reason for organizations to continue a fierce dispute within saturated markets (red oceans) where large investments are made in pursuit of sustainable and profitable growth when the result is often only small market share gains. Therefore, the authors state that for a company to be in a "blue ocean", the premise is to make competitors irrelevant by avoiding such fierce competitive battles and by offering customers something unique and yet untapped in a given business segment. Thereby producing value innovation – aligning innovation with immediate utility in a competitive price (Kim & Mauborgne, 2005; Osterwalder & Pigneur, 2010).

To answer the questions: how to make competition irrelevant? how to unveil unexplored markets and create the blue ocean? Kim and Mauborgne (2005) developed a four-action framework that allows one to systematically explore ways of rearranging attributes that generate value for clients to offer entirely new experiences while keeping the cost structure low. As shown in Figure 1, the matrix generated from these four actions

leads companies to act based on the answers to build new value curves for their products/services.

**Figure 1** Four action framework reflecting on the creation of a new value.



Source: adapted from Kim and Mauborgne (2005).

The “Blue Ocean Strategy” calls into question the need for companies to seek a position where competition is not included, to avoid large investments in already saturated markets. In this sense, demand is created rather than contested, hence, there is ample opportunity for growth that is both profitable and rapid (Kim & Mauborgne, 2005; Osterwalder & Pigneur, 2010), competition is, therefore, irrelevant because the “rules of the game” are waiting to be defined (Kim & Mauborgne, 2005). The authors also point out that a large part of the blue oceans have not yet been mapped, as the focus of the works on strategy in recent decades has been concentrated in the red oceans with fierce competition.

The "strategic move" is the appropriate unit of analysis to explain the creation of blue oceans and high-performance support. Therefore, such strategic movement is a set of managerial decisions and actions that provide important products and services capable of creating new markets (Kim & Mauborgne, 2005). In this sense, the authors conclude that a blue ocean is created when a company achieves an innovation that simultaneously creates value for both the buyer and the company.

Furthermore, Gandia et al. (2017) point out that there is heterogeneity for publications related to blue ocean strategy, as well as a growing trend in the theme. Corroborating with the wide application of blue ocean strategy many authors proposes new approaches identifying key opportunities towards creation of new value curves, such as future of F1 racing (Markopoulos et al., 2020); Smart Houses (Orlov & Chubarkina, 2017); Fitness clubs (Vieira & Ferreira, 2018); Agribusiness organizations (Carvalho et al., 2014), so on.

## 2.2 Autonomous Vehicles and the Traditional Car Industry

According to Lima (2015), the first AV prototype was developed in Japan in the mid-1970s, being able to track white street marks with computer vision at speeds up to 30 km/h. Only 10 years later, the first car-like robot would emerge in Europe in Bundeswehr University Munich (UniBW) on Germany as part of the PROMETHEUS project. Also in the 1980s, it was seen the first American contribution with a project called “No hands across America” from the Carnegie Mellon University (CMU) which has developed a car (Navlab 5) capable of performing autonomous navigation from Washington DC to San Diego with 98% automated steering and manual longitudinal control. However, the watershed on AVs research and development came in 2004 in the USA with a series of public annual challenges, named DARPA Gran Challenges.

Through, countless contributions and advances have been made on AV throughout the 21<sup>st</sup> century (Reschka, 2015; Poorsartep, 2014).

AVs represent a potentially disruptive and beneficial change to the current road transportation system business model, since such vehicles will facilitate driving; increase road safety; reduce emissions of pollutants; reduce traffic jams; as well as will allow drivers to choose to do different things other than driving (Attias, 2017; Enoch, 2015; Schellekens, 2015; Schreurs & Steuer, 2015). Thus, access to fully automated vehicles will also improve mobility for those who cannot or do not want to drive, improving their quality of life (Attias, 2017; Poorsartep, 2014). As a result, AV can provide significant economic, environmental and social benefits (Mutz et al., 2016; Fagnant & Kockelman, 2015; U.K. Department for Transport, 2015).

AVs technology is now the greatest bet of big carmakers, led in the United States by Ford, GM and Tesla and in Europe by Audi, Mercedes, and Volvo, as well as some technology giants like Google and Uber (Nascimento, Salvador & Vilicic, 2017; Fagnant & Kockelman, 2015). According to the former authors, Google’s AV (Waymo) have reached in 2017 the milestone of more than five million kilometers driven on American avenues, streets and roads and Uber’s AV (in partnership with Volvo) have reached over 1.5 million driven kilometers in their testing cities of Pittsburgh, Phoenix and Toronto. Not to mention that vehicles with semi-autonomous capabilities SAE’s (2016) levels 2 and 3 of automation are already being marketed – such as Tesla’s Roadster; Model S and Model X as well as Mercedes-Benz’s S65; Infiniti’s Q50S, BMW’s 750i xDrive (all level 2) and most recently Audi’s A8 which as stated by Nascimento, Salvador & Vilicic (2017) is the first mass-produced vehicle to have a level 3 embedded system.

The Society of Automation Engineers (SAE, 2016) provides a taxonomy describing the full range of driving automation levels, which as depicted in Figure 2 ranges from ZERO (no driving automation) to FIVE (full driving automation).

**Figure 2** Summary of SAE’s automation levels

		Steering, acceleration / deceleration	Monitoring of driving environment	Fallback when automation fails	Automated system is in control
Human driver monitors the road	0 No Automation				N/A
	1 Driver Assistance				Present in some driving modes
	2 Partial Automation				Present in some driving modes
Automated driving monitors the road	3 Conditional Automation				Present in some driving modes
	4 High Automation				Present in some driving modes
	5 Full Automation				

Source: adapted from SAE (2016) based on Nascimento, Salvador, and Vilicic (2017) and Hawes (2016).

It is worth noting that on levels 4 and 5 an AV can autonomously drive and monitor the road environment without the need for human intervention in case of constraints (US. Department of Transportation, 2016). Furthermore, the French authors Attias and Mira-Bonnardel (2017), state that levels 4 and 5 are considered by their

country's authorities as really disruptive and in the near future French urban spaces will quite surely implement these last two levels on dedicated areas or lanes.

As the aforementioned authors pointed out, the automotive industry is going through some radical changes, and it's been struggling to find the right positioning. For a long time, such industry was predominately explained by a unique business model: car sales (as products). Within this perspective, a car should be understood more than just a simple artifact for mobility, since, according to Steg (2005, p.147) "car use not only fulfills instrumental functions, but also important symbolic and affective functions". For the author, behavioral models aiming to explain the reasons to have a car should not only focus on instrumental factors related to usage (e.g.: speed, flexibility, and convenience), since, "for many people, the car seems to be a status symbol, people can express themselves by means of their car" (Steg, 2005 p.148).

However, this traditional business model of selling cars is losing ground to alternative forms of commerce (Attias & Mira-Bonnardel, 2017). Evidence across car-reliant cultures are pointing to a slow (but general) decline in-car use and ownership (Mulley, 2017; Shaheen & Cohen, 2016; Karlsson, Sochor & Strömberg, 2016). Thereby, a business model in which cars are offered as a bundle of products and services – that is: a Product-Service System [PSS] (Tukker, 2004) – is gaining strength and it is being tackled by many companies and scholars. As stated by Burns, Jordan, and Scarborough (2013):

“(...) using a shared, self-driving and purpose-built fleet of vehicles could reduce the total cost of ownership from US\$1.60 per mile down to US\$0.50 per mile, this is more than a 10-fold improvement compared to personally owned vehicles” (Burns, Jordan & Scarborough, 2013:p.101).

“As a result, traditional players in the industry find themselves obliged to form new alliances with companies in emerging sectors (e.g. performance economy, circular economy, digital economy, etc.)” (Attias & Mira-Bonnardel, 2017, p. 72), therefore an important part of the opportunities offered by PSS lies on the correlation between product and service activities (Mahut et al., 2015).

At last, it seems clear that the future will involve a mobility revolution combined with a cultural revolution of the entire industry and society. Nevertheless, there are still many questions that need to be answered before AV reach the roads, to name a few: security and reliability issues; impacts of AV driving on mobility behaviors and human-machine interactions; consumer acceptance; cities revenues; as well as regulatory, ethical and liability frameworks (Nascimento, Salvador & Vilicic, 2017; Scherurs & Steuwer, 2015; Schellekens, 2015).

Those are relevant questions that need to be addressed and taken seriously by governments and carmakers, since, according to Poorsartep (2014), technology itself is no longer the major hindrance for AVs' implementation, the major roadblocks are now consumer acceptance and regulatory frameworks.

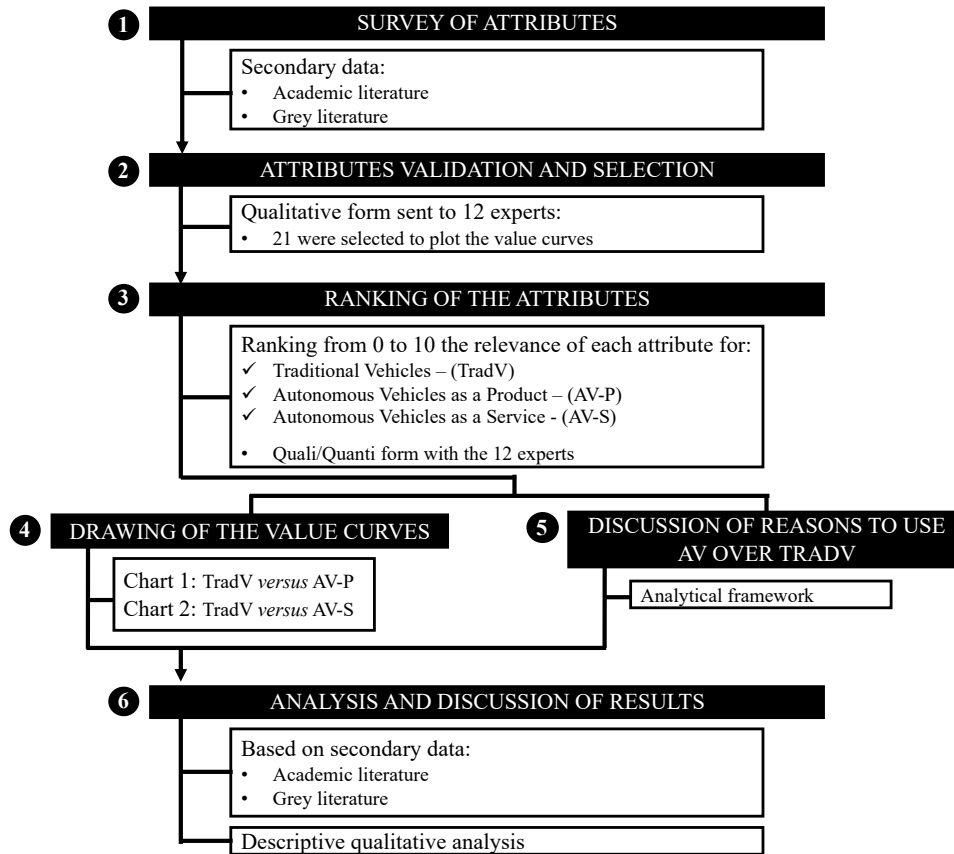
### **3 Methodology**

Considering that this paper aimed at drawing value curves for Autonomous Vehicles (AV) over traditional vehicles when considering AVs as a service and as a product as well as discussing the main reasons to use AVs over traditional cars, the research design adopted in the present study was characterized as qualitative of exploratory-descriptive nature.

It is exploratory in a sense that the AVs field of study is still little addressed in the business literature and thus, there is a lack of business-like academic knowledge

regarding this object of study (Gandia et al., 2019; Cavazza et al., 2017); it is also descriptive because it aims at describing and analyzing phenomena (Malhotra, 2001; Gil, 2008) – here the AV value curve configuration under the Disruptive Innovation paradigm and the Four Action Framework perspectives. Figure 3, highlights the research design carried out in this study.

**Figure 3.** Research design



*Source:* Prepared by the authors

Stage 1 consisted on surveying the attributes for creating the value curves in order to compare the Autonomous Vehicles<sup>1</sup> both as products and as services with Traditional Vehicles. Such attributes survey was based on secondary data (academic and grey literature) – similarly to what Enoch (2015) has adopted in his work – in this preliminary stage, we were able to list 26 attributes in total.

Next, we proceeded with the validation of the raised attributes, for that we sent a GoogleDocs form to twelve experts in the subject of AVs and urban mobility from different areas of knowledge (e.g. Engineering, Business, Economics, Law, etc.) in France, Belgium, and Brazil. Based on their insights, we were able to reduce the number of attributes to be used in the plotting of the value curves from 26 to 21, being categorized into a) nine human attributes and, b) twelve machine attributes.

Stage 3 consisted on sending a quali/quantitative form to the same 12 experts (approached on stage 2) in which they were asked to rank each attribute from ZERO - not

<sup>1</sup> It is worth highlighting that SAE's level 4 of automation was considered as a reference in this study, similarly to Schellekens (2015) on his study about the self-driving cars and the chilling effect of liability law.

necessary/present at all, to TEN - extremely necessary/present) for each vehicle category: Traditional Vehicles; AVs as Products and; AVs as Services, as well as to give their insights on each attribute by considering both scenarios for AVs (being offered as a product and as a service).

Inspired by Kim and Mauborgne's (2005) four action framework, stage 4 consisted of drawing the value curves based on the arithmetic means for each attribute ranked by the experts on the previous stage. By considering the Traditional Vehicles as a basis for comparison, two distinct value curves were drawn: chart 1) Traditional Vehicles (TradV) *versus* Autonomous Vehicles as a Product (AV-P) and; chart 2) Traditional Vehicles (TradV) *versus* Autonomous Vehicles as a Service (AV-S).

After drawing the curves and discussing the human and machine attributes that should be eliminated, reduced, created and raised for each scenario (chart 1 and 2), stage 5 consisted on creating an analytical framework in order to discuss and analyze the reasons for using Autonomous Vehicles over Traditional Vehicles based on Steg's (2005) premises as well as on other relevant works.

In parallel, stage 6 consisted of analyzing and discussing the results based on secondary data to support the findings (academic and grey literature) – via descriptive qualitative analysis (Sanderlowski, 2000; 2010; Kim, Sefcik & Bradway, 2016).

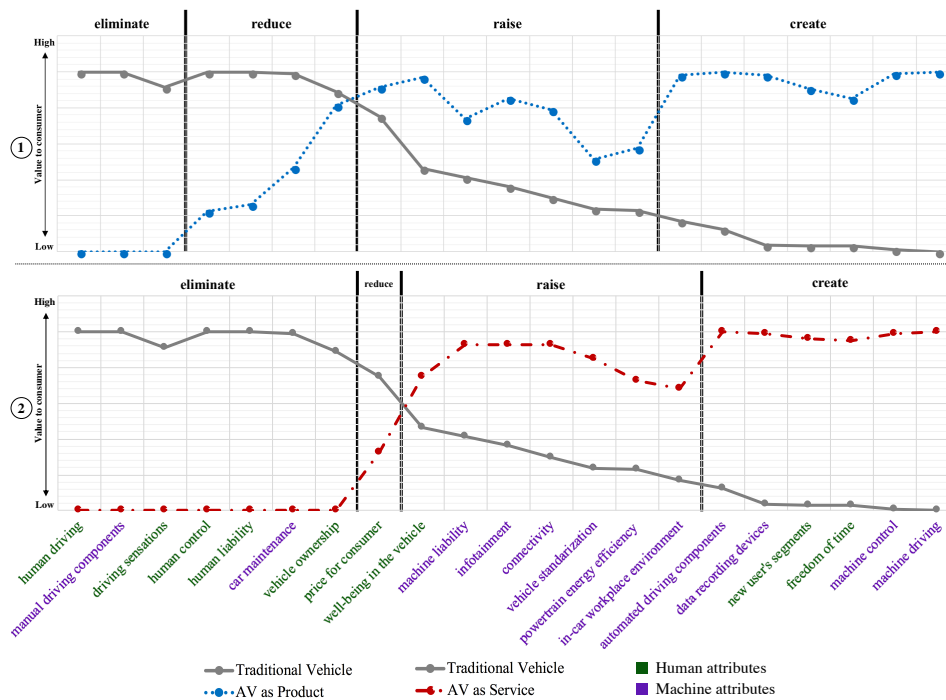
#### **4 Results and discussion**

We present here the value curves for TradVs compared to AV-P and AV-S. For better results' understanding, we considered the TradVs' value curve (grey lines) as a standard for analysis. Therefore, based on Kim and Mauborgne's (2005) four-action framework, Figure 2 displays the attributes that must be eliminated, reduced, created and raised.

By analyzing the charts of Figure 4 (1- TradVs *versus* AV-P; and 2 - TradV *versus* AV-S) it can be noticed in both cases a "mirror-like" behavior of the curves. That is, indispensable TradVs' attributes appear on both AVs curves as eliminated and/or reduced; and after crossing the inflection point, the trend remains, since attributes considered as non-essential and/or non-existent for TradVs are raised and/or created in the AVs' curves.

**Figure 4** Traditional Vehicles versus AVs as Product as Service value curves.





Source: research data, inspired by Orsato (2009, p.184), Bottacin, Madureira and Pedroso (2014, p.13).

#### 4.1 Eliminated attributes

Of the 21 attributes ranked in this study, results show that for AV-P the first 3 (**human driving; manual driving components and; driving sensations**) will be eliminated. It is interesting to note that 2 of these 3 attributes are considered as “human attributes” whereas only manual driving components is a “machine attribute” (Robertson et al., 2017)

All the three eliminated attributes are considered indispensable for a traditional vehicle since automated driving is not present, a human driver will always be needed, as well as manual driving components such as pedals; steering wheel, mirrors and so on. Therefore, the driving sensations (being those either positive or negative) will also always be present (SAE, 2014).

On the other hand, in the value curve for AV-S we observed that, besides these 3 attributes, the other four (**human control; human liability; car maintenance; vehicle ownership**) will likely be eliminated (Robertson et al., 2017).

As expected, the three eliminated attributes for AV-P will also not be present here, since a level 4 AV will not require human driving, therefore rendering moot manual driving components as well as driving sensations. The other four attributes will be eliminated, since the car will not be an asset owned by the passenger but offered by a service provider (such as Uber; Lift; Didi Chuxing; among other car-sharing services) (Antoniali et al., 2018).

In this sense, the user (passenger/rider) is likely not to have human control (the routes might be previously established by the service provider as well as other in-car attributes and features), as well as might not be liable in case of accidents; will likely not bear maintenance costs and of course, will not need to own the vehicle, given that in this scenario he/she will be a simple consumer (user) from a service provider (Fagnant & Kockelman, 2015; Cavazza et al., 2017).

#### 4.2 Reduced attributes

In this category, four attributes that will be reduced on AV-P. Those being: **human control; human liability; car maintenance** and; **vehicle ownership**. Similarly, to the eliminated attributes, only 1 out of the 4 attributes to be reduced is considered as a “machine attribute”.

Human control will be reduced because even though the act of driving will be autonomous, the car owner might still have control regarding routes to be taken; when and where to pull over if needed; as well as other car controls such as lights; A/C; sounds, etc.; that the car will still be a personally owned asset, however, no driving will be truly required. Therefore, in case of an accident, it will be more complex to blame the owner of the vehicle, once now he/she will no longer be in control of the vehicle, instead will be a simple passenger (rider) (Hevelke & Nida-Rümelin, 2015; Cavazza et al., 2017).

Car maintenance will likely be reduced (Brennan & Barder, 2016 p.9) once there is a growing trend among OEMs and researchers that such AV will be electric. An electric powertrain is much simpler than an Internal Combustion Engine (ICE), it has much fewer moving parts (approximately 200 against around 2000 in an ICE). Furthermore, since driving will be automated, wear and tear of components are likely to be reduced when compared to a human driver (Gustafsson & Johansson, 2015).

As for ownership, we hypostatize a small reduction for a couple of reasons, such as a possible high price tag of the vehicle; high insurance costs; lack of interest by part of the consumers, among others. If on one side, we can observe a significant change in the traditional configuration of having/owning a vehicle for a new one with AVs, on the other hand, there is still a lot to be surpassed if we consider that (Steg, 2005).

It's important to highlight that, mainly in this configuration, considering symbolic and instrumental aspects/reasons for having a car such as the pleasure of being behind the wheel, the choice of the car's configurations, design, and layout, it is more prudent to state that attributes like human control and vehicle ownership are likely to decrease but not disappear, as Michele Kreber (auto-trader senior) points out: “People want driverless performance when they're commuting and maybe on long road trips, but they want the option to drive themselves” (Phelan, 2018).

As for human liability, such an attribute will still be considered that even with the machine having the driving control, the owner of the car could be held liable for any accident or infraction (Hevelke & Nida-Rümelin, 2015).

Regarding AV-S, the only attribute to be reduced is **price for consumer**, which, when comparing AV-S and AV-P curves, it is clear that owning an AV will likely be much more costly than using it as a service (at least for the initial introductory stage), corresponding to Burns, Jordan and Scarborough (2013, p.101) statement about costs reduction of sharing an AV over own a car. Furthermore, a 2016 World Economic Forum study identified that 37% of consumers said that they are likely to share a ride in a self-driving taxi with strangers (WEF, 2018), this way, it is observed that there is users' predisposition to share AV-S.

It's also worth mentioning here the study of Wadud (2017), that seeks to compare the costs (and benefits) of vehicle automation for private vehicles among different income groups and commercial vehicles in the taxi and freight sectors in the UK. According to the author, the main findings of the study is that “commercial operations clearly benefit more from automation because the driver costs can be reduced substantially through automation. Among private users, households with the highest income will benefit more from automation because of their higher driving distances and higher perceived value of time, which can be used more productively through full automation” (Wadud, 2017 p.163).

### 4.3 Raised attributes

Among the seven attributes to be raised for an AV-P, five are considered as “machine attributes” and only two (price for consumer and well-being in the vehicle) are considered as “human attributes”.

In this context, the more components a vehicle has, the more aggregated value it has, and consequentially, more expensive it will likely be. In this sense, an AV with all the needed sensors, radars, lidars and cameras for safely driving the car, will probably be more expensive than a traditional vehicle (**price for the consumer** as an end product) – at least in the near future (Litman, 2018 p.7; KPMG, 2012).

Shifting the discussion to comfort, as pointed out by SAE (2016) a level 4 AV will no longer need human intervention, therefore fallback in case of automation fails will be on the system, not on the human. In this sense the internal layout of the car can be completely redesigned, allowing a bigger focus on **well-being in the vehicle** for both leisure and work. Therefore other attributes such as **infotainment** (bundle of information and entertainment) and **connectivity** might also be raised, these two attributes together represent an important part of the AVs’ concept, since the central proposal for this type of vehicle is to offer of a series of possibilities to the user, radically changing the in-car experience (Yun et al., 2016; Cavazza et al., 2017).

As discussed in the attributes to be eliminated, while human liability will probably be reduced, **machine liability** will likely be raised. In the case of an accident, the burden will not fall entirely on the car owner, but rather on the car itself, that is, OEMs liability will likely be higher (Lederman, Garrett & Taylor, 2016). Examples of this are accidents involving autonomous or semi-autonomous vehicles (Tesla, Uber, etc.) and the machine named, instead of a human, as the cause of the accident [e.g. "Tesla car that crashed and killed driver was running on autopilot, the firm says" Guardian staff and agencies (2018)].

In the perceivable future, AVs will begin to take the streets on a larger scale, yet still much less when compared to traditional vehicles. Therefore the number of models and brands available for autonomous vehicles will be more limited, which will lead to a higher initial **vehicle standardization** of marketed models, an example is Tesla’s portfolio of vehicles, the company currently markets only four models: Roadster, Model S, Model 3 and Model X – all imbedded with level 2 autonomous capabilities (Tesla autopilot).

At last, as previously mentioned on the attributes to be reduced, it is likely that these AVs will be electric (or hybrid), therefore it is believed that **powertrain energy efficiency** will be raised as well (Brennan & Barder, 2016; Gustafsson & Johansson, 2015; Gandia et al, 2019).

As for AV-S, for the seven attributes to be raised, only one is labeled as a “human attribute” – **well-being in the vehicle** (similarly to AV-P), since there is no need to drive, the tendency is that well-being inside the vehicle will be raised (Yun et al., 2016; Cavazza et al., 2017). It is worth noting, however that differently from As-P when offered as a service an AV might be shared by different commuters, in this sense well-being might not be as high as in a personally owned AV.

All the other six attributes to be raised are considered as “machine attributes”, five of them (**machine liability; infotainment; connectivity; vehicle standardization** and **powertrain energy efficiency**) are also likely to be raised on As-P. The only difference is that the attribute **in-car workplace environment** would be created on an AV-P however raised on an AV-S. In fact, if we consider that cars are by default liminal spaces between, home, work, and third places. It makes sense to think that future car concepts will bring the convergence of these spaces, thanks to the self-driving prophecy (Ozenc, 2017; Zakharenko, 2017).

#### 4.4 Created attributes

As for the attributes that need to be created for an AV-P when compared to TradV, only two were not considered as “machine attributes”, being those: a) **new user’s segments** – since level 4 AVs enable groups previously neglected by OEMs, such as people with disabilities; people who cannot or do not want to drive, the elderly and even underaged to have access to the usage and ownership of a vehicle (Attias, 2017), and b) **freedom of time** – since driving will no longer be needed; the user will have freedom of time to do other activities such as reading a book; watching a movie; sleeping, etc (Ozenc, 2017; Zakharenko, 2017).

Regarding the “machine attributes” that might need to be present in such vehicle, the attribute **in-car workplace environment** is closely linked to well-being inside the vehicle (attribute to be raised) and freedom of time (attribute to be created), since in TradV all the in-car layout is designed for “on the road focus” – that is: human driving. However as previously mentioned, on a level 4 AV driving is no longer a necessity, therefore the in-car layout can be completely redesigned giving greater focus to other activities, such as work while in the commute – which could be a great time saver for many people that spend many hours of their days stuck on traffic jams (Ozenc, 2017; Zakharenko, 2017).

The other four “machine attributes” that may be necessary for an AV-P compared to a TradV are: **automated driving components; data recording devices; machine control** and; **machine driving**, that is, all are technical attributes necessary for the proper and safe driving of the vehicle (SAE, 2014; 2016).

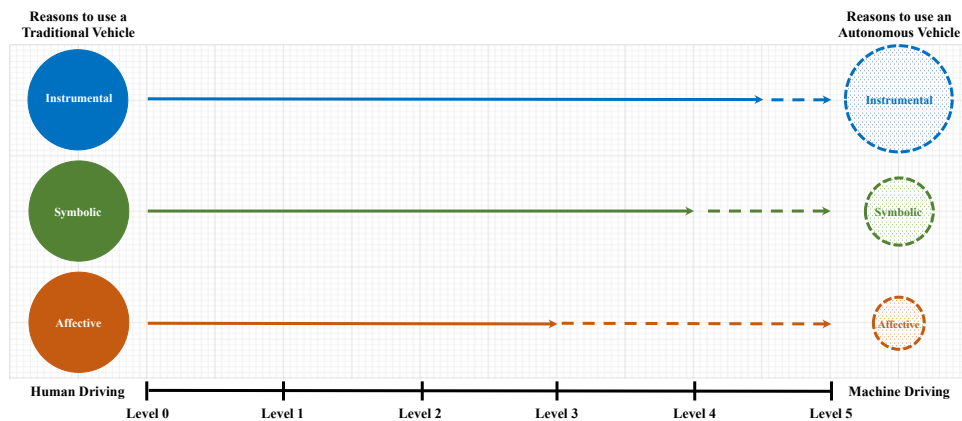
Since level 4 vehicles are not yet being marketed (only level 2 and 3 are currently available for purchase in certain markets), automated driving components for complete dynamic driving tasks still need to be created, also machine control – to monitor the driving algorithms, sensors, cameras, radars, lidars; as well as data recording devices – such as airplane “black boxes” purpose of facilitating the investigation of accidents and incidents (Barbosa et al., 2016; Bose, 2015) and last but not least: machine driving – that is, the driving algorithm itself that would be responsible for all driving decisions that should be taken; e.g: knowing when to change lanes; when to make left and right turns; when to stop; when to parallel park, etc (Morris, Madzudzo & Garcia-Perez, 2018).

Finally, regarding AV-S, the attributes to be created for AV-P would also go to be created, and among them four are considered as “machine attributes” (**automated driving components; data recording devices; machine control** and; **machine driving**) and two are “human attributes” (**new user’s segments** and **freedom of time**).

#### 4.5 Reasons to use Autonomous Vehicles over Traditional Vehicles

After drawing the value curves for AVs over traditional vehicles, the next step was to discuss the main reasons that might lead people to use an Autonomous Vehicle over a traditional car. Based on the previously discussed attributes, it is worth noting the distinction between human and machine attributes and the way that such distinctions could lead to different motives to use a car, based on instrumental, symbolic and affective attributes as suggested by Steg (2005). Figure 5 depicts an analytical framework for explaining the reasons to use an AV over a TradV.

**Figure 5** Analytical framework for reasons to use an AV over a Trad-V.



Source: research data, inspired by Steg (2005), SAE (2016), Nascimento, Salvador and Vilici (2017) and Hawes (2016).

The closer the attributes ranked in Figure 4 are from SAE’s lower automation levels (0, 1, 2 and 3) – in which total or partial human intervention is needed – it is possible to trace a parallel with the motives that lead people to use traditional cars, as discussed by Steg (2005) – see Figure 5. This is evident by relating Figure’s 4 human attributes, such as "human driving", "driving sensations", "human control", "vehicle ownership", "price for consumer" and "well-being in the vehicle"; to instrumental motives (e.g.: "the car quality is more important to me than its brand" and "I only have a car to travel from A to B"), symbolic (e.g.: "a car provides status and prestige" and "you can know a person by looking at his/her car") and affective (e.g., "I love driving" and "I like to drive just for fun") described by Steg (2005, p.154).

From 1885 up to the current stage of automation (SAE level 3), Steg’s (2005) reasons to use a car have not changed dramatically, however, it is not possible to know for sure how such motives will be configured to the extent that SAE’s higher automation levels (4 and 5) develop and consolidate in the market.

On the other hand, as the attributes are shown in Figure 4 approach SAE’s higher automation levels, it is possible to observe – by the dashed lines and circles on Figure 5 – that Steg’s (2005) current motives to car use will likely be configured in different manners than today’s. In a sense that various human attributes required at lower levels of automation (such as "human driving", "human control" and "human liability") will gradually be replaced by machine attributes (such as "machine driving" and "machine liability").

Thus, a rupture regarding the motives to use a car might be observed starting from the introduction of a vehicle that would not require human intervention at all times (starting on SAE’s level 3). For over 100 years, instrumental, symbolic and affective motives, derived from the role of a driver in the control of a vehicle, will give way to new and yet still uncertain approaches. As Hodson (2016) points out: “we will discover how our behavior changes when we have autonomous vehicles on the road”.

However, when analyzing Figure 5 it is possible to infer that the reasons for using an AV will likely have superior instrumental motives to those existing for a TradV. In contrast, the affective and symbolic motives suggested by Steg (2005) will probably change in a “machine driving” scenario. This can be inferred by considering the absence of attributes to be raised and created (Figure 4) related to symbolic and affective motives (Steg, 2005), we observed that the almost complete presence of "machine attributes" (exceptions of "new user’s segments" and "freedom of time") may be responsible for such phenomenon. In other words, in a vehicle in which the person will no longer need to have

driving control, it seems evident the reduction or transformation of affective values such as "driving sensations".

Likewise, considering that one of AVs' proposals is to provide mobility solutions from a machine control standpoint over the possibility of human errors, and such control promises to bring greater assertiveness to mobility (Fagnant & Kockelman, 2015), the creation of attributes such as "machine control" and "machine driving" (Figure 4) positively correlate with currently available instrumental motives, such as "I only have a car to travel from A to B" (Steg, 2005).

At last, it is worth emphasizing that the given analytical framework proposal is not to suggest a generalized increase of instrumental motives, as well as a reduction of affective and symbolic ones, but of those currently known as motives to traditional car use (Steg, 2005). We believe that new affective motives may arise, as well as symbolic, to the detriment of those valued by the current user of a TradV, factors that are still unknown but need to be taken into account by AV's OEMs and stakeholders.

## 5 Concluding remarks

This work aimed at drawing new value curves for Autonomous Vehicles (AVs) over Traditional Vehicles when considering AVs as a service and as a product as well as discussing the main reasons to use an AV over a traditional car.

By analyzing the results one can notice that indispensable TradVs' attributes appear on both AVs curves as eliminated and/or reduced; and after crossing the inflection point, attributes considered as non-essential and/or non-existent for TradVs are likely to be raised and/or created in the AVs' curves.

By the four-action framework and value curve models (Kim & Mauborgne, 2005), the results point to the arrival of a "new" vehicle concept that includes: different ownership forms; free time for users (no driving required); 'infotainment'; social integration of elder and handicapped people; in all, factors that will cause the extinction of some markets and creation of others.

The AVs' value curves display different characteristics when compared to TradVs. When analyzing the new value proposition of the autonomous vehicles we realize that, in fact, these vehicles have in their business model several attributes that fit them into a new market perspective compared to the current picture of TradVs. It is worth mentioning that for AV-S, the value curve is even more distinct from the TradVs' curve, since besides having all the attributes related to the technological issues of the vehicle, it is necessary to consider all the attributes related to the implementation of this vehicle in the market as a service and not a product. Since, as pointed out by Kenney (2017 p.3) "investors may be undervaluing mobility-as-a-service severely today, and that in 5 years autonomous taxi networks could command a market capitalization of over \$5 trillion. In comparison, the global automotive manufacturing industry probably will be roughly one-third of that size". In this sense, the author concludes that AV-S "presents a massive growth opportunity for technology players or automakers that are able to piece together a successful autonomous strategy".

In addition, given the required infra-structure adaptations and changes in legislation, AV-S can act as catalysts towards Mobility-as-a-Service (MaaS) schemes by acting as first- and last-mile solutions to a systemic multimodal approach of the urban commute.

After drawing the value curves for AVs over traditional vehicles, the next step was to discuss the main reasons that might lead people to use an AV over a TradV. It is worth noting here the distinction between human and machine attributes and the way that

such distinctions could lead to different motives to use a car, based on instrumental, symbolic and affective attributes as suggested by Steg (2005).

On the proposed analytical framework, we can observe that as automation levels increase (SAE, 2016), machine driving components of the vehicle also increase (while human attributes tend to decrease), so it is likely that Steg's (2005) motives to use a car will be reconfigured, with a probable increase in the instrumental motives (e.g., quality, flexibility, convenience, safety) and a reconfiguration of the symbolic and affective ones since the car will come to be seen not simply as a privately owned asset but much more as an on-demand service.

As limitations of the research, we highlight the emergence of the topic which incurs in difficulties to find scientific academic content to support the discussions as well as difficulties in gathering primary data (e.g.: lack of access to more experts in the area and confidentiality of the information especially from OEMs). Regarding future studies, it would be interesting to validate the value curves with empirical and statistical approaches as well as to go deeper into the outputs of the analytical framework. In this sense, we believe that the attributes found in this study could be the first step to further discuss in-depth such issues.

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