INNOVATION, TECHNOLOGY AND SOCIETY: A STUDY OF THE CONTROVERSIES AROUND AUTONOMOUS VEHICLES IN BRAZIL AND FRANCE

INOVAÇÃO, TECNOLOGIA E SOCIEDADE: ESTUDO DAS CONTROVÉRSIAS EM TORNO DOS VEÍCULOS AUTÔNOMOS NO BRASIL E NA FRANÇA

INNOVACIÓN, TECNOLOGÍA Y SOCIEDAD: UN ESTUDIO DE LAS CONTROVERSIAS EN TORNO AL VEHÍCULO AUTÓNOMO EN BRASIL Y FRANCIA

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ABSTRACT

Objective: The purpose of this article is to understand the controversies surrounding autonomous vehicles, explaining how this disruptive innovation has been implemented in different ways in Brazil and France.

Methodology: We mobilized the perspective of the Actor-Network Theory that overcomes an individualistic view by describing the heterogeneous interactions between humans and non-humans in the innovation process. The method of this study was cartography of controversies. Data were collected through YouTube videos, scientific articles, law texts, texts in magazines and by inserting one of the researchers in a discussion group on the subject.

Originality/Relevance: This study departs from a perspective that circumvents the technological determinism of a technoscience that tends to discard broader social implications such as transformations in experiences, ethical and moral issues, inequalities and work.

Main Results: Autonomous vehicles transit through different uncertainties that permeate controversies involving four central issues: business models, transport planning and urban mobility, public policies, ethical aspects and legal issues.

Theoretical/methodological contributions: The study demonstrates that there is the performance of multiple autonomous vehicles in practices related to public policies, ethical and legal aspects, urban mobility and new business models – in each practice, vehicle technology is enacted in different ways. So far, a VA is not a stabilized artifact, it is a technology whose design is, today, in the midst of several controversies.

Keywords: Disruptive Innovation; Actor-Network Theory; Smart Mobility; Public Policy.

RESUMO

Objetivo do estudo: O objetivo do presente artigo é compreender as controvérsias presentes em torno dos veículos autônomos explicitando como esta inovação disruptiva vem sendo enactada de diferentes formas no Brasil e na França.

Metodologia/abordagem: Mobilizamos a perspectiva da Teoria Ator-Rede que supera uma visão individualista pela descrição das interações heterogêneas entre humanos e não humanos no processo de inovação. O método deste estudo foi a cartografia de controvérsias. Os dados foram coletados por meio de vídeos do *YouTube*, artigos científicos, textos de leis, textos em revistas e pela inserção de um dos pesquisadores em um grupo de discussão sobre o tema.

Originalidade/Relevância: Este estudo parte de perspectiva que contorna o determinismo tecnológico de uma tecnociência que tende a descartar implicações sociais mais amplas como transformações em experiências, questões éticas e morais, desigualdades e trabalho.

Principais resultados: Os veículos autônomos transitam em diferentes incertezas que perpassam por controvérsias envolvendo quatro questões centrais: modelos de negócios, planejamento de transporte e mobilidade urbana, políticas públicas, aspectos éticos e questões jurídicas.

Contribuições teóricas/metodológicas: O estudo demonstra que existe a performação de múltiplos veículos autônomos em práticas relacionadas as políticas públicas, aspectos éticos e jurídicos, mobilidade urbana e novos modelos de negócio – em cada prática a tecnologia dos veículos é enactada de diferentes formas. Até o momento, um VA não é um artefato estabilizado, trata-se de uma tecnologia cujo desenho encontra-se, hoje, em meio a diversas controvérsias.

Palavras-chave: Inovação Disruptiva; Teoria Ator-Rede; Smart Mobility; Política Pública.

RESUMEN
Objetivo: El propósito de este artículo es comprender las controversias en torno a los vehículos autónomos, explicando cómo esta innovación disruptiva se ha implementado de diferentes maneras en Brasil y Francia.
Metodología: Movilizamos la perspectiva de la Teoría del Actor-Red que supera una visión individualista al describir las interacciones heterogéneas entre humanos y no humanos en el proceso de innovación. El método de este estudio fue la cartografía de las controversias. Los datos fueron recolectados a través de videos de YouTube, artículos científicos, textos de leyes, textos en revistas y mediante la inserción de uno de los investigadores en un grupo de discusión sobre el tema.
Originalidad / Relevancia: Este estudio parte de una perspectiva que sortea el determinismo tecnológico de una tecnociencia que tiende a descartar implicaciones sociales más amplias como transformaciones en las experiencias, cuestiones éticas y morales, desigualdades y trabajo.
Resultados principales: Los vehículos autónomos transitan por diferentes incertidumbres que permean controversias que involucran cuatro temas centrales: modelos de negocio, planificación del transporte y movilidad urbana, políticas públicas, aspectos éticos y aspectos legales. Aportes teóricos/metodológicos:
Aportes teóricos / metodológicos: El estudio demuestra que existe la actuación de múltiples vehículos autónomos en prácticas relacionadas con políticas públicas, aspectos éticos y legales, movilidad urbana y nuevos modelos de negocios – en cada práctica, la tecnología vehicular se promulga de diferentes maneras. Hasta el momento, un VA no es un artefacto estabilizado, es una tecnología cuyo diseño se encuentra, hoy por hoy, en medio de varias controversias

Palabras clave: Innovación Disruptiva; Teoría del Actor-Red; Movilidad Inteligente; Política Pública.

1 INTRODUCTION

One of the main discussions in urban mobility concerns smart mobility, which presupposes the insertion of technologies in mobility, aiming at accessibility, reducing congestion, and reducing polluting gases (Gandia, 2020). In this context, one of the new actors is vehicles with autonomous driving technology. These vehicles represent an innovation that strongly impacts urban mobility and transport systems (Cavazza et al., 2019; Gandia et al., 2019). Autonomous vehicles (AVs) do not require driver control (Cavazza et al., 2019). According to Gandia et al. (2019), The first vehicle equipped with an automated steering system appeared in the mid-1980s at Carnegie Mellon University. Since then, different companies and

research centers have turned to the increasingly autonomous development of VAs – knowing that there are different levels of automation. Several companies are pushing this technology, seeking to get ahead of AVs' development (Gandia et al., 2019). Studies indicate that they will be widely used (Gandia et al., 2019).

From Cavazza et al. (2019), we realized that the issues around autonomous vehicles concern a diversity of elements: in the field of business models (different business segments and structures), legal aspects (regulations, guidelines, and policies government), ethical and morals (accidents and changes resulting from AVs), transportation planning (autonomous systems, traffic control, and demand forecasting) and consumer behavior (expectations, perceptions and consumer reactions). In addition to issues such as privacy, licensing, security, and insurance (Gomes, 2021). Despite the various works, research, and tests already carried out on such topics, the existence of VAs is permeated with uncertainties. One of the reasons we opted for the theoretical contribution of the Actor-Network Theory (ANT) in this paper.

Actor-Network Theory overcomes traditional views on innovation by understanding that they occur in performative processes permeated by controversies. We can describe that disruptive innovation destabilizes structures and generates externalities from this perspective (Callon, 1998). Furthermore, from this perspective, markets are hybrid, collective, the result of practices, and permeated by uncertainties beyond any stability (Callon, 1998; Kjellberg & Helgesson, 2006). In addition, from the perspective of ANT, a technological artifact "[...] can be enacted, at the same time, in the most different practices, in different locations, constituting, in fact, multiple objects" (Ferreira & Lessa, 2019, p. 07). In this sense, it is necessary to conceive the existence of a multiplicity of objects formed in different socio-material configurations (Ferreira & Lessa, 2019) as we intend to describe in the case of autonomous vehicles.

In this sense, the present study is inspired by: (a) the research by Law and Mol (1995) on how Doppler was enacted as an instrument for the diagnosis of obstructed veins, as a technology that helps to assess the health of a fetus and as a diagnostic object under evaluation; (b) in the study by Law and Mol (2008) who describe how in each of the analyzed practices "a sheep" was different, namely: in veterinary practice (the veterinary sheep), in epidemiological practice (the epidemiological sheep), in economic practice (the economic sheep) and the practice of the

farmer (the farming sheep); and (c) in the investigation by Vieira et al. (2020) on how the Uber app was enacted in different ways from its insertion in a Brazilian capital (user technology, service provision, economic issues, and the Uber driver).

From this, the objective of this paper is to understand the controversies present around autonomous vehicles, explaining how this disruptive innovation has been enacted in different ways in Brazil and France. By collecting data referring to these two contexts, we also intend to explain how there are controversies with common and distinct elements in both.

2 THEORETICAL BACKGROUND

2.1 Innovation and actor-network theory

Most discussions are still based on the role of innovations for economic development and the role of the entrepreneur in the innovative process (Cavalcanti, 2016; Burtet, 2019). The Actor-Network Theory perspective replaces the individualistic view of the entrepreneur with the description of heterogeneous interactions between humans and non-humans (Callon, 2008; Cavalcanti, 2016; Burtet, 2019).

For Akrich, Callon, and Latour (2002), all innovation is a collective activity (involving humans and non-humans). Latour (2016) exemplifies the development of the contraceptive pill due to actors' interests such as feminist activist Margaret Sanger, chemist Gregory Pincus, the wealthy widow Catherine Dexter McCormick and molecules (steroids).

From the perspective of this article, the notion of interest presented by Callon (1986) is relevant. For Cavalcanti (2016), interest refers to processes in which authors seek to ensure that others will fulfill specific roles – in these "identities processes" are defined in a relational, negotiated, and always a provisional way (Callon, 1986). Thus, one of the advances of ANT is "[...] the understanding that organizations, the economy, innovations, the various actors, technologies, the social, are effects generated from arrangements (sets of relationships) of the network" (Burtet, 2019, p. 52). To understand innovation is necessary to go beyond the traditional view and assume that it is simultaneously technical and social.

Another conception that we need to consider to think about innovation beyond a naturalized view is that realities are multiple (Mol, 2002). Therefore, there is no single truth about innovation as a "fact"; it is more important to follow the issues of interest around it

(Latour, 2012). To understand the notion of multiplicity is necessary to consider that the term enactment indicates that an object does not exist without being linked to practices (Mol, 2002). Reality is a relational process in which entities (people, things, discourses, objects, theories) are "performed in and through the relationships in which they find themselves" (Burtet, 2019, p. 59).

In Callon's (2008) perspective, innovation cannot be understood linearly and is always the interaction result. According to Cavalcanti (2016, p. 01), "[...] innovation as the result of a heterogeneous network formed by human and non-human elements". It is essential that studies do not focus only on the technical aspects of innovation: "[...] it is not enough to be interested only in laboratory activities and what scientists do, but it is also important to address the set of heterogeneous professional, and that participate, in one way or another, in the conception, elaboration, and transport of innovations" (Cavalcanti, 2016, p. 10). Therefore, it is necessary to accompany autonomous vehicles throughout society beyond experiments and tests in research centers and academic research.

In the present perspective, "[...] innovation networks stimulate the proliferation of new social identities and trigger the creation of unexpected groups" (Cavalcanti, 2016, p. 11). Finally, to analyze how all the actants (researchers, entrepreneurs, governments, laws, public highways, government policies, intelligent systems, academic research, study centers, and others) act as "[...] and modify the meaning of the elements [...]" (Latour, 2012, p. 65), one of the possibilities is the cartography of controversies.

2.2 Controversies analysis

In the study of innovations, it is possible to verify the existence of a multiplicity of heterogeneous elements (Akrich, Callon & Latour, 2002). Hence the tool is important for the analysis of controversies: "[...] innovation by definition is created by instability and unpredictability" (Cavalcanti, 2016, p. 04). To describe the processes, we can use cartography (Latour, 2012; 2016). In controversies, "the intervening actors develop contradictory arguments and points of view that lead them to propose different versions of the social and natural worlds" (Callon, 1986, p. 3).

Controversies are disputes and conflicts, the study of which reveals the diversity of interests mobilized, since in controversies, "groups and anti-groups in conflict with opposing positions in the debate arise" (Cerretto & Domenico, 2016, p. 91). The controversies make it possible to describe the unstabilized issues and the multiplication of voices (Angotti, Rheingantz & Pedro, 2019). When describing the controversies, it is possible to perceive the "many changing frames of reference" in forming collectives (Latour, 2012, p. 53-54).

Tureta, Américo, and Clegg (2021, p. 01), report that the description and interpretation of practices, interests, and relationships of heterogeneous actors can benefit from the controversies cartography because it analyzes multiple viewpoints. Therefore, through the analysis of controversies, it is possible to describe the "[...] genesis of social processes that sustain contemporarily and carefully forged senses of normality is brought to light, including both the currents that became dominant and those that were dominated" (Tureta, Américo & Clegg, 2021, p. 01). In the case of autonomous vehicles, the analysis of controversies can reveal situations of disagreement between heterogeneous actors engaged in Brazil and France.

3 METHODOLOGY

The study method is the controversies cartography that serves us to "track social connection" (Latour, 2012, p. 53). By following the controversies, it is possible to describe the negotiations and conflicts that can stabilize certain practices.

Data collection was carried out through documentary research from material available on the internet in YouTube videos, scientific articles, texts of laws, texts in magazines (gray literature), interviews, and through the insertion of one of the researchers in a Whatsapp discussion group on autonomous vehicles (Group of the Terrestrial Mobility Laboratory – LMT). This group is composed of 21 researchers from different areas (automation engineering, computer science, administration, law, and social communication) and several research institutions: Federal University of Paraná (UFPR), Federal University of Lavras (UFLA), CentraleSupélec (France) and Université Paris-Saclay (France). The codes below were adopted to organize the citation of voices from the discussion group and documents (Figure 1).

Source	Description	Code
Whatsapp Discussion Group	Doctoral candidate in Law at Université Paris-Saclay	GDW/FR-1
	Ph.D. student in Business Administration at CentraleSupelec	GDW/FR-2
	Professor and researcher of Automation Engineering at UFLA	GDW/BR-1
	Professor and researcher of Automation Engineering at UFLA	GDW/BR-2
	Master in Business Administration in the Strategy, Marketing, and Innovation	GDW/BR-3
	Professor and researcher of Business Administration at UFLA	GDW/BR-4
Official documents	National Urban Mobility Policy Law - Law No. 12,587	BR/2012
	Route 2030: focus on encouraging R&D projects	ROTA 2030
	National Strategy for the Development of Automated Road Mobility 2020-2022 (https://www.ecologie.gouv.fr/sites/default/files/20171_strategie-nationale-vehicule%20automatise_web_0.pdf)	SNDM
	Law n° 2019-1428 of December 24, 2019, on the orientation of mobility, article (https://www.legifrance.gouv.fr/jorf/id/JORFTEXT000039666574)	FR/2019
	Decree No. 2018-211 of March 28, 2018, relating to the experimentation of vehicles with the driving delegation on public roads (https://www.legifrance.gouv.fr/loda/id/JORFTEXT000036750342/2021-01-25/)	FR/2018
	National Telecommunications Agency (Act No. 4776, of September 1, 2020)	ANATEL/ 2020
Private company	Auto Insurance CEO	DSA
News Reports	Brazil reduces traffic deaths but is far from the target for 2020 (http://agenciabrasil.ebc.com.br/geral/noticia/2018-09/brasil-reduz-mortes-no-transito-mas-esta-longe-da-meta-para-2020)	REP-1
	The WRI Brasil Cities program is part of the WRI Ross Center for ... (https://wribrasil.org.br/pt/o-que-fazemos/cidades-sustentaveis)	REP-2
	Transforming Transportation: a promessa e a realidade da Nova Mobilidade (https://wribrasil.org.br/pt/blog/2019/01/transforming-transportation-promessa-e-realidade-da-nova-mobilidade)	REP-3
	Deaths from traffic accidents fall for the second year in a row (https://www.gov.br/saude/pt-br/assuntos/noticias/obitos-por-acidentes-de-transito-caem-pelo-segundo-ano-consecutivo)	REP-4
	Jean-Baptiste Djebbari and Agnès Pannier-Runacher announce the publication (https://www.ecologie.gouv.fr/jean-baptiste-djebbari-et-agnes-pannier-runacher-annoncent-publication-strategie-nationale-2020-2022)	REP-5
	Self-driving cars: 7 Takeaways for Innovation Investors (https://ark-invest.com/articles/analyst-research/self-driving-cars/)	REP-6
	Véhicules autonomes, éthique, prévention et… « décision de tuer » (https://www.nextinpact.com/article/46139/vehicules-autonomes-ethique-prevention-et-decision-tuer)	REP-7
Videos	Can you drive better than a computer? (https://www.youtube.com/watch?v=WMRziLak2Zo&ab_channel=PBSTerra)	VYA2021

	Automotive industry: Anfavea releases first results for 2018 (https://www.automotivebusiness.com.br/noticia/26996/industria-automotiva-anfavea-divulga-primeiros-resultados-de-2018)	AB2018
	Autonomous Vehicles - Representative of the Federal Public Ministry (https://www.youtube.com/watch?v=8aIWwyB8A3s)	MPF-BR
	Autonomous Vehicles - Legal and legal aspects (https://www.youtube.com/watch?v=8aIWwyB8A3s)	MCTI-BR
	Autonomous Vehicles - National Data Protection Authority https://www.youtube.com/watch?v=8aIWwyB8A3s	ANPD-BR
	Ministry of Infrastructure of Brazil (https://www.youtube.com/watch?v=4Y8-2NHDPco)	MINFRA-2021
	Ministry of Infrastructure of Brazil (Coordinator of the Electronics Technical Commission of the Automotive Engineering Association of Brazil) (https://www.youtube.com/watch?v=4Y8-2NHDPco)	AEA/2021
Reports	Road Safety Country Overview (https://ec.europa.eu/transport/road_safety/sites/default/files/erso-country-overview-2016-france_en.pdf)	ERSO-2016
	The global health observatory (Https://www.who.int/gho/countries/en/)	OMS
	Institut National de la Statistique et des Études Économiques (https://www.insee.fr/fr/statistiques/1405599?geo=DEP-75)	INSEE
	(https://cidades.ibge.gov.br/brasil/geral/panorama)	IBGE
	(https://assets.kpmg/content/dam/kpmg/xx/pdf/2020/07/2020-autonomous-vehicles-readiness-index.pdf)	KPMG/ 2020
	Autonomous Vehicles Readiness Index (https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/Elements%20of%20success%20Urban%20transportation%20systems%20of%2024%20global%20cities/Urban-transportation-systems_e-versions.pdf)	PKW/2020
	The autonomous vehicle: ethical issues (https://www.ccne-ethique.fr/sites/default/files/cnpen-avis-vehicule-autonome-avril-2021.pdf)	CCNE/ 2021
	The Innovative Mobility Landscape the Case of Mobility as a Service (https://www.itf-oecd.org/sites/default/files/docs/innovative-mobility-landscape-maas.pdf)	ITF1/21

Figure 1. Data Source.

The controversies cartography was the method used to analyze the data, which allows the monitoring of disagreements and their developments (Venturini, 2010; Latour, 2012). It was possible to describe the controversies, actors, and positions around the autonomous vehicles innovation.

4 AUTONOMOUS VEHICLES AND CONTROVERSIES DISCUSSION

When mapping controversies, it is possible to visualize the movements and intermediate states between radical doubt and uncontested certainty – a space in which utterances transit (Latour, 2016). This study indicates that the VAs face different uncertainties permeating business models, transport planning, urban mobility, demand forecast, public policies, and ethical and legal aspects (regulations, government guidelines, and responsibilities) (Figure 2).

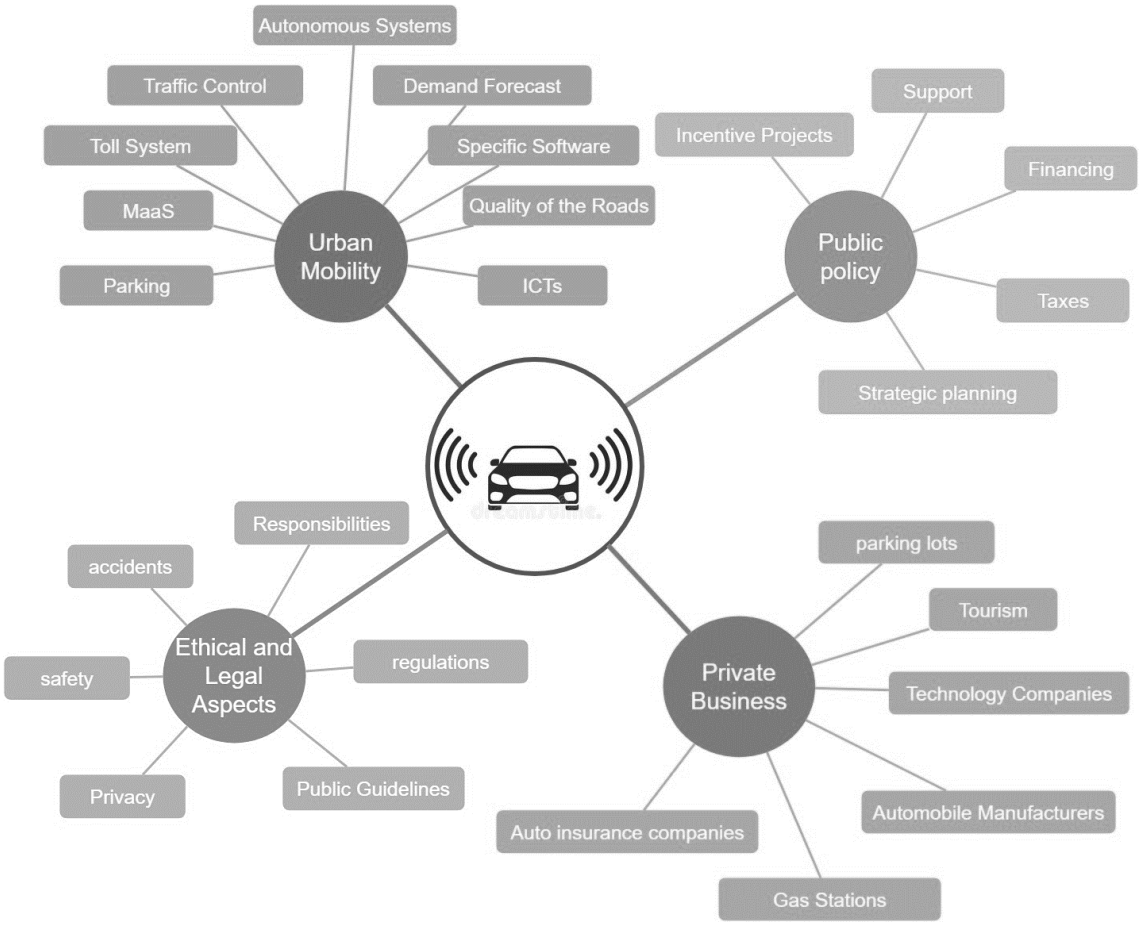

Figure 2. AVs controversies central issues.

In Figure 2, the central issues identified in the research involving the controversies around autonomous vehicles focused on ethical and legal aspects, private business, urban mobility, and public policies. It is possible to perceive that, considering the particularities of the countries, the controversies and issues present in Brazil are also current in France. The perspective of comparison between Brazil and France arises from two central aspects. First, according to the General Coordinator of Traffic Safety, in an institutional webinar shown on

the website of the Ministry of Infrastructure of Brazil, the country is one of the largest vehicle-producing markets in the world (MINFRA-2021). Second, France is one of the pioneer countries in studies with AVs and with the most significant number of published research (Antonialli, 2019), which can be considered an excellent cradle of learning for Brazilian researchers. In addition, there are common issues between Brazil and France, such as the problems faced in mobility by public transport users (broken vehicles, delays, overcrowding, etc.) (Doré, 2019). It also happens in other European countries (Reigner & Brenac, 2019; Lombardi & Ciceri, 2021) and Brazil but with different intensities.

4.1 Public policies

One of the distinct issues between Brazil and France is the difficulty in Brazil in harmonizing State incentives to automakers and the automotive industry. In Brazil, Law No. 12,587 of January 3, 2012 establishes guidelines for the National Urban Mobility Policy to integrate means of transport to improve accessibility and mobility of people (BR/2012). In addition, Route 2030 (Law No. 13,755, of December 10, 2018) is a federal government program aimed at the automotive chain. Its objective is to support technological development, competitiveness, innovation, vehicle safety, environmental protection, and energy efficiency (ROTA 2030, 2021). According to the president of the National Association of Automotive Vehicle Manufacturers (ANFAVEA), an institution that represents vehicle assemblers installed in Brazil, this program is the most important driver of research and development in the country's automobile industry (AB2018). In the perception of researchers, in Brazil, the government is dependent on automakers, and they are the most interested in Route 2030 (GDW/BR-1). For one researcher, although the Rota 2030 program has projects to encourage innovation for automakers, it does not consider that the significant players are high-tech companies, so the driving projects would need to be geared towards public/private partnerships.

> The primary sources of public power [in Brazil] are what vehicles in the current model deliver. As long as there is no alignment of interests, projects will not develop as they could. Even before that, if these interests, challenges, [...] of each stakeholder, are not put on the table, each side will still take care of its own. Fragmentation does not support the definition of an enabling regulatory framework - which is what will sustain and promote all the rest of the system's actions. It is what differentiates us from France (comparing the specificities of France and Brazil). (GDW/FR-2, 2021).

In this sense, while Brazil still focuses its resources on adapting (inserting incentives for the use of technology) bills for car manufacturers, France authorized by decree the experimentation with vehicles on public roads (FR/2018). In addition, the Ministers in charge of Transport and Industry (Jean-Baptiste Djebbari and Agnès Pannier-Runacher) published the document *Stratégie nationale de développement de la mobilité routière automatisée 2020-2022*. During the Ministerial Committee for Transport Development and Innovation (CMDIT) held on December 15, 2020, ministers released the development strategy for automated road mobility. As of that date, France has chosen to consider the development of automated vehicles as an opportunity for more on-demand, cleaner, and more inclusive mobility (REP-5).

As described by Jean-Baptiste Djebbari, Minister of Transport, the law that governs mobility is from December 2019, and France is one of the first European countries to have a legislative and regulatory framework that allows the circulation of these vehicles until 2022. With actions and specific projects aimed at autonomous vehicle development companies and traditional automakers (SNDM, 2021). As can be seen in the KPMG/2020 survey, France has excellent road conditions and good infrastructure. However, in line with technological issues, it has a low density of electric charging stations and insufficient 4G internet coverage.

Data from KPMG/2020 show that France stands out in work technology and innovation and the establishment of public-private partnerships. However, there are still questions and doubts about harnessing the potential and mitigating the obstacles in developed and developing countries. According to Makhtar Diop, Vice President of Infrastructure at the World Bank, the technological aspects are not enough to experience the full impact of mobility. It is necessary to find solutions adapted to specific realities, deal with technical knowledge, understand the basic system and identify needs that mainly refer to infrastructure issues (REP-3). In this sense, mobility is a movement beyond going from A to B, including safety, comfort, and accessibility (PKW/2020). And there is still a lot to think about and actions to be taken:

> I was on the metro in Paris, going to a tourist spot, and my father and cousin needed to carry me to the boarding station because there was no ramp for wheelchair users. Think about it, I was in Europe, and there was no ramp for me to get off (GDW/BR-4).

It is essential to highlight that the Ministry of Infrastructure has already started a movement on autonomous vehicles through the National Traffic Secretariat (Senatram). According to Frederico Carneiro (Director General of Senatram), the need to bring and improve this technology is essential for entering the international market. In addition, the Brazilian Ministry of Infrastructure believes that this intelligence will reduce the number of traffic fatalities (MINFRA/2021).

In addition, other government institutions envision the insertion of VAs in Brazil. The National Telecommunications Agency (Anatel) published Act No. 4776 of September 1, 2020, which reserved an exclusive frequency band for the Vehicle Communication System. According to the document, the initiative was institutionalized considering the technological evolution of vehicular connectivity to mobile communications networks to help and protect drivers and passengers. For the coordinator of the Electronic Technical Commission of the Brazilian Association of Automotive Engineering, this was an important step, considering that even the United States had problems with this happening somehow (AEA/2021).

The insertion of technologies, mainly autonomous and that boost mobility as a service, bring changes in mobility and can influence the way people live, work, access services, goods, and leisure, impacting the quality of transport and economic activities (ITF1/ 21). Also, according to the ITF1/21 report, the possible contradictory effects of socio-economic policies, the unlimited needs of users, and the multiplicity of stakeholders in the organization of the mobility system can lead to unsustainable mobility solutions and negative externalities such as pollution, congestion urban, overuse of public parking spaces, risk of death and severe injury, noise, and disruption of communities and ecosystems.

4.2 Ethical and legal aspects

The legal aspects involve safety, civil liability, and ownership of data generated by autonomous vehicles. Concerning ethics, the main controversy is related to what Gomes (2021) called the selfish behavior of the VA. There are legal demands to be clarified, technological barriers to overcome, and environmental and social issues that must be considered (Muller, Park, Lee, Fusco & Correia, 2021).

A controversial point in the legal aspect is a civil liability in the case of accidents with autonomous vehicles. According to Ryan (2020), each nation has its laws interpretations, even in the case of Brazil and France, which are signatories of the same convention of law (the Vienna convention of 1968). This discussion still generates a lot of controversies (GDW/FR-1).

In March 2021, the Vienna Convention of 1968 entered into force, the international treaty on-road transit to which Brazil and France are parties. According to MPF-BR (2021), the signing of this contract means that Brazil will mirror this legal system, specifically concerning the traffic code. However, Brazil still incorporated the latest amendments to the Vienna Convention. Legally, Brazil would have to establish two premises: i) say what a VA is, that is, develop what an autonomous vehicle is for legal purposes; and, ii) clarify what would be an admissible concept of the accident with VAs to build a legal system able to regulate civil liability in case of accidents and damages (MCTI-BR).

In France, this responsibility has already been established; however, only applied in the experimentation tests (MPF-BR, 2021). Loi n° 2019-1428 (in France) exempts the driver from liability when the automated steering system is activated. On the other hand, if, at the moment of the accident, the driver, in an attempt to avoid the accident, activates the driving control system, he can be recognized as responsible (FR/2019). In that case, a moral person who did not intentionally commit a fault can take responsibility. Thus, while the implementation of VAs promises to reduce accident rates (especially caused by human errors), there is great difficulty in establishing a legal consensus since the liability rules in legislation are complex to determine (Lee & Hess, 2020).

Another factor related to safety, but related to ethical aspects, is the selfish behavior that the vehicle can perform. Dubljević (2020) highlights that the VA can decide to protect the owner and the car at all costs or in an instrumental way, reducing the number of lives lost and prioritizing the environment.

> We know that it will reduce the number of accidents. But we don't know if, at a given moment, we identify a person crossing the street in the middle of the street. Will we run over that person to save whoever is in the car? Or will the car decide to turn and crash into a wall? Or into another car, to save pedestrians, since the user inside the car has airbags and security systems? (DSA, 2021).

In France, the Comité Consultatif National d'Éthique presented the Minister with an opinion on the ethical issues of road vehicles equipped with automated driving functions (REP-7). This committee is responsible for comprehensively addressing the ethical issues of digital and artificial intelligence. The primary mission of shed light on scientific progress, raise new societal issues, and take an ethical look at these developments. According to the opinion, the protection of human life will always be the top priority (CCNE/2021). Therefore, it makes it clear that the protection of people precedes that of animals and goods. But, there are no arguments between goods and animals. On a note, Mercedes-Benz made a different choice, ensuring it could save the driver instead of trying to save several other lives (REP-7). It also doesn't mention animal protection concerning the integrity of VAs.

Another ethical point to consider is the privacy of drivers, passengers, pedestrians, and road users. Automated driving vehicles perceive their environment due to multiple visual and distance sensors for their navigation needs (Ryan, 2020). The data collected is not limited to VA passengers but to other road or road users. Its algorithms analyze perceived scenes and interpret situations. They exchange information with the infrastructure about signage, traffic conditions, or the behavior of other vehicles that circulate nearby. This data processing raises questions about privacy, personal data protection, and individual freedoms (CCNE/21).

According to the CCNE/21 report, data collected by the VA regarding vehicle users and their environment (other vehicles, houses, etc.) can be made available to private or public operators. This creates a tension between the vehicle user's fundamental freedoms, including their freedom of movement, and the fundamental freedoms of other people and respect for their privacy (CCNE/21). The user is also subject to a tension between his choice to use a VA and the collection of his data that this choice implies.

Another point regarding this issue is that data is the most valuable commodity in the intelligent system. Thus, the data generated by the autonomous vehicle, directly or indirectly, when interacting with other cybernetic entities and services is gaining importance and can be monetized, generating a new business.

> Who will own the data? That is, will the data be from the manufacturer? Will they be from the software operator? Will insurance companies and vehicle owners be able to demand that this data be given to us? And the passenger, where does he go? How is he in this story? (GDW/FR-1, 2021).

Thus, the vehicle can be seen as a data platform, hosting the data generated by itself. The vehicle can be seen as a service platform, mediating access to this data, potentially collaborating with cloud-based services (Docherty, Marsden & Anable, 2018) that severely impact several other actors. This information supports the assumptions of Pütz et al. (2019) that there is a need for regulatory intervention both for the ownership, provision, and use of data and its monetization, which is still far from being resolved.

4.3 AVs in urban mobility

According to the World Health Organization, in Brazil, land transport accidents are responsible for 50 million injuries and 1.25 million deaths worldwide (REP-4). Still, according to the WHO report, India, China, the United States, and Russia are the first four countries with the highest traffic fatality rate. In the ranking, Brazil occupies fifth place (REP-1). In 2016, in France, 3,477 traffic deaths were recorded, 1,002 of them in the urban perimeter (ERSO-2016). In both countries, studies on mobility are no longer developing. As can be seen in the speech of the MPF-BR:

> Brazil, the research part is solid. Since I arrived from France and started my part of the research here in Brazil, the autonomous vehicle at the University of São Carlos was already being tested on public roads (MPF-BR, 2021).

According to this government official, Brazil has excellent researchers; it needs research support and multidisciplinary research covering legal, security, and economic aspects.

The National Association for Data Protection coordinator adds that although Brazil already has excellence in terms of research with VAs, it still leaves something to be desired in terms of the flow of investment in research. There is an urgent need to start testing here in Brazil in the face of Brazilian environmental conditions. In terms of infrastructure and environmental issues.

The road conditions, and road signage, for example, in the north of the country, in the northeast of the country, or in the interior, are very different. So imagining autonomous traffic on a highway (in a freight transport scenario), what would the VA reactions look like in a poor conservation scenario? Are these specific scenarios in the country that have to be brought to the

teams, and use cases have to be trained so that the vehicle can know these patterns through deep learning, and will this be done by development teams from manufacturers abroad? I think it's unlikely. (...) unless there are public policies that can attract them here. In this way, investment in research teams is needed, and the starting point is that we will start to be able to deal with these specific scenarios in Brazil (ANPD-BR, 2021).

Several issues come to the fore about transport planning and the businesses and enterprises that the insertion of these vehicles will impact. The first one is about the traffic department; traffic fines are a significant source of money for governments. In the automated vehicle, there is obedience to traffic and, therefore, there will be a loss of revenue in this regard (Clements & Kockelman, 2017). Another issue is about public or shared transport; considering that automation is expanded to buses and trains, labor savings can be transferred to passengers through lower fares, thus improving the competitiveness of mass transport. For some members of research groups, when autonomous vehicles are added to the shared travel service, buses can be replaced by more flexible and less expensive services. For others, however, shared autonomous service is not a direct substitute for public transport; for this to happen, there must be a capacity that meets high demand (Bösch et al., 2018).

VAs can significantly improve the performance and efficiency of urban transport as it moves more quickly with precision to all sides, reducing labor costs. On the other hand, it can generate unemployment and loss of income at gas stations since automation is much more viable and economical in electric vehicles. Therefore, transport planning and mobility policy issues are broadly associated with other issues such as quality of public transport services and employment/unemployment.

Among the many changes foreseen for the transport paradigm (Mulley, 2017), the arrival of new information and communication technologies, which are an essential and driving part of automation technology, increasingly promote the development of business concepts for the use of more efficient vehicles, transport network optimization, better infrastructure utilization, and seamless switching. For Gandia (2020), three factors should be considered: 1) data collection, 2) autonomous (and electric) vehicles, and 3) multimodal transport. All factors must be analyzed as part of a single ecosystem (Gandia, 2020).

In this sense, the concept of mobility as a Service (MaaS) has been gaining ground in recent years. It has become a solid market option, as it presents a shift from the existing property-based transport system to one based on access (Jittrapirom et al., 2017). MaaS meets the transport needs of users through a single interface of a service provider, combining different modes of transport to offer a customized mobility package (Liyanage, Dia, Abduljabbar & Bagloee, 2019). This approach places the user at the center, as pointed out by Jin et al. (2016), so the consumer needs to be open to adopting new technologies and services.

4.4 VAs impact on private sector business

With the insertion of VAs, different business models can be impacted, generating multiple representations and enacting the reality of the actors. The absence of a driver can be perceived as a positive thing as it reduces labor costs by replacing work routines with automated systems (Gomes, 2021). Or negative, since there may be job losses for drivers and drivers in this same context and reinvestments and restructuring in some businesses.

Positive aspects also for car-sharing service providers, since it meets the needs of individuals, allowing accessibility in a flexible way and at a lower cost. However, for the automotive industry, automation will lead to greater car-sharing, and consequently, the need to own a vehicle can decrease significantly, leading to economic losses (REP-6).

It is believed that the traditional automotive industry can be subsumed by MaaS (Mobility as a Service) platforms, especially with the insertion of autonomous vehicles, which can become one of the most valuable investment opportunities in the public equity markets (REP-6). Although the MaaS systems currently studied occur in developed countries (Jittrapirom, 2017), and advances in MaaS are being built, mainly in Europe (Muller et al., 2021), they can be inserted in emerging countries like Brazil. However, incentives and public policies are needed for this. (Gandia, 2020).

Another possibility discussed for the automotive industry is the partnership between automakers and technology companies. Autonomous technology raises the price of the vehicle, also increasing the cost of acquisition. In France, the proximity of automakers and technology companies has already started, driven by government projects and actions. In Brazil, this reality is moving slowly.

> Companies have been behind for a while on the vehicle assembly issue, so this fear has already turned into something out there (Referring to France). The big players there are technology companies. Automakers are just partnering with them. [...] This is a big problem here in Brazil, the government is the boss of automakers here, and they are terrified of the insertion of VAs. (GDW/BR-2, 2021).

Due to artificial intelligence applications, technology companies (hardware and software) are important actors in the VA production process. According to Clements and Kockelman (2017), artificial intelligence has become quite efficient and critical for making quick decisions in real-time and complex transport environments. One of the possibilities is the interaction with e-commerce platforms and logistics innovations that can allow choosing what and where to buy through the system installed in the vehicle. Supermarkets enabled with information and communication technology systems will be able to interact, facilitating access to delivery of the product at the establishment or delivering food ordered directly to consumers.

> Vehicles are intelligent, and products are sold through the embedded system. The person connects his shopping list, the vehicle searches for prices, the person buys in 2 or 3 locations, and the vehicle chooses the best route to pick up these goods. Amazon? Google? Magazine Luiza? Just think about saving time and money with it! (GDW/BR-1)

Such savings can also impact gas stations. Although Mersky and Samaras (2016) claim that fuel consumption with vehicle automation has increased by 10%, several other possibilities for VAs can dampen fuel efficiency. Clements and Kockelman (2017) highlight, for example, the ability to park oneself, the possibility of joining Maas, and generating mobility sharing. In addition, VAs are more efficient with electricity, less polluting, and more environmentally friendly (Pourabdollah et al. 2017), but impacting one of the most controversial markets in Brazil, the oil market.

Another business model that VAs can impact is car insurance companies. The leading service offered is associated with human error, such as the risk of collision, being run over, theft, and robbery (Skeete, 2018). As they have advanced security properties, it can reduce insurance sales.

> Self-driving cars are likely to have a dramatic impact on global health impacts. Auto accident rates are expected to decrease by more than 80% as robots take over drunk and distracted drivers (REP-6).

For this reason, Xu and Fan (2019) question whether the insurance market is close to being extinguished or will need to be reinvented by mitigating failures in technology systems or Cyber risk. As noted, total vehicle automation enacts in different ways in various segments. Being quite promising, efficient, and sustainable in some, leading directly to revenue losses and the need for reconfiguration in others (Heard et al., 2018). In addition to the impacts caused in the employment of taxi drivers, delivery people, and drivers. However, investing in an autonomous vehicle to be used in delivery services, taking and picking up people, or even mixing users and packages when they share the same destination can generate new opportunities, accessibility, and quality of life.

5 FINAL CONSIDERATIONS

Everything that refers to autonomous vehicles has multidisciplinarity and uncertainties. For example, it depends on the government's incentive to automakers and systems developers. The certainty that the vehicles will be of interest to these online sales companies and the certainty that the automaker and developers will not be held responsible for any damage that this vehicle causes. Following the discussions that involve researchers and professionals from different areas interested in autonomous vehicles, these issues are still not defined either in Brazil or in France. The big difference is that France has incentives to build partnerships between the industrial and service sectors, new technology companies, and traditional actors in the automotive sector. They are alliances between the government and autonomous vehicles (in Latour's terms). In Brazil, Rota 2030 continues to be a start, with actions such as benefiting mobility and logistics companies that have invested in research with technological innovations related to mobility or the logistics chain.

The study demonstrates the performance of multiple autonomous vehicles in practices related to public policies, ethical and legal aspects, urban mobility, and new business models – in each practice, vehicle technology is enacted differently. So far, a VA is not a stabilized artifact; it is a technology whose design “is an endless process” (Callon, 2004, p. 3) and is currently amid several controversies. In this sense, VAs are one of the most anticipated technological developments with far-reaching implications (Bissell et al., 2018). The context

of this study is marked by the urban mobility and transport market, being the result of a continuous process that involves materially heterogeneous entities (Kjellberg & Helgesson, 2006). And that has suffered several destabilizations with the insertion of shared economy models, electric cars, and now the VAs. About the entities that make up this market, in the case of VAs, we have technologies, programs, companies, legislation, psychological and cultural aspects, researchers, GPS, regulations, universities and research centers, platforms, business models, etc). With this, a diversity of human and non-human actors translate diverse and contradictory interests (Latour, 2012), giving rise to controversies.

According to Venturini (2012), the evolution of a controversy is not uniform. Sometimes disputes can remain dormant for years before and then explode. For example, vehicle control is what the traffic code recommends, but which, in the end, would not be possible in all situations, only in controlled environments and at low speeds. One of the questions that have been asked is how this would be functional both in Brazil and in France. Furthermore, how to win over the consumer who will have to pay a good price for the vehicle, for training in this system, for vehicle insurance, and who, in the end, will have an obligation to supervise the vehicle and the environment through which to circulate, running the risk of being held responsible in case of accidents with material and personal damages.

As limitations of the study, we highlight: a) focus on only one group of researchers and limited systematization of "gray literature"; b) not representing the controversies in the graphic terms presented by Venturini (2010; 2012), and (c) limited description of the number of actors and their positions. In future research, we suggest: a) building for controversies involving autonomous vehicles, the mandala of actors disputing positions in controversies, the hierarchical tree of controversy (Cerretto & Domenico, 2016) and other indications by Venturini (2010; 2012); b) follow through ethnography or netnography "laboratories" for the development, testing and study of autonomous vehicles and c) continue to follow the technology of autonomous vehicles, their translations, alliances and agencies throughout society with a focus on Brazil.

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