BRUNA HABIB CAVAZZA

CRITICAL SUCCESS FACTORS FOR THE INSERTION OF AUTONOMOUS VEHICLES AS A PRODUCT SERVICE SYSTEM IN A COUNTRY

LAVRAS-MG
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FATORES CRÍTICOS DE SUCESSO PARA A INSERÇÃO DE VEÍCULOS AUTÔNOMOS COMO UM SISTEMA DE PRODUTOS E SERVIÇOS EM UM PAÍS

Tese apresentada à Universidade Federal de Lavras, como parte das exigências do Programa de Pós-Graduação em Administração, área de concentração Administração, linha Gestão Estratégica, Marketing e Inovação, para obtenção do título de Doutor.

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Para os meus pais, meu porto seguro e maiores responsáveis por essa conquista, Mário e Karla,

Para a outra metade do meu coração, meu irmão Renato,

Para meus avós, meu maior abrigo e morada,

Para todos os meus professores, pelo exemplo e por despertar em mim a paixão pelo saber.

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Deus sabe o que faz, sabe o que tira, sabe o que trás.

For everything there is a season,
and a time for every matter under heaven (Ecclesiastes 3:1)

GENERAL ABSTRACT

Autonomous vehicles (AVs) are embedded in the most significant historical change to the automobile and transportation industry. Governments, universities, and organizations worldwide identify AVs as a key-research factor. Based on theories of disruption and innovation, the general objective of this work is to analyze AVs as a Product-Service System (PSS), seeking to identify critical success factors (CSFs) for their insertion in a country in order to propose and test an innovation framework.Starting from an teorical investigation and field approach, this thesis was drawn up as academic articles. Article 1 reviews the management and business research field of Autonomous Vehicles (AVs) in a bibliometric context to identify strategies, practices, and management tools; and summarizes existing studies and research gaps. The study is qualitative and descriptive, based on a bibliometric review on Web of Science, Scopus, and Science Direct, followed by a systematic integrative review. Results show that, in the near future, AVs will certainly be introduced in the society. However, such insertion is still surrounded by uncertainties, doubled by governments' lack of planning. Paper 2 aimed at identifying the CSFs and proposes a theoretical model of the innovation radar for the insertion of AVs as a PSS in a country. The study has exploratory-descriptive nature, quantitative-qualitative approach and adopted theoretical-empirical procedures. Through a systematic literature review, it was possible to map the main CSFs for a country, next, we used questionnaires to filter key CSFs that could be used in AVs scope and context, and thus, we have the proposition of a theoretical framework that allows the mapping the CSFs. The framework presents 4 key dimensions that work like anchors: (1) Technology and Innovation, (2) Social and Political Environments (3) Consumer and Market, (4) Infrastructure and Patters. Among these four anchors, we imbedded 12 factors of the innovation system that can serve as pursuit avenues. Paper 3 seeks to map and discuss the innovation context of Brazil and France. The study has exploratory-deciptive nature, quantitative-qualitative approach and adopted theoretical-empirical procedures. A case study method was used, with questionnaires as a data source. The results obtained in Brazil and in France were crossed with official data and statistics and corroborate the use of this tool. Through the outputs of this research we could address the gap between the development of AVs, the differences between two national contexts, and the lack of specific knowledge about how to manage disruptive innovation in countries. Hence, the main contribution of this thesis is the integration of data and information from different sectors (social, political, economic, technological, and structural) of a given country, making it possible to map, discuss, and divedeeper on the real panorama for AVs' insertion. As for future studies we suggest to extend the data collection to other countries and also, based on the outputs of this research, a future agenda must include the elaboration of key guidelines for AVs governance, including short, middle, and long term actions and requirements for the complete and successful insertion of AVs in the countries.

Keywords: Management. Vehicles. Innovation.Mobility.

RESUMO GERAL

Veículos autônomos (VAs) estão incorporados na mudança histórica mais significativa para a indústria automobilística e de transportes. Governos, universidades e organizações em todo o mundo os identificam como um fator-chave de pesquisa.Com base nas teorias de disrupção e inovação, o objetivo geral deste trabalho é analisar os VAs como um Sistema de Produtos-Serviços (SPS), buscando identificar fatores críticos de sucesso (FCS) para sua inserção em um país, a fim de propor e testar um framework de inovação. Partindo de uma investigação e abordagem de campo, esta tese foi elaborada no formato de artigos acadêmicos. O artigo 1 revisa o campo de estudos de VAs no âmbito da administração em um contexto bibliométrico para identificar estratégias, práticas e ferramentas de gestão; e resume os estudos existentes e as lacunas de pesquisa. O estudo é qualitativo e descritivo, baseado em uma revisão bibliométrica nas bases de dados Web of Science, Scopus e Science Direct, seguida de uma revisão integrativa sistemática. Os resultados mostram que, num futuro próximo, os VAs certamente serão introduzidos na sociedade. No entanto, essa inserção ainda é cercada por incertezas, acentuadas pela falta de planejamento dos governos.Observou-se uma lacuna de pesquisa sobre modelos e plataformas de negócio e teorias de inovação radicais e responsáveis. O artigo 2 buscou identificar os FCS e propor um modelo teórico do radar de inovação para a inserção de VAs como um SPS. O estudo foi caracterizado como empírico, de natureza quantitativo-qualitativae abordagem exploratório-descritiva. Através de uma revisão sistemática da literatura, foi possível mapear os principais FCS para um país encontrados na literatura, em seguida, utilizou-se questionários como ferramenta para filtrar FCS chave que poderiam ser utilizados no escopo e contexto das VAs, assim, temos a proposição de um framework teórico que permite mapear a capacidade inovadora de um país. O framework apresenta 4 dimensões-chave que funcionam como âncoras: (1) Tecnologia e Inovação, (2) Ambiente Social e Político (3) Consumidor e Mercado, (4) Infraestrutura e Padrões. Entre essas quatro âncoras, foram incoporados 12 fatores do sistema de inovação que podem servir como caminhos de busca.O artigo 3 buscou mapear e discutir o contexto de inovação do Brasil e da França. A pesquisa é caracterizada como empírica, natureza qualitativa e abordagem exploratório-descritiva. O método de estudo de caso foi usado, com questionários como fonte de dados. Os resultados obtidos no Brasil e na França foram cruzados com dados e estatísticas oficiais e corroboram o uso dessa ferramenta. Através dos resultados desta pesquisa, é possível abordar a lacuna entre o desenvolvimento dos VAs, as diferenças entre dois contextos nacionais e a falta de conhecimento específico sobre como gerenciar inovações disruptivas nos países. Assim, a principal contribuição desta tese é a integração de dados e informações de diferentes setores (sociais, políticos, econômicos, tecnológicos e estruturais) de um determinado país, possibilitando mapear, discutir e aprofundar o panorama realpara inserção de VAs. Quanto a estudos futuros, sugerimos estender a coleta de dados a outros países e também, com base nos resultados desta pesquisa, uma agenda futura deve incluir a elaboração de diretrizes-chave para a governança de VAs, incluindo ações e requisitos de curto, médio e longo prazo para a inserção completa e bem sucedida de VAs nos países.

Palavras-chave: Administração. Veículos. Inovação. Mobilidade.

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SUMMARY

FIRST PART

1 INTRODUCTION

In the present section, we initially sought to synthesize introductory aspects related to autonomous vehicles (Avs) as a product service system (PSS), its impacts as well as its development and its relation with the movement of the Urban Mobility studies. Following is the specification of the question, objectives and justifications of the research, ending with the description of the structure of this document.

1.1Contextualization and motivation

Autonomous Vehicles (AVs)[1]– also known as self-driving vehicles; driverless cars or even; robotic cars –are vehicles that don't require any sort of conductor or teleoperation control (FRAZZOLI; DAHLEH; FERON, 2002). They are considered an integral part of the new forms of mobility (ATTIAS, 2016) and have become focus of many R&D projects, being considered by many authors as the greatest disruptive innovation in the automotive industry (ATTIAS, 2016; ATTIAS; MIRA-BONNARDEL, 2016; ENOCH, 2015; FAGNANT; KOCKELMAN, 2015; MUTZ et al., 2016; POORSARTEP, 2014; SCHELLEKENS, 2015; SCHREURS; STEUWER, 2015).

The development of AVs is an important innovation that promises to have great impact on the issues of urban mobility and on several spheres. In fact, AVs are embedded in the most significant historical change to the automobile and transportation industry. Governments, universities, and organizations worldwide identify AVs as key-research factor. The AVs' imminent arrival have the potential to fundamentally alter transportation systems by avoiding deadly crashes, providing critical mobility to the elderly and disabled, increasing road capacity, saving fuel, and lowering emissions, being important to consider the impacts of such disruptive innovation on society, structure and functioning of companies (FAGNANT; KOCKELMAN, 2015).

Nowadays, the proliferation of autonomous vehicles is far from guaranteed. High costs related to additional car equipment services, and maintenance as well as further investmentsinroadway infrastructure hamper large-scale production and mass consumer availability (GRAU, 2012; HICKEY, 2012; KPMG; CAR, 2012). According to Fagnant

[1]In this work, Autonomous Vehicles (AVs) is referred to vehicles equipped with Automated Driving Systems (ADS) of automation levels 4 and 5 as defined by the Society of Automotive Engineers (SAE).

andKockelman (2015, p. 168) “complex questions related to legal aspects, liability, privacy, licensing, security, and insurance regulation still remain to be solved.” It’s important to consider that AVs may introduce new risks, in a sense of system failures that can occur. Being connected to the cloud and operated by a central unit system, there will be security and privacy concerns related to cyber security threats, where vehicles can be controlled remotely. Further, vulnerable abuse of information, tracking and data sharing could violate the passenger privacy and those cars could be used for some terrorist activities (HUCKO, 2017).

The fact is that there is a long way to go from the current concept of having / owning a vehicle - including here symbolic, instrumental, and affective factors (STEG, 2005) to this new configuration with autonomous vehicles. In this sense, complementary trends in shared rides and vehicles may lead us from vehicles as a privately-owned asset to an on-demand service (FAGNANT; KOCKELMAN, 2015). In fact, with the emergence of issues related to Mobility as a Service (MAAS) it is consistent to think that the deployment of these vehicles will occur in a model that combines a bundled offer of product and service, that is a Product-Service System (PSS) in order to provide value to society (JOHNSON; MENA, 2008).

In this sense, the traditional process of manufacturing, commercializing, and using cars as products is losing ground to alternative transport forms. Although academic, commercial, legal and social advances are essential for the dissemination of this innovation, it is understood that, regarding disruptive innovations, technology cannot be established as the process’ exclusive key-factor, but combined with the establishment of other factors so that countries and society can adopt or change their related business model (CHRISTENSEN, 2006; PORTER, 1993).

For hence, Rayna and Striukova (2016) history has shown that technological revolution without adequate society acceptance is a pitfall for many businesses and countries.In this context, and considering all the economic and social benefits but also all the imminent impacts and risks associated to the arrival of the autonomous vehicles, “many governments are keen to move towards an AV future as soon as possible” (KPMG, 2018).

However, it is worth noting that new models are often hard to define, since they can serve at the same time as scale models, role models and ideal models (BADEN-FULLER; MORGAN, 2010), and organizations and countries rarely articulate strategies to align their innovation efforts with their business and social strategies (PISANO, 2015). Specially regarding a macro scenario, we must consider that the conclusions and aspects will vary according to the country. “Indeed the optimal AV future of one city may differ from

anothernearby, depending on patterns of travel and availability of public transport alternatives. But basic standards of interoperability will need to be put in place across countries and potentially entire continents" (KPMG, 2018, p. 7).In other words, for the AVs to become a successful innovation we must consider the key aspects of its business, social and legal system (SAWHNEY; WOLCOTT; ARRONIZ, 2006).

These aspects could be understood as the essential factors or dimensions that must be prioritized to achieve tactical and strategic goals, even if other aspects are neglected (ROCKART, 1979). These factors, also known as "Critical Success Factors" (CSFs), represent the areas, activities, and organizational processes that use the resources available to increase the competitiveness of a given product, service or organization (NASCIMENTO, 2016). In this sense, we understand that the first step in the process of designing innovations associated with new models and business for autonomous vehicles as a PSS is to consider what are the main features and aspects of this vehicle in order to promote the insertion and adoption in a country and also the shift to unexplored markets.

It is important to highlight that, even though there is large and growing literature on CSFs, it is "not providing practitioners with the tools to enable more effective interventions in major systems implementations" (KING; BURGESS, 2006). CSF are usually associated with indicators, and can be represented on the radar chart form giving a view of performance or ability of the country or organization with respect to a certain technology, service or innovation.

1.2 Problem, objectives and justifications

Considering this context, some questions emerged as guidelines to this work such as 'what is the purpose of an autonomous vehicle from a social and business perspective in the countries?' 'What is the connection between AV and technology, legislation, market and business and society?' 'What are the Critical Success Factors for AVs in the countries, and how do they relate to each other?' 'Which factors and indicators could be present on the innovation radar?'

Thus, based on theories of disruption, innovation and critical success factores (CSFs), the general objective of this doctoral thesis is to analyze the development of autonomous vehicles as a product-service system, seeking to identify critical success factors for their insertion in a country in order to propose and test an innovation radar.

The specific objectives are:

- Carry out a systematic literature review aiming to investigate and understand the main theoretical contributions related to AVs in the field of business and management studies;
- Identify the critical success factors and propose a theoretical model of the Innovation Radar for the insertion of AVS as a PSS in given country;
- Analyse and discuss the innovation context of Brazil and France based on the Innovation Radar for the insertion of Autonomous Vehicles as a PSS.

It is worth emphasizing that the field of studies in autonomous vehicles is still insipient. A previous study by Gandia et al. (2017) shows that there is a growing demand on this topic over the years, mainly after 2012. It was observed that the number of publications exceeded the trend line, showing an exponential growth of the field in recent years; this fact can be corroborated when analyzing the average science growth rate, which according to Bornmann and Mutz (2015) is around 8% to 9% per year, while the average growth rate of publications on AVs in the analyzed period was 40 % which corroborates with the current relevance of the subject.

The researchs shows that the AVs area presents heterogeneity, considering authors with most papers, and category analysis. The authors point out that multidisciplinary is present in 95 areas of science in the field (categories). It was observed that there was a migration of the field from multidisciplinary to pluridisciplinary. Although there is a predominance of sciences more related to the technical evolution of AVs, we noted a growing presence of sciences that permeates automated vehicles. We believe that the maturity reached by the studies in technical fields such as engineering, computer science, and automation raised questions about how this technology (already well developed) could be implemented in the market, which are the agents involved (government, industry, academia, civil society and consumers) and what are the social, economic, ethical, managerial, environmental, legal, political impacts and implications that such vehicles will cause on urban mobility. Although there are studies related to business, economics, and management, there is a slight evolution of these domains related to AVs (GANDIA et al., 2017).

Corroborating with this outputs, as an initiative to discuss aspects related to economics and business, Attias (2016) aims to promote multidisciplinary reflection that allow us to highlight different issues related to various disciplines. Particularly, in her book, there are studies related to economics, management science, social sciences, and engineering sciences.

Theories and concepts about the subject ‘Disruptive Innovation” has been widely discussed in management literature, but not yet in terms of its implications for innovation policy design. In fact, the insertion of AVs in a country has numerous technical and social implications that must be, at least, acknowledge by the authorities, police makers and also, academics and practitioners.

In this sense, this doctoral thesis seeks to offer useful insides and data to enable appropriate policy responses to emerging innovation needs, trends and phenomena (SELHOFER et al., 2012). It has also, important managerial implications for understanding how managers can think more systematically about business innovation. By linking innovation to the value creation and competitive strategy, we believe that the Innovation Radar will facilitate enhancing the influence of marketing in the strategy dialogue (CHEN; SAWHNEY, 2010).

Starting from a systematic view of the field and, thus, defining critical success factors, culminating in the development of an innovation radar framework we intend to provide a diagnostic tool that captures where the AVs could excel and where it lags in innovation across its business system. We also seek to discover new opportunities to innovate in directions that they may not have considered and to conquer new and untough markets (CHEN; SAWHNEY, 2010; KIM; MAUBORGE, 2017; SAWHNEY; WOLCOTT; ARRONIZ, 2006). In addition, the results of this study suggest that different types of innovation are associated with different aspects of performance. Therefore, countries need to carefully choose their innovation focus based on their competitive advantages, with the outputs of this framework we believe that it is possible to build a link or a tight connection between the business strategy and the technology and innovation side that can drive long-term innovation leadership and define future implications (PISANO, 2015; SAWHNEY; WOLCOTT; ARRONIZ, 2006). Thus, the outputs of this research can be considered as a source for the understanding the autonomous vehicles studies in different countries.

1.3 Thesis structure

The project obeys the structure of articles, provided in the norms of the Federal University of Lavras (UFLA, 2016). In this sense, the main components of this scientific document are:

Part one:

The **Introduction** composed by the sections: contextualization and motivation; problem, objectives and justifications; and work structure. The **Theoretical Background**, comprising the main theoretical concepts necessary to understand the research and arranged in the sections: autonomous vehicles and product service system; disruptive innovation and countries, and critical success factors and the innovation radar. As for the **Methodology**, the details are described within each article on part two of this thesis; in part one, it is described the research ontology and research type. Next we present the **General Considerations** highlighting a synthesis of the main findings of each article as well the main research gaps and trends for future studies and the research limitations. At last, the bibliographical references of part one are listed according to the "Associação Brasileira de Normas Técnicas" – ABNT.

Part two:

In this session, the three articles that make up this doctoral thesis are presented: **Article 1** – Management and Business of Autonomous Vehicles: A Systematic Integrative Bibliographic Review; **Article 2** – Critical Success Factors for the insertion of Autonomous Vehicles as a Product Service System in a country, and; **Article 3** – Innovation Radar for the insertion of a disrupt technology in a country: the case of Autonomous Vehicles in Brazil and France.

2 THEORITICAL BACKGROUND

In this chapter the main theoretical foundations are presented, as well as key concepts that will guide the development of this research, providing theoretical and analytical support for the initial understanding of the problem.

2.1 Autonomous Vehicles as a Product Service System

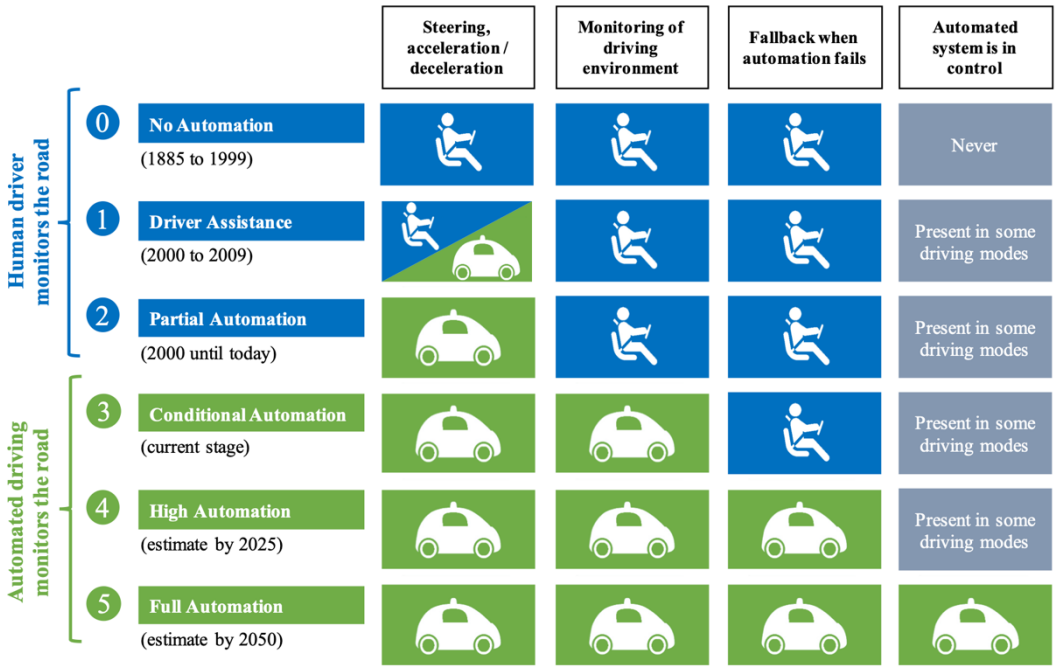
In the present century, mobility has come to be understood as one of the main issues of our contemporary society, being a central topic discussed worldwide. Autonomous Vehicles (AVs) are considered an integral part of the new forms of mobility (ATTIAS, 2016) and have become focus of many R&D projects, being considered by many authors as the greatest disruptive innovation in the automotive industry (ATTIAS, 2016;ATTIAS; MIRA-BONNARDEL, 2016;ENOCH, 2015;FAGNANT; KOCKELMAN, 2015; MUTZ et al., 2016; POORSARTEP, 2014; SCHELLEKENS, 2015; SCHREURS; STEUWER, 2015).

The Surface Vehicle Recommended Practice from SAE International provides a taxonomy describing the full range of levels of *driving automation* in on-road *motor vehicles* and includes functional definitions for advanced levels of *driving automation* and related terms and definitions. There are six levels of driving automation in the context of motor vehicles, these levels range from no driving automation (level 0) to full driving automation (level 5) (SAE INTERNATIONAL, 2016).

Figure 1 summarizes the six levels of driving automation in terms of these elements. According to the report, SAE’s levels of driving automation are descriptive and informative, rather than normative and technical rather than legal. Elements indicate minimum rather than maximum capabilities for each level. In this table, “system" refers to the driving automation system or Automated Driving System (ADS), as appropriate (SAE INTERNATIONAL, 2016). It is worth noting that SAE’s higher automation levels (4 and 5), an automated system

can conduct the driving task and monitor the driving environment, and the human doesn't need to take back control of the vehicle when constraints appear (U.S. DEPARTMENT OF TRANSPORTATION, 2016).

Figure 1 - Summary of Levels of Driving Automation.



Source: adapted by the authors based on SAE International (2016) andNascimento, Salvador and Vilicic (2017).

Numerous carmakers, such as: Audi, BMW, Cadillac, Ford, GM, Mercedes-Benz, Nissan, Toyota, Volkswagen, and Volvo, are already undergoing tests with AVs (FAGNANT; KOCKELMAN, 2015), not to mention that vehicles with semi-autonomous capabilities are already being marketed – such as Tesla's model S, model X and most recently model X as well as Mercedes-Benz's S65, Infiniti's Q50S and BMW's 750i xDriv.

Governments worldwide (U.S.A., France, Germany, Italy, England, among others) have also shown great interest on AVs' benefits by introducing legislations allowing the testing of such technology on their roads (SCHOITSCH, 2016). Within the academia,

research centers, and universities, many studies for AVs' consolidation are under progress (GUIZZO, 2011; LIMA, 2015). However, in the scope of business and management it is noticeable a lack of studies, little has been discussed about the real managerial implications regarding the arrival of AVs in the market (CAVAZZA et al., 2017; GANDIA et al., 2017).

By representing a potentially disruptive and beneficial change to the current transportation business model AVs are bound to change the future of urban mobility, and such transformation will not only affect the means of transport but society as a whole. This in a sense that the traditional transport model (dominated by private cars, taxis, and buses) is likely suffer an exponential decline in the coming years, giving rise to "intermediaries" means of transport – mostly designed in the form of shared vehicles (ATTIAS, 2016; ENOCH, 2015; MUTZ et al., 2016; SCHREURS; STEUWER, 2015). In this context, AVs will facilitate commuting, increase road safety, reduce pollutants' emissions, reduce traffic jams, as well as allow people to choose to do different things other than driving. AVs will also improve mobility for those who cannot or do not want to drive and will provide significant economic, environmental, and social benefits (ANTONIALLI et al., 2017; ATTIAS, 2016; MUTZ et al., 2016).

Nevertheless, there are many issues that still need to be addressed such as the possible impacts of autonomous driving on mobility behaviors and human-machine interactions, as well as consumer acceptance, regulatory, and liability frameworks (SCHELLEKENS, 2015; SCHREURS; STEUWER, 2015). Therefore, due to their disruptive nature, AVs are likely to change the structure of cities (ZAKHARENKO, 2016), but is still complex to understand how life will be affected by this disruptive innovation in a sense that the timing, scale, and direction of the AVs' impacts are uncertain and the opportunities to influence investment decisions are limited (GUERRA, 2016).

As pointed out by Attias and Mira-Bonnardel (2016, p.69), the automotive industry is going through some radical changes, and it's been struggling to find the right positioning. Thus, "while cooperation with traditional players is necessary, OEMs find themselves obliged to form alliances with new entrants, often far removed from their core business" such as Google, Uber, Apple among other tech-companies.

Being that said, the traditional business model of selling cars as products is losing ground to alternative forms of commerce. As pointed out by Johnson and Mena (2008), manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer more profitable business relationships.

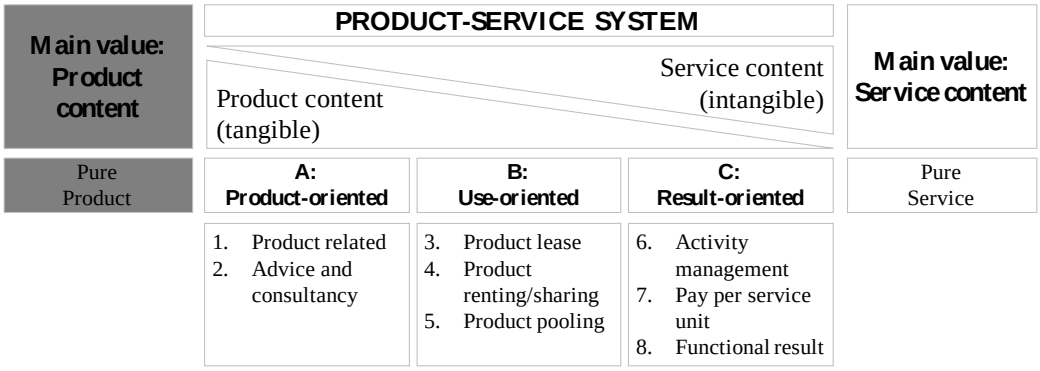
A Product-Service System (PSS) can be defined as consisting of tangible products and intangible services designed and combined with the aim of fulfilling users' needs or of a given function (POULAIN, 2017; TUKKER, 2004). In other words, PSS may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality (WONG, 2004).

In this sense, a business model in which cars are offered as services is gaining strength and it is being tackled by many companies and scholars. As Burns, Jordan and Scarborough (2013, p.101) stated: "an analysis by Larry Burns, the former Vice President of GM, estimates 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".

"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, 2016, 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).

Tukker (2004) drew a categorization of PSS by creating eight different types of Product-Service Systems, that according to the author exist with quite diverging economic and environmental characteristics. As displayed on Figure 2, it can be noted that types of PSSs vary on a spectrum in which on one end the main value rests on product content (tangible) and on the other on service content (intangible).

Figure 2 - Categories of Product-Service Systems.



Source: adapted from Tukker (2004, p. 248).

There are three main categories of PSS within the spectrum (TUKKER, 2004, p. 248). The first one is product-oriented where the business model is still mainly geared towards sales of products, but some extra services are added. The second category is use-oriented**,** herethe traditional product still plays a central role, but the business model is not geared towards selling products. The product stays in ownership with the provider, and is made available in a different form, and sometimes shared by a number of users. Finally, the third category is result-oriented where the client and provider in principle agree on a result, and there is no pre-determined product involved.

Within each main category, there are PSSs with quite different characteristics, and based on Tukker's (2004, p. 248-249) framework AVs as a PSS are likely to be positioned on the middle category, that is, use-oriented PSSs in which according to the author is composed of three different PSSs:

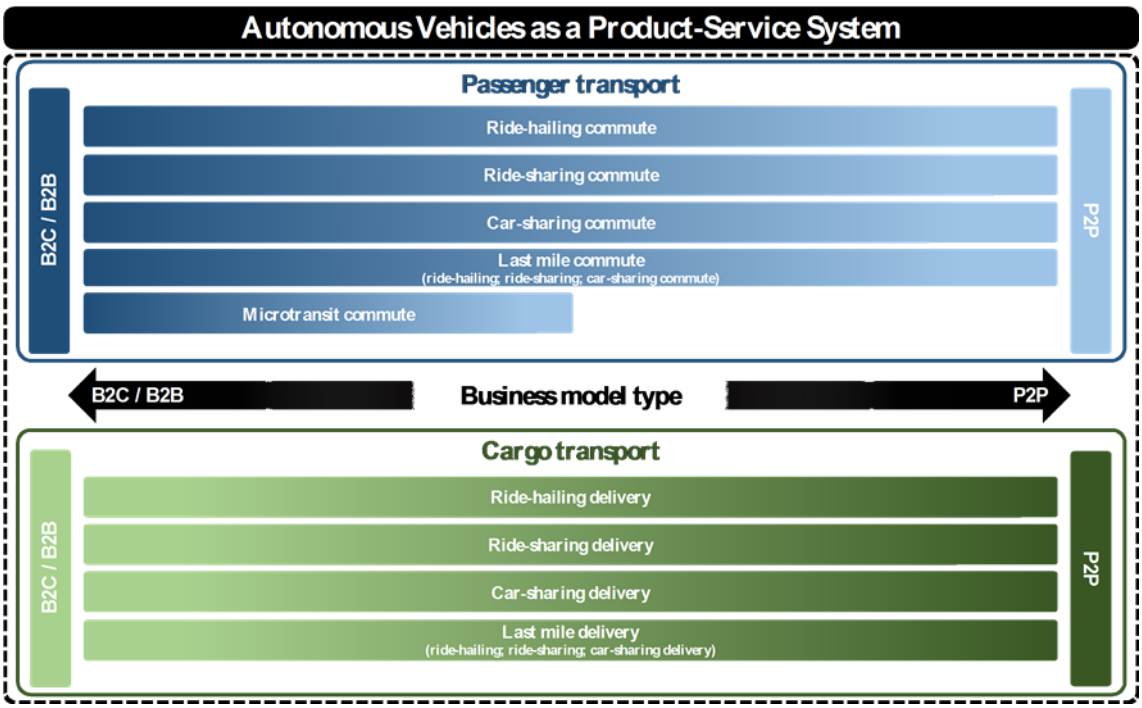
- **Product lease:**The provider has ownership, and is also often responsible for maintenance, repair and control. The lessee pays a regular fee for the use of the product; in this case, normally he/she has unlimited and individual access to the leased product.
- **Product renting or sharing:**Here, also, the product in general is owned by a provider, who is also responsible for maintenance, repair, and control. The user pays for the use of the product. The main difference to product leasing is, however, that the user does not have unlimited and individual access; others can use the product at other times. The same product is sequentially used by different users.
- **Product pooling:**This greatly resembles product renting or sharing. However, there is a simultaneous use of the product.

Nonetheless, AVs represent a potentially disruptive and beneficial change to the current road transportation system business model, since such vehicles could facilitate driving; increase road safety; reduce emissions of pollutants; reduce traffic jams; as well as could allow drivers to choose to do different things other than driving (ATTIAS, 2016; ENOCH, 2015; SCHELLEKENS, 2015; SCHREURS; STEUWER, 2015). Thus, access to fully automated vehicles would also improve mobility for those who cannot or do not want to drive, hence, improving their quality of life (ATTIAS, 2016; POORSARTEP, 2014). As a result, AVs could provide significant economic, environmental, and social benefits (FAGNANT; KOCKELMAN, 2015; MUTZ et al., 2016).

Therefore, such disruptive innovation (AVs as a PSS) represents a solution to an unmet need (NOGAMI; VELOSO, 2017), since it represents an innovation in products, services, and business models that offer different solutions and alternatives to the market, and are mainly direted at non-traditional consumers, hence, it changes social practices and ways of living, working, and interacting (CHRISTENSEN, 2001).

As an advancement in this area, in our previous work, *Typologies of uses for Autonomous Vehicles as a Product-Service* we were able to design a set of use typologies for the AVs as a PSS. As detailed on Figure 3, AVs are better fitted on the "use oriented" category of Tukker's (2004) PSS model, that is: the traditional product (AV) still plays a central role, however the business model is not geared towards sales, in this sense, the product is not in the ownership of the service provider consumer, instead it stays in the ownership of a service provider (or even other ownership forms), and is made available to the service provider's consumers in different forms (typologies).

Figure 3 - Typologies for Autonomous Vehicles as a PSS.



Source: Antonialli et al. (2018).

As for the typologies, two main groups were identified: 1) passenger transport (in blue), and 2) cargo transport (in green). Within each group two set of business models arose; a) Business-to-Consumer (B2C) and/or Business-to-Business (B2B) where the service

provider (or its partners) owns the fleet of vehicles and not only is in charge of managing the rides, the application, and the algorithm of the service, but is also responsible for all fleet costs (maintenance, storage, parking, insurance, and fuel), and b)Peer-to-peer (P2P) - also known as C2C (consumer to consumer) or O2O (owner to owner) - in which the individual can offer the transportation service by him/herself or opt to rent his/her vehicle to a service provider to handle the transportation service. Furthermore, within each set of business model, three main sub typologies were identified: 1) car-sharing; 2) ride-sharing and 3) last mile issue – which can be further subdivided into car-sharing and ride-sharing as well (Antonialli et al., 2018).

For each type of the afore mentioned business models, we were able to divide them even further into different usage sub-typologies. For passengers' transport (both B2C/B2B and P2P) we extracted five: 1) ride-hailing; 2) ride-sharing; 3) car-sharing; 4) last mile; and 5) microtransit commute. As for cargo transport (both B2C/B2B and P2P as well) we identified the same typologies as for passengers, except for microtransit, however, instead of focusing on passengers' commute, the focus is on logistics, freight, and goods delivery.

In fact, AVs as a PSS can be considered a relevant innovation that promises to have great impact on the urban mobility, thus, it is crucial for governments and policy makers worldwide to consider all the aspects of this innovation and its relation with governance and public policies. This next topic seeks to discuss disruptive innovation with a view to its relevance for innovation policy.

2.2 Disruptive Innovation

The concept of innovation is quite varied, mainly depending on its application. In general ways, it is related to insertion in the market and society of something new and also it is about generating value in this context. Many authors base the concept of innovation by relating it to Schumpeter's approach to creative destruction (1942; 2009). For this author innovation could be related to a) the introduction of a new good; b) the introduction of a new method of production or commercialization of existing assets; c) the opening of new markets; d) the conquest of a new source of raw materials and e) the breaking of a monopoly. Following this path, the OECD's Oslo Manual states that innovation could be related to a) a product, b) a process, c) the organization and d) the marketing (OECD, 2005).

Furthermore, it's important to understand the concept of a disruptive innovation. Christensen (1997) states – in his seminal work: *"The Innovator's Dilemma"* – that disruptive

technologies bring to the market a very different value proposition than those previously available; which generally by being technologically straightforward, offer different packages of attributes that are not often considered important to mainstream customers.

According to the author, technological innovations generally come in two types: 1) incremental (sustaining) technologies and, 2) radical (disruptive) technologies. In the former, products are made better over time to meet the demands of costumers who are willing to pay more for better products. In this sense, most technological advances in a given industry are sustaining in character; on the latter, the introduced products bring to market a very different value proposition than had been previously available (CHRISTENSEN; RAYNOR, 2003; ENOCH, 2015; MARKIDES; GEROSKI, 2005).

It is worth highlighting that, although the term *disruptive technology* is widely used, *disruptive innovation* seems more appropriate since few technologies are intrinsically disruptive; rather, it is the business model that the technology enables who creates the disruptive impact (CHRISTENSEN, 2013). That is, few technologies or business ideas are intrinsically sustaining or disruptive in character; rather, their disruptive impact must be molded into strategy as managers shape the idea into a plan and then implement it.

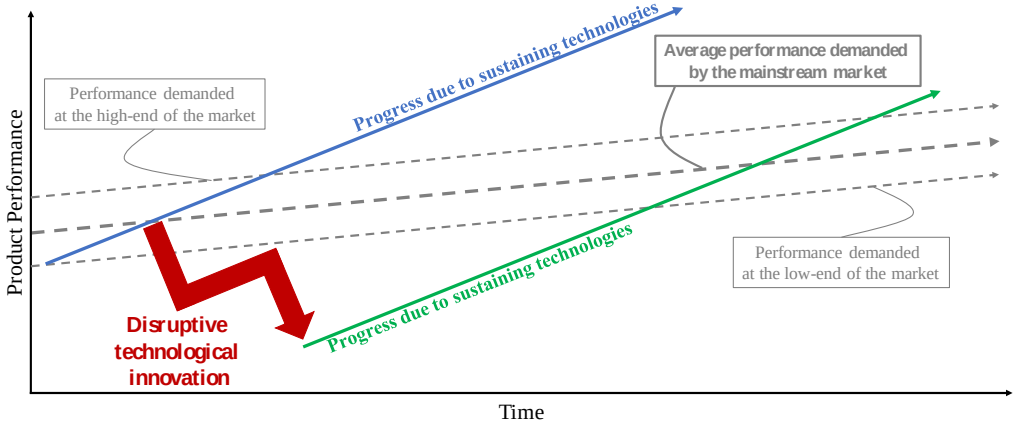
As depicted in Figure 4, every market has an expected performance rate demanded by its customers, the doted grey arrows represent such performance rates over time (for high-end, low-end and average consumers). As exemplified by Christensen (1997), the automobile companies keep giving its consumers new and improved engines, but they are unable to utilize all that performance due to factors such as traffic jams, speed limits, and safety concerns, hence constraining how much performance can be indeed used.

In every market, there is a different trajectory of improvement that companies provide as they introduce new and improved products, the blue solid upward arrow in Figure 4 represent such pace of technological progress (incremental innovations) that almost always surpasses the customers' ability to use them. Thus, a company whose products are squarely positioned on mainstream customers' current needs will probably overshoot what those same customers are able to utilize in the future. This happens because companies keep striving to make better products that they can sell for higher profit margins to not-yet-satisfied customers in more demanding tiers of the market.

The distinction between sustaining and disruptive innovation (highlighted by the red arrow on Figure 4 is that disruptive innovations, do not attempt on bringing better products to established customers in existing markets; instead, they disrupt and redefine such trajectory

by introducing new products (and services) that are not as good as currently available products. However, once the disruptive product gains a foothold in new or low-end markets, the improvement cycle (represented by the green upward arrow) begins.

Figure 4 - The Disruptive Innovation Model.



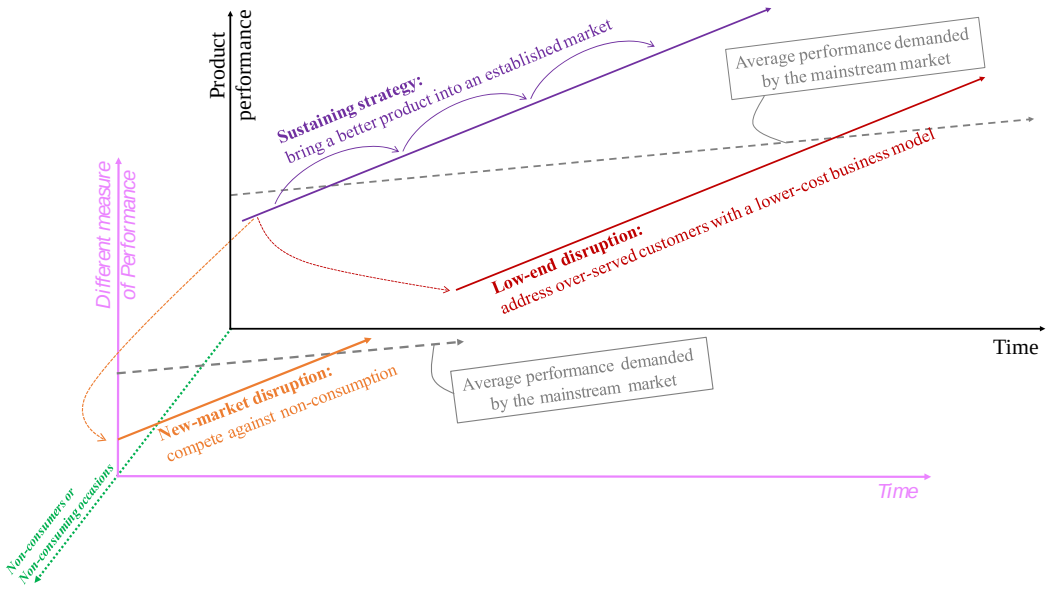
Source: adapted from Christensen (1997).

It is important to highlight that, according to Christensen and Raynor (2003) disruptive innovations can come in two general types: 1) *low-end disruption* – whick attacks the least-profitable and most overserved customers at the low end of the original value network (explained on Figure 4 and, 2) *new-market disruption* – which enables a whole new population of people to begin owning and / or using the product (service) in a more convening setting.

As shown in Figure 5, a new dimension (doted green arrow) has been added to the model, it represents new contexts of consumption and competition, therefore, new value networks. As pointed out by the authors, it entails a new market in which the product / service offers a different value proposition than the original market, that is, customers who previously lacked the money or skills to buy and use the product (service), or different situations in which a product (service) can be used-enabled by improvements in simplicity, portability, and cost.

Still according to Figure 5, along this new third axis a new value network (pink chart) can be drawn, highlighting different performance measures for the product over time, hence, it can be called new-market disruptions (orange arrow). The first Personal Computers were a good example of a new-market disruption, because the initial customers were new consumers which had not owned or used the prior generation of computers.

Figure 5 -New Market Disruption Model.



Source: adapted from Christensen and Raynor (2003).

Noteworthy, hybrid disruptions – combining new-market and low-end approaches – are also very common; budget airlines are a good example of such disruption in a sense that these companies target customers who are not flying-people (car, buses and trains users) as well as they have the ability to pull customers out of the low end of the major airlines' value network.

New technologies, such as Autonomous Vehicles, might fit in the hybrid disruption model. According to Nagy, Schuessler and Dubinsky (2016) and Poorsartep (2014) they might be able to create new markets or radically change, or disrupt, the *status-quo* in existing ones. Therefore, disruptive innovations by representing a solution to an unmet need (NOGAMI; VELOSO, 2017), are mainly directed at non-traditional consumers, hence, they change social practices and ways of living, working, and interacting (CHRISTENSEN, 2001).

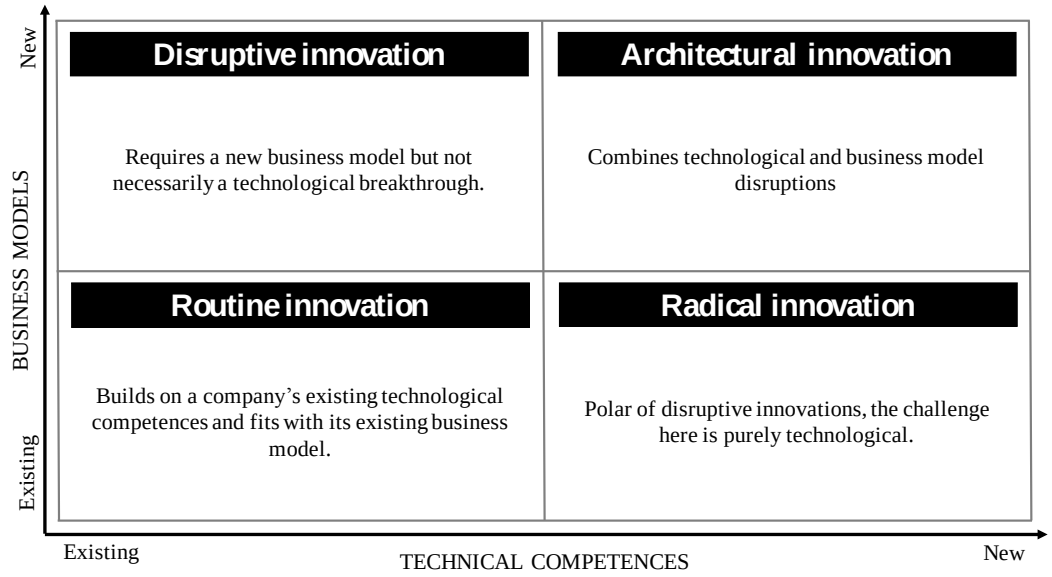
In this sense, and taking into account that a strong technological inertia has been affecting the automotive technical artefact (CHANARON, 2001), traditional car manufacturers' and new industry players (such as Google, Tesla, Otto and Uber) – desiring to extend their influence to new clienteles – are preparing for the future by investing heavily in Autonomous Vehicles (ATTIAS, 2016). Thus, AVs are stepping out the science fiction realm and are now becoming a reality (SCHREURS; STEUWER, 2015).

At last, for Poorsartep (2014) this automobile revolution is upon us and is a matter of *when will it happen*, and not *if*, therefore, we should strive to embrace it. Additionaly, Attias

(2016, p. 100) emphasizes that “not only does the self-driving car seem to be the city car of the future, it is also at the origin of the greatest revolution that the automobile industry has ever known” – being considered as a true paradigm shift (ATTIAS, 2016; ENOCH, 2015).

More recently, Pisano (2015) offer a new contribution regarding the types of innovation.The author points out that “when creating an innovation strategy, companies have a choice about how much to focus on technological innovation and how much to invest in business model innovation” (PISANO, 2015, p. 4). In this context he proposed a matrix where he characterizes innovation along two dimensions: “the degree to which it involves a change in technology and the degree to which it involves a change in business model, although each dimension exists on a continuum, together they suggest four quadrants, or categories, of innovation” (PISANO, 2015, p. 8). This matrix (Figure 6), considers how a potential innovation fits with company’s existing business model and capabilities.

Figure 6 - The Innovation Landscape Map.



Source: Prepared by the authors based on Pisano (2015) and Calza, Parmentola and Tutore (2017).

The categories proposed by Pisano (2015, p. 8) are elucidated as follows:

a) **Routine Innovation:** builds on a company’s existing technological competences and fits with its existing business model—and hence its customer base;

b) **Disruptive Innovation:** requires a new business model but not necessarily a technological breakthrough. For that reason, it also challenges, or disrupts, the business models of other companies;

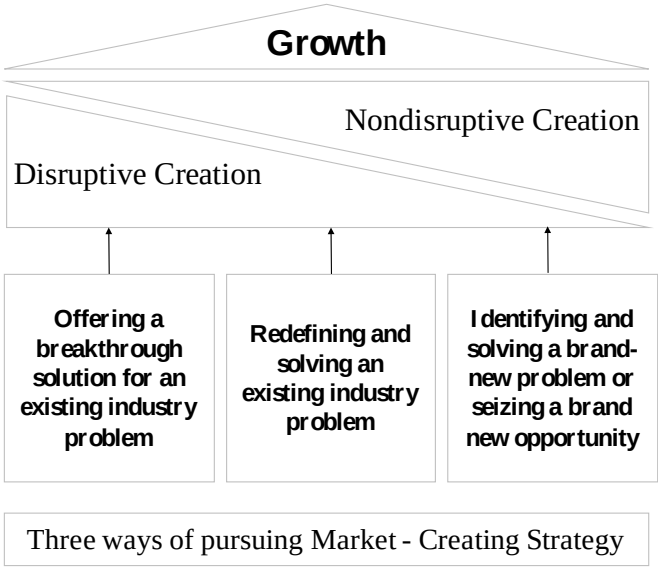
c) **Radical Innovation:** This kind of innovation s the polar opposite of disruptive innovation. The challenge here is purely technological;

d) **Architectural Innovation:** The most challenging for incumbents to pursue, it combines technological and business model disruptions;

In this context, considering these different typologies for innovation and the different perspectives related to market creation, Kim and Mauborgne (2017) argue that we still have an incomplete picture of how markets are created.According to authors, "non-disruptive creation is a driver of new growth as fundamental as disruptive creation [...] and new markets and cycles of growth have always been created by both (KIM; MAUBORGNE, 2017, p. 41). Thus, creative destruction and disruptive innovation can be considered as part of the process, making it necessary to consider that non-disruptive creation also generates new markets and growth.

Based on this facts, Kim and Mauborgne (2017) propose a holistic model of market creation, which encompasses 3 basic ways of realizing market-creation strategies - and thus making the transition to the blue ocean: a) offer a revolutionary solution to a problem in the industry; b) Identify and solve a whole new problem or take advantage of an unprecedented opportunity; and c) Redefine and solve an existing problem (KIM; MAUBORGNE, 2017, p. 43). The model is shown in Figure 7.

Figure 7 - Growth Model of Market-Creating Strategy.



Source: adapted from Kim and Mauborgne (2017, p. 44).

In short, as we can observe in the Figure 7:

> "offering a breakthrough solution for an existing industry problem generally results in disruptive creation. Identifying and solving a brand-new problem or seizing a brand-new opportunity most often gives rise to nondisruptive creation. And redefining and solving an existing problem draws on elements of both disruptive and non disruptive creations" (KIM; MAUBORGNE, 2017, p. 48).

This approach can be very useful and interesting in the autonomous vehicles scope, if we consider that they will redefine and solve several existing problems related to the urban mobility bringing to light incremental technologies allied to a disruptive business model. In fact, AVs as a PSS can be considered a relevant innovation that promises to have great impact on the urban mobility, thus, it is crucial for governments and policy makers worldwide to consider all the aspects of this innovation and its relation with governance and public policies. This next topic seeks to discuss disruptive innovation with a view to its relevance for innovation policy.

2.3 Managing Disruptive Innovation in Countries

When we start to analyze the disruptive innovation in a macro concept, considering its adoption and management in a country, it is necessary to consider some specificities. In fact, "Christensen's framework has been widely discussed in management literature, but not yet in terms of its implications for innovation policy design" (SELHOFER et al., 2012, p. 12). It's important to consider that governments and policy makers need to explore whether and how

innovation policy should pay specific attention to disruptive innovation developments in order to give policy responses properly to emerging innovation needs, trends, and phenomena (SELHOFER et al., 2012).

Many public policymakers are already focusing their attention on autonomous transportation, and on understanding its potential impact (BCG, 2016). It's worth mentioning that policy making and policy implementation do not occur in a vacuum. "Rather, they take place in complex political and social settings, in which individuals and groups with unequal power interact within changing rules as they pursue conflicting interests" (WORLD BANK, 2017, p. 29). Thus, a strategic response for policy must address the cross-sectoral nature of disruptive innovations, as well as to manage some 'business case conflicts' – considering that desired and expected externalities from accelerating disruptive innovation deployment do not coincide with the industry's business case as well as to anticipate unwanted side-effects of interventions and disruptive innovation in service sectors (SELHOFER et al., 2012).

In the technological scope, "Information and communication technology (ICT) is a key enabler of innovation in the transport and logistics service industry" (SELHOFER et al., 2012, p. 10). According to the Global Review of Innovation Policy Studies (SELHOFER et al., 2012, p. 10), there are 3 important innovation trends triggered by ICTs that must be considered by the governments and policy makers:

1. New e-services: the integration of traditional services with new, innovative information services facilitated by the internet. However these enhanced services do not have a significant disruptive potential.
2. New players: ICT has facilitated the market entry of a new intermediary: different types of transportation e-marketplaces. They may have a disruptive impact on several aspects of the industry; for instance, they tend to alter the role of traditional transport intermediaries (e.g. freight forwarders) and the relationships between these firms and other actors in the supply chain.
3. New alliances: Another innovation resulting from the diffusion of ICT and web technologies is the formation of new types of alliances between third-party logistics providers (3PLs) and companies operating in other service sectors such as financial services, management consulting, and ICT vendors. Some of these alliances have given rise to the creation of a new category of service provider called fourth- party logistics provider (4PL). This can be seen as a disruptive trend in service provision

and business models, as the 4PL model enables customers to outsource to a single organization the entire re-engineering of their supply chain processes.

In this sense, a strategic response for policy must address the cross-sectorial nature of disruptive innovations, as well as to manage some 'business case conflicts' – considering that desired and expected externalities from accelerating disruptive innovation deployment do not coincide with the industry's business case as well as to anticipate unwanted side-effects of interventions and disruptive innovation in service sectors (SELHOFER et al., 2012).

In fact, AVs are being piloted in a number of countries and are running on public roads, albeit only in a handful of locations such as Phoenix in the US State of Arizona and in Singapore, even though this innovation could take 10 years or 30 to effectively 'reach the market', the social and political implications "are so far-reaching that policymakers need to start planning now for our AV future" (KPMG, 2018, p. 6).

As pointed out by the KPMG Autonomous Vehicles Readiness Index, there are many implications beyond the technological spectrum: "regulations on vehicle insurance will need to adapt, including who is responsible for a driverless vehicle's actions. Driving licenses could become redundant, although many countries use them as an identity card. Road traffic regulations, designed for use by humans, will ultimately be replaced by protocols, determining priority at junctions and giving way to emergency vehicles" (KPMG, 2018, p. 6).

Innovations in the automotive industry are usually guided by macro and micro environmental developments such as scarcity of raw materials, discussions on traffic growth, gas emissions and pollution, climate change, among others. This context makes the challenges of this sector exceed the technological level, also covering planning and logistics issues, as well as social and economic aspects.

Considering current trends in major economies, especially in China, promoting the development of AVs is to be advised, in spite of the uncertainty. The risk of "backing the wrong horse" has to be weighed against the risk of losing competitiveness in the emerging technology (SELHOFER et al., 2012).

In fact, if innovation policy decides to support the insertion of AVs the best approach is therefore probably to encourage the move to 'mobility as a service'. This could have positive side-effects such as reducing emissions and freeing up parking space in cities.

Due to the complexity and relevance of the theme, it is essential to carry out some studies to develop tools and methods to assess the openness and preparedness of countries for autonomous vehicles (KPMG, 2018), as well as to map and analyze the critical success

factors for insertion of AVs into different national contexts (WORLD ECONOMIC FORUM, 2019). The next topic discuss the main aspects related to the concept of Critical Success Factors and the Innovation Radar.

2.4 Critical Success Factors and Innovation Radar

There are several definitions and concepts for the term Critical Success Factors (CSFs) in the literature. Initially, Rockart (1979) states that CSFs are the:

> "limited number of areas in which results, if satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where "things must go right" for the business to flourish. If results in these areas are not adequate, the organization's efforts for the period will be less than desired" (ROCKART, 1979, p. 9).

For Brotherton and Shaw (1996) CSFs can be understood as the essential aspects that must be achieved by an organization or areas that produce the greatest competitiveness.They are not goals, but actions or processes that can be controlled and affected by management to achieve organizational objectives. In addition, Grunert and Ellegard (1992) point out that these skills or resources explain most of the observable differences in perceived value and relative costs. So, one can consider CSFs as the areas, activities or organizational processes that should be prioritized as "one or more competitive factors that use the resources available to increase the competitiveness of an organization" (NASCIMENTO, 2016, p. 36).

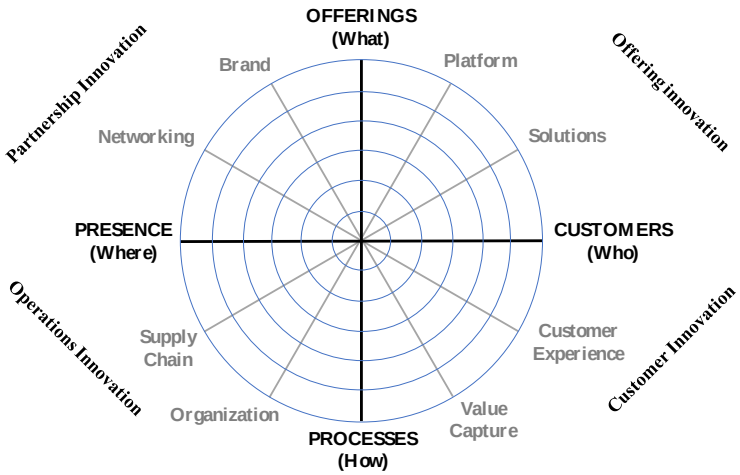
The identification of CSFs can be effective for 1) determining where management attention should be directed; 2) developing measures success; and 3) identifying the key information as well as the main characteristics of an organization and thus limiting gathering unnecessary data; and 4) assisting the definition of knowledge and technologies essential for the survival and competitive advantage of the analyzed object (COLAUTO et al., 2004; NASCIMENTO, 2016; ROCKART, 1979).

Thinking about methods and measures for important aspects of an organization or country an important tool to have disruptive products or services creating and delivering value is the Innovation Radar proposed by Sawhney, Wolcott and Arroniz (2006). According to the authors, "successful business innovation requires careful consideration of all aspects of a business" and thus "when innovating, a company must consider all dimensions of its business system" (SAWHNEY; WOLCOTT; ARRONIZ, 2006).

In this sense, there are three basic premises or characterizations related to business innovations: a) business Innovation is about the creation of new value (for customers and

consequently for the firm), not new things; b) business Innovation can occur in any dimension of a business system; c) business innovation is systemic and requirescareful consideration of all aspects of a business (SAWHNEY; WOLCOTT; ARRONIZ, 2006). Starting from this three basic statements, a radar of innovation is proposed. It highlight 12 key dimensions for business innovation and explore the relation between each other. The framework presents four key dimensions that works like a business anchor: (1) the offerings a company creates, (2) the customers it serves, (3) the processes it employs and, (4) the points of presence it uses to take its offerings to market. Between these four anchors, they embed eight other dimensions of the business system that can serve as avenues of pursuit. Figure 8 shows the framework of the innovation radar(CHEN; SAWHNEY, 2010; SAWHNEY; WOLCOTT; ARRONIZ, 2006).

Figure 8 - Innovation Radar.



Source: adapted from Sawhney, Wolcott and Arroniz (2006).

Next, Table 1 presents a short description of all the 12 dimensions originally proposed by the authors:

Table 1 - Dimensions of the Innovation Radar.

Dimension	Definition	Examples
Offerings	Develop innovative new products or services.	Gillette Mach3Turbo razor / Apple iPod music player and iTunes music service
Platform	Use common components or building blocks to create derivative offerings.	General Motors OnStar telematics platform / Disney animated movies
Solutions	Create integrated and customized offerings that solve end-to-end customer problems.	UPS logistics services Supply Chain Solutions / DuPont Building Innovations for construction
Customers	Discover unmet customer needs or identify underserved customer	Enterprise Rent-A-Car focus on replacement car renters / Green

	segments.	Mountain Energy focus on “green power”
Customer Experience	Redesign customer interactions across all touch points and all moments of contact.	Washington Mutual Occasio retail banking concept / Cabela’s “store as entertainment experience”
Value Capture	Redefine how company gets paid or create innovative new revenue streams.	Google paid search / Blockbuster revenue-sharing with movie distributors
Processes	Redesign core operating processes to improve efficiency and effectiveness.	Toyota Production System for operations / General Electric Design for Six Sigma (DFSS)
Organization	Change form, function or activity scope of the firm.	Cisco partner-centric networked virtual organization / Procter & Gamble front-back hybrid organization for customer focus
Supply Chain	Think differently about sourcing and fulfillment.	Moen ProjectNet for collaborative design with suppliers / General Motors Celta use of integrated supply and online sales
Presence	Create new distribution channels or innovative points of presence, including the places where offerings can be bought or used by customers.	Starbucks music CD sales in coffee stores / Diebold RemoteTeller System for banking
Networking	Create network-centric intelligent and integrated offerings.	Otis Remote Elevator Monitoring service / Department of Defense Network Centric Warfare
Brand	Leverage a brand into new domains.	Virgin Group “branded venture capital” / Yahoo! as a lifestyle brand

Source: Sawhney, Wolcott and Arroniz (2006, p. 76).

The Innovation Radar presents itself as a significant tool for discussing and structuring a field based on trends in a targeted way (GOLOVATCHEV; KELLMEREIT; BUDDE, 2008). However, while working on a holistic picture, Sawhney, Wolcott and Arroniz's (2006) proposal addresses broader issues in an organizational context and does not deal with aspects of heterogeneity in sectors, contexts, and objectives.

Thus, innovation being an indisputably relevant factor in the present era for all contexts, it is important to consider it beyond the local level, expanding the focus to regional as well as national aspects, as approached in the context of the European Union by De Prato, Nepelski and Piroli (2015). Thus, an Innovation Radar, as a way of guiding innovation, demands adaptations (OLIVEIRA et al., 2014). As adapted from Mansell and Wehn(1998), this study will focus on the national context for the development of an Innovation Radar.

3 METHODOLOGY

This chapter aims to base the type of research and describe the methodological procedures that will guide the investigations, considering, as mentioned in the Subsection '1.3', a singular description of the methodologies, that is, directed to each of the four (4) articles for the thesis document.

As previously mentioned, the general objective of this doctoral thesis is to analyze the development of autonomous vehicles as a Product-Service System seeking to identify critical success factors for their insertion in a country in order to propose and test an innovation radar.

With constructivist epistemological foundation, the present research is classified as descriptive and qualitative using as method the study of cases and participant observation. For the data collection, the following instruments were used: secondary data; qualitative interviews using semi-structured script with specialists in the area, focus group and questionnaires. Regarding the data analysis, for the interviews and the focus group the qualitative analysis was developed from the content analysis technique and the questionnaires were quantitatively analyzed for descriptive purposes.

This research was carried out since October 2016. Theoretical and empirical research is being carried out at the Federal University of Lavras - MG - Brazil and in the Laboratoire Génie Industriel at École CentraleSupelc - Paris - France supported by extensive theoretical-bibliographic research.

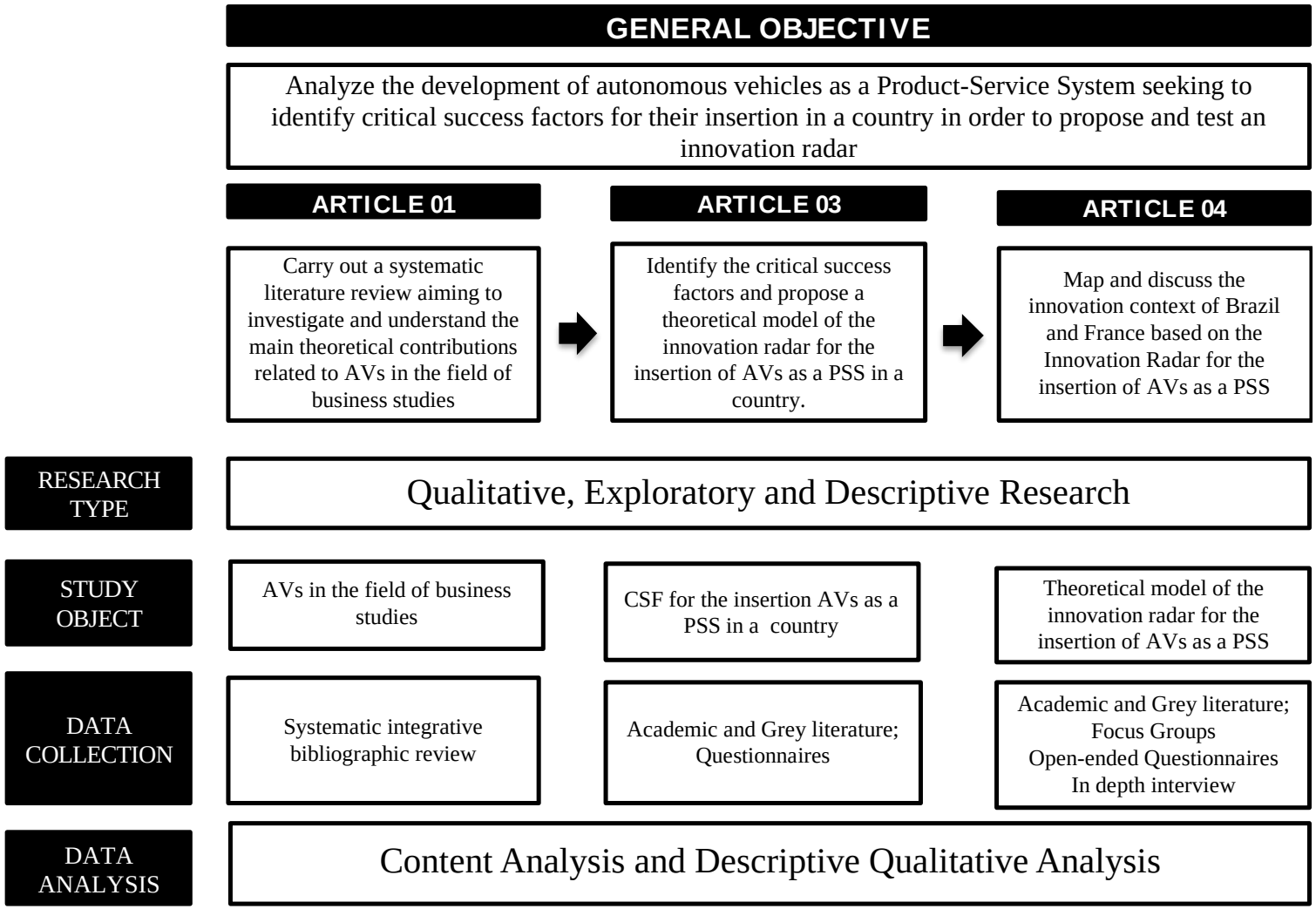
It should also be noted that the sequence that underlies this doctoral thesis is as follows: **Article 1** – Management and Business of Autonomous Vehicles: A Systematic Integrative Bibliographic Review; **Article 2** – Critical Success Factors for the insertion of Autonomous Vehicles as a Product Service System in a country, and; **Article 3** – Innovation Radar for the insertion of a disrupt technology in a country: the case of Autonomous Vehicles in Brazil and France.

Over part two of this thesis, the details of the methodological procedures are described within each paper that make up this doctoral thesis.

3.1Summary of the thesis' methodology

Figure 9 provides an overview of the research outline that had been carried out in this doctoral thesis.

Figure 9 – Summary of the Research Methodology.



Source: Prepared by the author (2018).

4 GENERAL CONSIDERATIONS

As this thesis was drawn up in the form of academic articles, the detailed conclusions are displayed on Part Two of this manuscript within each of the four articles. However, the main considerations are presented here as well as some suggestions for future studies and research limitations.

The first step of this work (Article 01) was to develop an integrative and systematic review seeking to better understand the AVs' field of study, encompassing the trends, gaps, and the main studied themes. The field's evolution reflects in a broad conceptual framework regarding AVs, however, when refining the search for the areas of Management & Business, fewer works were yielded, indicating a possible gap between the technological advances on R&D and its eventual market insertion and consolidation. Besides this gap, we observed that there is a lack of knowledge about aspects of management, that is, areas that are fundamental for the design of future business models, mobility scenarios, and the impacts of AVs insertion are not being explored and the available information is decentralized, shallowland with no meaningful connections and insights. Considering that the business models plays an extremely important role in the events that precede advancement of AVs (Yun et al., 2016), so that the way in which this innovation might be established by uncertainties, may impact directly on governments' lack of planning for such arrival (Guerra, 2016).

After identifying the issues related to AVs field of study, its relation and gaps with business and management the next two articles were designed in order to develop a theoretical framework (Innovation Radar) for the insertion of AVs as a PSS in a given country based on Critical Success Factors.

As outputs of Article 02, we have the proposition of a theoretical framework that allows the mapping of the innovative capacity of a country. The Innovation Radar highlightstwelve Critical Success Factors for the insertion of AVs in a given country and explore the relation amongeach other. The framework presents four key dimensions that work like anchors: (1) Technology and Innovation, (2) Social and Political Environment (3)Consumer and Market, (4)Infrastructure and Patters. Amongthese four anchors, we imbedded 12 factors of the innovation system that can serve as avenues of pursuit.

Finally, in Article 03 the Innovation Radar is used as a tool to study the situation / context of innovation in two countries: Brazil and France. Hence, the main contribution of this work is the integration of data and information from different sectors (social,

political,economic, technological, and structural) of a given country, making it possible to map, discuss, and divedeeper regarding the real situation for the insertion of AVs.

We sought to fill a gap in the literature, related to the definition, adequacy, and application of an artifact to support the insertion and management of a disruptive innovation in a country. Finally, we present a proposal for methodological advancements, associated to critical success factors, with an empirical approach and easy adaptation and application around the world. A radar framework to identify CSFs to be used in order to contribute to processes related to innovative capacity, governance and market reach efficiency, and effectiveness in the current and real context of the countries.

Although some studies and research present - in a partial and generalized way - some determinant factors for the insertion of the AVs in a country, there is a need to obtain a clear and assertive diagnosis that allows the formulation of guidelines and actions for the capable development of a country.

As for future studies we suggest to extend the data collection to other countries and also, based on the outputs of this research, a future agenda must include the elaboration of key guidelines for AVs governance, including short, mid, and long term actions and requirements for the complete and successful insertion of AVs in the countries.

REFERENCES

ANTONIALLI, F. et al. Autonomous Vehicles, are they “riding” in a Blue Ocean? **Proceedings of the European Conference on Innovation and Entrepreneurship**, [ECIE]. Paris, France, 12, 2017.

ATTIAS, D. **The Automobile Revolution**: Towards a New Electro-Mobility Paradigm.1st ed. Gewerbestrasse (Switzerland): Springer International Publishing, 2016.

ATTIAS, D., MIRA-BONNARDEL, S. Extending the Scope of Partnerships in the Automotive Industry Between Competition and Cooperaiton. In: ATTIAS, D. **The Automobile Revolution**: Towards a New Electro-Mobility Paradigm.1st ed. Gewerbestrasse (Switzerland): Springer International Publishing, 2016.

BADEN-FULLER, C.; MORGAN, M. S. Business models as models. **Long Range Planning**, v. 43, n. 2-3, p. 156-171, Apr./June 2010.

BCG. **Self-Driving Vehicles, Robo-Taxis, and the Urban Mobility Revolution**. The Boston Consulting Group and the World Economic Forum. 2016. From: https://www.bcg.com/pt-br/publications/2016/automotive-public-sector-self-driving-vehicles-robo-taxis-urban-mobility-revolution.aspx

BORNMANN, L.; MUTZ, R. Growth rates of modern science: A bibliometric analysis based on the number of publications and cited references. **Journal of the Association for Information Science and Technology**, v. 66, n. 11, p. 2215-2222, Apr. 2015.

BROTHERTON, B.; SHAW, J. Towards an identification and classification of critical success factors in UK hotels plc. **International Journal of Hospitality Management**, v. 15, n. 2, p. 113-135, 1996.

BURNS, L.; JORDAN, W.; SCARBOROUGH, B. **Transforming personal mobility**. Broadway NY: Columbia University, 2013.

CALZA, F.; PARMENTOLA, A.; TUTORE, I. **Green Innovation Development**: A Multiple Case Study Analysis. In: 12th European Conference on Innovation and Entrepreneurship ECIE 2017, 2017, p. 116.

CAVAZZA, B. H. et al. Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. **Proceedings of the European Conference on Innovation and Entrepreneurship**, [ECIE]. Paris, France, 12, 2017.

CHANARON, J. J. Innovating in intelligent automobile transportation: towards an industry-wide consortium? **International Journal of Automotive Technology and Management**, v. 1, n. 2-3, p. 358-368, 2001.

CHEN, J.; SAWHNEY, M. Defining and measuring business innovation: The innovation radar. **MIT Sloan Management Review**, 2010.

CHRISTENSEN, C. M. **The Innovator's Dilemma**: When New Technologies Cause Great Firms to Fail. Boston: Harvard Business School Press, 1997.

CHRISTENSEN, C. M. The past and future of competitive advantage. **MIT Sloan Management Review**, v. 42, n. 2, p. 105–109, Jan. 2001.

CHRISTENSEN, C. M.; RAYNOR, M. E. **The Innovator's Solution**: Creating and Sustaining Successful Growth. Boston: Harvard Busniess School Press, 2003.

CHRISTENSEN, C. M. The ongoing process of building a theory of disruption. **Journal of Product Innovation Management**, v. 23, n. 1, p. 39-55, 2006.

CHRISTENSEN, C. M. Disruptive Innovation. Human computer interaction-brief intro. The Encyclopedia of Human-Computer Interaction. 2nd ed. The Interaction Design Foundation, 2013.

COLAUTO, D. et al. Os fatores críticos de sucesso como suporte ao sistema de inteligência competitiva: o caso de uma empresa brasileira. **Revista de Administração Mackenzie**, v. 5, n. 2, p. 119-146, 2004.

DE PRATO, G.; NEPELSKI, D.; PIROLI, G. Innovation radar: identifying innovations and innovators with high potential in ICT FP7, CIP & H2020 projects. Seville: JRC-IPTS, 2015.

ENOCH, M. P. How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport. **Technology Analysis & Strategic Management**, v. 27, n. 8, p. 910-924, Mar. 2015.

FAGNANT, D. J.; KOCKELMAN, K. Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. **Transportation Research Part A: Policy and Practice**, v. 77, p. 167-181, July 2015.

FRAZZOLI, E.; DAHLEH, M.A.; FERON, E. Real-time motion planning for agile autonomous vehicles. **Journal of Guidance, Control, and Dynamics**, v. 25, n. 1, p. 116-129, 2002.

GANDIA, R. M. et al. Autonomous vehicles: Scientometric and bibliometric studies. In: Gerpisa International Colloquium: R/Evolutions. **New technologies and services in the automotive industry**. Paris, 2017, p. 25.

GOLOVATCHEV, J.; KELLMEREIT, D.; BUDDE, O. **Innovation radar-a strategic approach for an innovation development and profitable launch of new product and services**. In: Management of Innovation and Technology, 2008. ICMIT 2008. 4th IEEE International Conference on (pp. 993-996). IEEE, Sept. 2008.

GRAU, A.**President, Icon Labs**. Telephone Interview, October 12, 2012.

GRUNERT, K. G; ELLEGAARD, C. The concept of key success factors: theory and method. **MAPP**, p. 1-28, 1992.

GUERRA, E. Planning for cars that drive themselves: Metropolitan Planning Organizations, regional transportation plans, and autonomous vehicles. **Journal of Planning Education and Research,** v. 36, n. 2, p. 210-224, 2016.

GUIZZO, E. How google's self-driving car works. **IEEE Spectrum Online**, 18, Oct. 2011.

HICKEY, J. **Vice President, Vínsula**. Telephone Interview, October 11, 2012.

HUCKO, F. **The development of autonomous vehicles**. Aalborg University Copenhagem, Compehagen: Denmark (Master Thesis), 2017.

JOHNSON, M.; MENA, C. Supply chain management for servitized products: a multi-industry case study. **International Journal of Production Economics**, v. 114, n. 1, p. 27-39, July 2008.

KING, S. F.; BURGESS, T. F. Beyond critical success factors: A dynamic model of enterprise system innovation. **International Journal of Information Management**, v. 26, n. 1, p. 59-69, Feb. 2006.

KPMG, CAR. **Self-Driving Cars**: The Next Revolution. Ann Arbor, MI, 2012.

KPMG. **Autonomous Vehicles Readiness Index**. Assessing countries openness and preparedness for autonomous vehicles. KPMG International, 2018, p. 1-60.

LIMA, D. A. **Sensor-based navigation applied to intelligent electric vehicles.**Doctoral thesis, Universit De Technologie De Compiègne, Compiègne, France, 2015.

MAHUT, F. et al. Survey on product-service system applications in the automotive industry. **IFAC-PapersOnLine**, v. 48, n. 3, 840–847, 2015.

MANSELL, R.; WEHN, U. **Knowledge societies**: Information technology for sustainable development. United Nations Publications, 1998.

MARKIDES, C.; GEROSKI, P. **Fast Second**: How Smart Companies Bypass Radical Innovation to Enter and Dominate New Markets. San Francisco: Jossey-Bass, 2005.

KIM, W. C.; MAUBORGNE, R. **Blue Ocean Shift**: Beyond Competition - Proven Steps to Inspire Confidence and Seize New Growth. Hachette Book Group, 2017.

MUTZ, F. et al. Large-scale mapping in complex field scenarios using an autonomous car. **Expert Systems with Applications**, v. 46, p. 439-462, Mar. 2016.

NAGY, D.; SCHUESSLER, J.; DUBINSKY, A. Defining and identifying disruptive innovations. **Industrial Marketing Management**, v. 57, p. 119-126, Aug. 2016.

NASCIMENTO, A. L. S. **Proposta de framework para avaliação de fatores críticos de sucesso de parques científicos e tecnológicos**. 2016. 179 p. Dissertação (Mestrado em Administração) - Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, 2016.

NASCIMENTO, S.; SALVADOR, A.; VILICIC, F. A era da autonomia. **Revista Veja**, v. 2554, n. 44, p.76-87, Nov. 2017.

NOGAMI, V. K. C.; VELOSO, A. R. Disruptive innovation in low-income contexts: challenges and state-of-the-art national research in marketing. **RAI Revista de Administração e Inovação**,v. 14, n. 2, p. 162-167, Apr./June 2017.

OECD (ORGANIZATION FOR ECONOMIC COOPERATION AND DEVELOPMENT) /Eurostat. **Guidelines for Collecting and Interpreting Innovation Data** — The Oslo Manual, 3rd ed. Paris: OECD, 2005.

OLIVEIRA, M. R. G. et al. Mensurando a inovação por meio do grau de inovação setorial e do característico setorial de inovação. **RAI-Revista de Administração e Inovação**, v. 11, n. 1, p. 115-137, 2004.

PISANO, G. P. You need an innovation strategy. **Harvard Business Review**, Boston, v. 93, n. 6, p. 44-54, June 2015.

POORSARTEP, M. Self-Driving Cars: Radical Innovation in the Transportation Industry. In: CHRISTIANSEN, B.; YILDIZ, S.; YILDIZ, E. **Transcultural Marketing for Incremental and Radical Innovation**. 1st ed. Hersey (Pennsylvania): IGIGlobal, 2014.

PORTER, M. E. **A vantagem competitiva das nações**. Rio de Janeiro: Ed. Campus, 1993.

POULAIN, B. State-of-the-art: Product and service systems modelling [Working Paper Nº 01]. **École Centrale Paris**, Châtenay-Malabry, France, 2017.

RAYNA, T.; STRIUKOVA, L. From rapid prototyping to home fabrication: How 3D printing is changing business model innovation. **Technological Forecasting and Social Change**, v. 102, p. 214-224, Jan. 2016.

ROCKART, J. F. Chief executives define their own data needs. **Harvard Business Review**, Boston, v. 57, n. 2, p. 81-93, Mar./Apr. 1979.

SAE INTERNATIONAL. **Surface vehicle recommended practice**: (R) Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles. USA, 2016, p. 1-30.

SAWHNEY, M.; WOLCOTT, R. C.; ARRONIZ, I. The 12 different ways for companies to innovate. **MIT Sloan Management Review**, v. 47, n.3, p. 1-22, July 2006.

SCHELLEKENS, M. Self-driving cars and the chilling effect of liability law. **Computer Law & Security Review**, v. 31, n. 4, 506-517, Aug. 2015.

SCHOITSCH, E. Autonomous Vehicles and Automated Driving Status, Perspectives and Societal Impact. Information Technology, Society and Economy Strategic Cross-Influences (IDIMT-2016). **24th Interdisciplinary Information Management Talks**, v. 45, n. 1, p. 405-424, 2016.

SCHREURS, M. A.;STEUWER, S. D.Autonomous Driving – Political, Legal, Social, and Sustainability Dimensions. In: MAURER, M. et al.**Autonomous Driving: technical, legal and social aspects**. Berlin: Springer, 2015, p. 149–171.

SCHUMPETER, J. A. **Creative destruction**. Capitalism, Socialism and Democracy, 1942. 825 p.

SCHUMPETER, J. A. **Can capitalism survive?: Creative destruction and the future of the global economy**. New York: Harper Perennial, 2009.

SELHOFER, H.et al. Disruptive Innovation: Implications for Competitiveness and Innovation Policy. **INNO-Grips–Global Review of Innovation Policy Studies**,2012. http://www. proinnoeurope. eu/innogrips2. Retrieved: January, 9, 2017.

STEG, L. Car use: lust and must. Instrumental, symbolic and affective motives for car use. **Transportation Research Part A: Policy and Practice**, v. 39, n. 2-3, p. 147-162, Feb./ Mar. 2005.

TUKKER, A. Eight types of product– service system: eight ways to sustainability? Experiences from suspronet. **Business Strategy and the Environment**, v. 13, p. 246-260, 2004.

U.S. DEPARTMENT OF TRANSPORTATION. **Federal Automated Vehicles Policy**: Accelarating the next revolution in roadway safety. 2016. from:<https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf>. Retrieved on January 2, 2017.

WONG, M. T. N. **Implementation of innovative product service systems in the consumer goods industry**. Doctoral dissertation, University of Cambridge, Cambridge, United Kingdom, 2004.

WORLD BANK. **World Development Report 2017**: Governance and the Law. Washington, DC: World Bank. doi: 10.1596/978-1-4648-0950-7. License: Creative Commons Attribution CC BY 3.0 IGO, 2017.

WORLD ECONOMIC FORUM. **Mapping Global Transformation - Brazil**. 2019. Available in https://toplink.weforum.org/knowledge/insight/a1Gb0000000LPqYEAW/explore/summary. Access in: 4th February, 2019.

YUN, J. J. et al. The relationship between technology, business model, and market in autonomous car and intelligent robot industries. **Technological Forecasting and Social Change**, v. 103, p.142–155, Feb. 2016.

ZAKHARENKO, R. Self-driving cars will change cities. **Regional Science and Urban Economics**, v. 61, p. 26-37, Nov. 2016.

SECOND PART

ARTICLE 01- Management and Business of Autonomous Vehicles: A Systematic Integrative Bibliographic Review

Preliminary version of the paper published on the proceedings of the 12th European Conference on Innovation and Entrepreneurship [ECIE, 2017].

Cavazza, B. H., Gandia, R. M., Antonialli, F., Nicolaï, I., Zambalde, A. L., Sugano, J. Y., Miranda Neto, A. (2017). Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. Proceedings of the European Conference on Innovation and Entrepreneurship, [ECIE]. Paris, France, 12.

Cavazza, B. H., Gandia, R. M., Antonialli, F., Nicolaï, I., Zambalde, A. L., Sugano, J. Y., Miranda Neto, A. (fortcoming article). Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. International Journal of Automotive Technology and Management - Special Issue on: SUPF 2017 Smart Urban Mobility Futures. ISSN online: 1741-5012, ISSN print: 1470-9511, Qualis A2.

Abstract
This paper reviews the management and business research field of Autonomous Vehicles (AVs) in a bibliometric context aiming to identify strategies, practices, and management tools; and summarizes the existing studies and highlight research gaps. Methodologically, the study is qualitative and descriptive, based on a bibliometric review on Web of Science, Scopus, and Science Direct, followed by a systematic integrative review. Results show that, in the near future, AVs will certainly be introduced in the society. However, such insertion is still surrounded by uncertainties, doubled by governments' lack of planning. The absence of business-related studies can be a determinant for AVs introduction, once business models (BM) play an important for AVs advancement. Nevertheless, especially in Europe, studies related to AVs "car-sharing" seem to be predominant. As such, we observe a research gap regarding BM and platforms and radical and responsible innovation theories.

Keywords: Autonomous Vehicles. Business. Management. Systematic Integrative Review. Bibliometric Review.

1 INTRODUCTION

The development of autonomous vehicles (AVs) is an important innovation that promises to have great impact on urban mobility. In fact, AVs are part of the most significant historical change to the automobile and transportation industry. Governments and universities worldwide identify AVs as key research factor. AVs' imminent introduction has the potential to fundamentally alter transportation systems by avoiding deadly crashes, providing critical mobility to the elderly and disabled, increasing road capacity, and saving fuel and lowering emissions, making it important to consider the impacts of such disruptive innovation on the society and the structure and functioning of companies (Thomopoulos & Givoni, 2017; Fagnant & Kockelman, 2015).

Among the stakeholders responsible for the dissemination of this innovation, the academia is an important precursor of AV development (Gandiaet al., 2017), being responsible for important theoretical and empirical research for this field's evolution. Although technological advances are essential for the dissemination of this innovation, it is understood that, in the case of radical innovations, technology cannot be established as an exclusive determinant but needs to be combined with the establishment of a business model that supports it (Christensen et al., 2006). This occurs since a business model is made up of four elements: (1) a value proposition for customers; (2) resources, such as people, money, and technology; (3) the processes that the organization uses to convert inputs into finished products or services; and (4) the profit formula that dictates the margins, asset velocity, and scale required to achieve attractive returns (Christensen et al.,2016).

However, the advancement of the technological innovations that permeate the AV and intelligent robot industries is part of a dynamic process due to the relationships among technology, business models, and marketplace (Yun et al., 2016). In this context, it is important to note the possibility of changes in the dynamic relationships among these three factors to obtain the expected results, such as the impact of urban mobility on social or environmental issues, which might not be addressed by technology alone.

Although there are some studies that generally analyze the context and environment of AVs, there is still a lack of theoretical and empirical research seeking to analyze AV from a market perspective, in relation to the aspects of planning and management. Therefore, it is important to consider the literature approaches related to the business and management (B&M) of AVs to better understand and disseminate the reality of these issues by interpreting

and integrating content, summarizing existing evidence, and identifying key issues and research gaps.

Consequently, this study aims to answer the following research question: how is AV research characterized within the business and management research field? Specifically, this paper investigates the main theoretical contributions related to AV in the B&M research field by conducting a bibliometric and systematic integrative literature review.

Therefore,this study will contribute to the field's systematization based on evidence in the literature, such as: i) characterizing the AV research field from the B&M viewpoint in its bibliometric context; ii) identifying strategies, practices, and management tools of the reviewed publications; and iii) summarizing existing evidence and identifying little or unexplored topics (gaps) within this study area.

Overall, there are several studies that seek to characterize the AV field. Works such as those of Bimbraw (2015); Gandia et al. (2018); Gerónimo et al. (2010); González et al. (2016); Piao and McDonald (2008); Shladover (1995, 2005); Sun, Bebis, and Miller (2006); Turner and Austin (2000); Vahidi and Eskandarian (2003); and Xiao and Gao (2010) offer a broad view of the field (without discriminating/choosing any specific knowledge areas), including issues such as chronology and the evolution of the AV field, as well as trends and gaps in AV technology.

On the other hand, there are several papers focusing on specific aspects/knowledge areas related to AVs such as Fagnant and Kockelman's (2015) study, which addresses major implications of the imminent introduction of AV, as well as seeks to identify opportunities, barriers, and policy recommendations. Additionally, Milakis, Van Arem, and Van Wee (2017) explore the potential effects of automated driving relevant to policy and the society.

Finally, it is also worth highlighting the studies of Brookhuis, de Waard, and Janssen (2001),de Winter et al. (2014), and Stanton and Young (1998), which focus on the human aspect of AVs, such as behavioral adaptation, driver's workload, and situation awareness.

In this context, the present study stands out by reviewing and unifying the literature on B&M in the AV context. In other words, the bibliometric and systematic review is important as it allows us to focus on this topic; identify authors, articles, dates, journals, and approaches; review seminal studies; integrate and synthesize the evidence from practical strategies, applications, and tools; and, finally, identify and disseminate specific information in a chronologically organized and directed way (Botelho, Cunha & Macedo, 2011).

2THEORETICAL BACKGROUND

2.1 Autonomous vehicles overview

AVs, also known as automated driving systems (ADS), are cars with motion and action capabilities that do not require any sort of conductor (driver) or teleoperation control(Frazzoli, Dahleh & Feron, 2002), and are considered an integral part of the new forms of mobility (Attias, 2017). ADS is the recommended terminology by the Society of Automotive Engineers (SAE) to refer to vehicles with different automation levels as to avoid multiples definitions with ambiguous meanings (SAE, 2016). This includes several terminologies widely used in the literature, such as autonomous vehicles/cars, self-driving cars, car-like robots, intelligent vehicles, driverless cars. Recently, there has been a significantly growing interest in AVs, as over the past few decades, several studies on them have been developed (Lima, 2015).

According to Lima (2015), the first AV was developed in Japan in the mid-1970s and was able to track white street markers with computer vision at speeds up to 30 km/h. Only 10 years later, the first autonomous vehicles would emerge in Europe in Bundeswehr University Munich (UniBW) in Germany, as part of the PROMETHEUS project. Additionally, in the 1980s, the first US contribution to the project called “No hands across America” from the Carnegie Mellon University took place. They developed a car named Navlab 5, capable of performing autonomous navigation from Washington DC to San Diego with 98% automated steering and manual longitudinal control. Another contribution came from Italy, within the ARGO Project, an offshoot from project PROMETHEUS with similar results.

Starting in 2004, as a part of the US Department of Defense strategy to develop new technologies for military uses, a series of prize competitions for American AVs, named DARPA Gran Challenges, took place in the USA. Through these events, countless contributions and advances have been made. It is worth noting the second edition, held in 2005, where several new sensors were developed, such as the 360◦ LIDAR. In November 2007, the third challenge, called the Urban Challenge, was located in a fake urban environment to simulate interactions with other vehicles and urban features. However, important interactions among pedestrians, cyclists, or traffic lights were still not required. To consider cooperative AV scenarios by means of wireless communication among collaborative

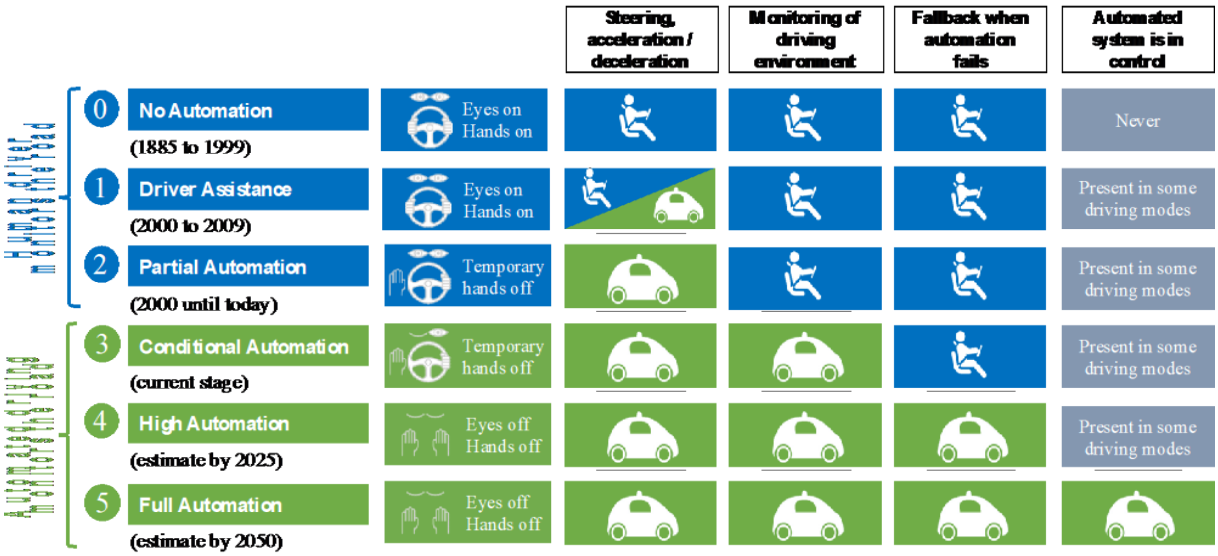
platooning, where vehicles drive in road trains with short inter-vehicular distance to save fuel and improve safety and throughput, the Grand Cooperative Driving Challenge was proposed. The first one happened on the Netherlands highways in 2011, focusing on the ability to carry out longitudinal control (platooning). The next challenge was held in 2016 and focused on automated and cooperative driving.

Over the few past years, many teams worldwide have continued the development of AVs. As pointed out by Guizzo (2011), in the USA, the results presented by the Google car based on the expertise gained during the DARPA Urban Challenge are impressive; its main components are a high-end laser scanner on the car's roof and a prerecorded map (constructed during a manual drive). As pointed out by Lima (2015), in Europe in 2012, the group supervised by Alberto Broggi has performed an impressive long-term autonomous navigation from Parma, Italy, to Shanghai, China, by applying cooperative driving. In 2014, they presented a full autonomous result for public traffic around the streets of Parma. Over the same period, another group, based in Germany, has presented some contributions on autonomous driving with the vehicle Bertha Benz (Ziegler et al., 2014) and validation of computer vision algorithms with the KITTI Vision Benchmark (Geiger, Lenz & Urtasun, 2012).Compared with Google's car, such European projects focus on sensor setup in terms of robustness, availability, and redundancy for final commercial terms.

It is also important to mention there are other groups working on AVs around the world (Lima, 2015). In Brazil, for example, the projects CADU (Lima & Pereira, 2013) and CaRINA (Fernandes et al., 2014), deal with several problems related to unstructured urban environments, different from those normally seen in Europe and USA.

The Surface Vehicle Recommended Practice from SAE International provides a taxonomy describing the full range of driving automation levels for on-road motor vehicles and includes functional definitions for the advanced levels of driving automation and related terms and definitions. There are six levels of driving automation in the context of motor vehicles (Figure 1), ranging from no driving automation (level 0) to full driving automation (level 5) (SAE, 2016).

Figure 1 - Overview of Driving Automation Levels.



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

According to SAE's (2016) report, the levels of automation are rather descriptive and informative instead of normative, having also a more technical perspective rather than a legal one. Specific elements indicate the minimum rather than maximum capabilities for each level. In this figure, "system" refers to driving automation system or ADS, as appropriate.

2.2 Business and management research

The flows of markets and different industries have created technological innovations that allow us to have certain lifestyles.In this sense, one can say that the business world fuels our economy.Therefore, carrying out research on B&M in essential for the advancement of economies and society as a whole. B&M research helps companies, governments, and other entities in many ways, such as contributing towards new strategic directions and ideas, evaluating and re-evaluating current processes and providing better ideas to make the current processes efficient in forecasting and predicting future trends (Akram, 2015). The author also

states that another important goal of B&M research is the invention and development of new business practices, instead of simply examining existing ones.

As pointed out by Easterby-Smith, Thorpe, and Jackson (2008), B&M research can be characterized as applied research, based on a systematic inquiry that helps solve business problems and contributes to management knowledge. This study field is characterized by its broad scope; therefore, B&M studies do not usually lend on enquires which might be considered as basic research (Remenyi et al., 2003); for the authors, "this field of study, particularly at the masters and doctoral degree levels, most frequently seeks to find answers to real problems. In fact, the best business and management research will directly lead to knowledge which will allow management to change the way things get done in order to be more efficient and/or more effective" (Remenyi et al., 2003:p.10).

As stated by Easterby-Smith, Thorpe, and Jackson (2008), there are four distinct factors that, when combined, set apart B&M research from other social science research types: 1) it is a transdisciplinary approach; 2) information access is difficult, since managers see information as competitive advantage on the market; 3) managers are educated and want information produced by classical research methods; and 4) findings must resolve practical management problems.

Finally, Remenyi et al. (2003) highlight that it is important to consider that stakeholders who have a direct interest in B&M research are different from those with interests in areas such as anthropology, education, sociology, psychology, and other social sciences. Thus, regardless which stakeholder group is being consider, there is a strong emphasis in B&M studies on the application of knowledge rather than on its creation.

2.3 Bibliometric and systematic review

Literature review articles are "a form of research using sources of bibliographic or electronic information to obtain search results from other authors, to theoretically support a particular topic" (Botelho, Cunha & Macedo, 2011:p.124).In bibliometric reviews, we consider the quantification of publications related to a topic under study, that is, frequency of publications over the years, authors, journals, countries, and other important data. On the other hand, systematic literature reviews should be designed to address a particular issue with the use of detailed, explicit, and systematic methods to raise, identify, select, interpret, collect, and analyze references (Botelho, Cunha & Macedo, 2011).

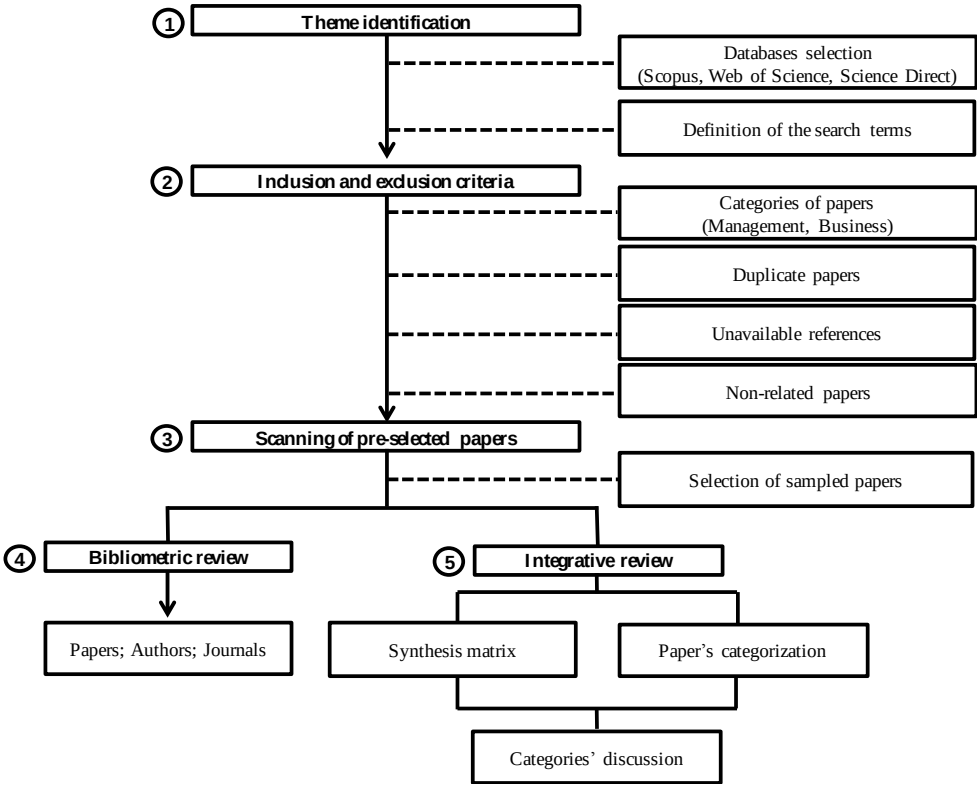
According to Whittemore and Knafl (2005), there are four types of systematic literature review: meta-analysis (a combination of results of studies with statistical formulas targeting analysis, comparisons, and the generation of new results), systematic (based on scientific research strategies, limits the scope of selection of articles, synthesizes studies, and evaluates them critically), qualitative (systematization and synthesis of qualitative studies' findings, transforming them into tools to build new theories), and integrative (reviews the past empirical and theoretical literature, presenting the state of the art on a theme, especially for result analysis and synthesis of previous research contributions and gaps).

In this study, we performed a bibliometric review, followed by an integrative systematic literature review. The integrative review refers to the fact that, in this method, concepts, opinions, and ideas arising from previous research are integrated (Whittemore & Knafl, 2005).

3 METHODOLOGY

The present research is characterized as qualitative and descriptive, using a bibliometric review and a systematic integrative review focusing on investigating and understanding the main theoretical contributions of AVs in the B&M area. Figure 2 highlights the research design carried out by this study.

Figure 2 - Research Design.



Source: Prepared by the authors.

Considering that AVs thematic is pluridisciplinary (Gandia et al., 2018) and that the B&M research field is characterized by a broad scope, encompassing several science branches and areas (Remenyi et al., 2003), to guarantee the highest possible number of papers in the research corpus, we chose to carry out the query in databases with broader scope of science categories (step 1). Therefore, the articles were searched from Scopus, Web of Science (WoS), and Science Direct (SD) in a single search, between 1945 to 2017, using the Boolean operator "OR." The following terms were searched for in the title, abstract, and keywords of the articles: *autonomous_car*; autonomous_vehicle*; autonomous_automobile*; driverless_car*; driverless_vehicle*; driverless_automobile*; self-driving_car*; self-driving_vehicle*; self-driving_automobile*; intelligent_car*; intelligent_vehicle* intelligent_automobile* and automated_driving_system**.We identified 6,713 papers on WoS, 27,855 papers on Scopus, and 6,796 papers on SD. It is worth clarifying that the Boolean operator underline "_" was used to ensure that the search yielded only results in which the pair of words appeared together. The operators star "*" (WoS and Scopus) and "" (SD) were used to ensure that both singular and plural terms were included in the search results.

As for the inclusion and exclusion criteria (step 2), the first criterion was to select publications classified as articles. Subsequently, we applied the databases category filter, that

is, all papers that were not listed within the B&M category were excluded from the query. Thus, we identified a total of 646 papers: 244 from Scopus, 56 from WoS, and 344 from SD. At this point, all articles' titles and abstracts were carefully peer-reviewed for further filtering. Of the 644 articles, 615 were excluded following the following criteria: a) duplicate references—identified more than once in different sources (8 papers); b) unachievable references—that could not be obtained by interlibrary loan, online search, or contacting the authors (3 papers) and; c) non-related references to the research question (how is the research on AV characterized within the business and management research field?) or just tangent the theme of interest (605 papers).

After step 2, we included 30 papers in the analysis. Those papers were pre-selected for in-depth reading and analysis (step 3).Next, during step 4, a bibliometric review was carried out, in which we analyzed the evolution of publications over the years, country publication frequency, publication languages, methodological approach of the papers, most cited paper, and also keywords recurrence in a Word Cloud.

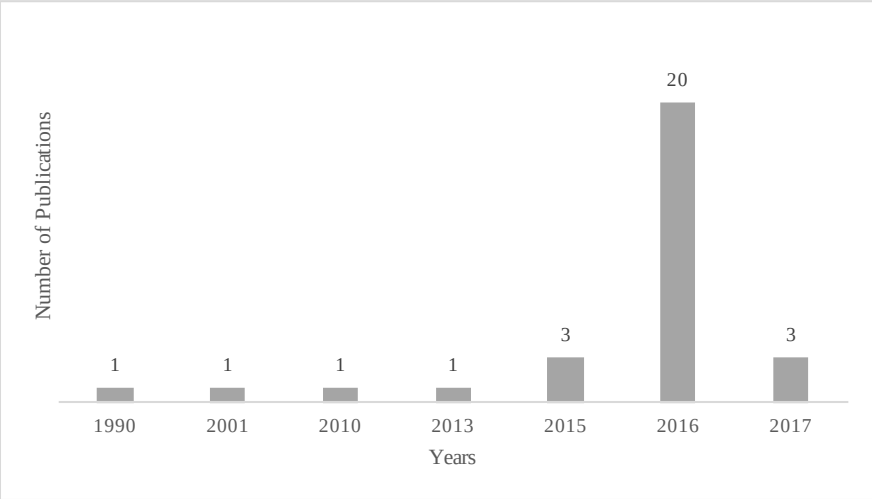
Finally, during step 5, we carried out a systematic integrative review.Initially, we conducted a detailed study of the main issues of each document (synthesis matrix), including keywords, research problem, goals, theoretical background, study type, methodological approach, main contributions, and future research proposals. Subsequently, based on the output of the synthesis matrix, we were able to create categories for the articles according to the main topic they addressed to facilitate the presentation and discussion of results. It is worth mentioning that this categorization was performed by two members of the team and was later validated by a third person to guarantee impersonality in the results.

4 RESULTS AND DISCUSSION

4.1 Bibliometric review

The first analysis considers the number of publications per year. Figure 3 displays the distribution of the 30 identified articles by the year of publication. Between 1945 and 1989, there were no publications in the field, as the first publication is in 1990, an article titled "Intelligent Vehicle-Highway Systems: U.S. Activities and Policy Issues" (Chen & Ervin, 1990).

Figure 3 - Publication frequency (1990–2017).

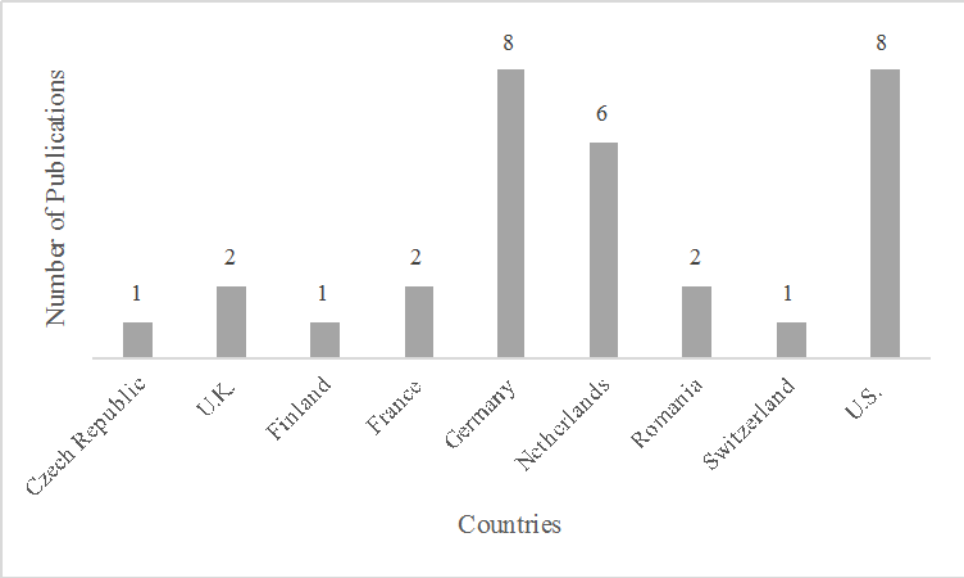


Source: Prepared by the authors.

Until 2015, publications were less frequent, with some years in which no article was published. Only from this year onward, publications showed a more consistent pattern, surging in 2016 to reflect the emergence and recent attention given to the subject matter. The most cited paper was by Tuominen and Ahlqvist (2010), with 29 citations. Regarding the authors with most publications, significant heterogeneity was observed, as each analyzed paper had a different author.

Further, all identified articles are in English, and regarding the originating country, the United States and Germany (Figure 4) are first in the number of publications.

Figure 4 -Country Publication Frequency.

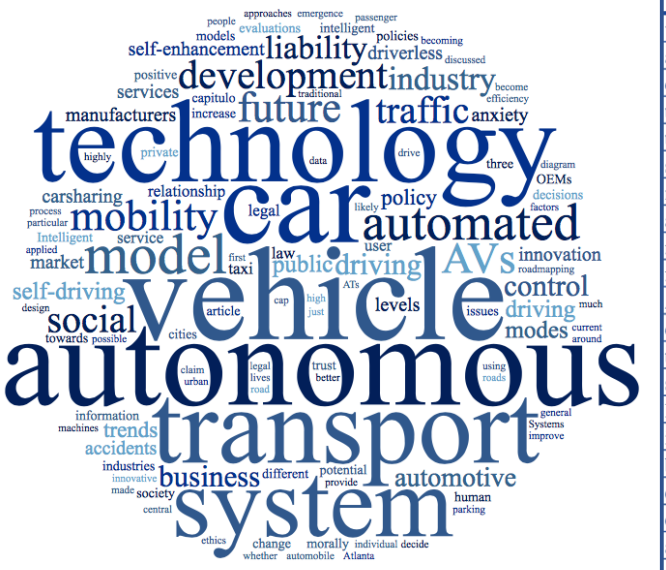


Source: Prepared by the authors.

It is also important to highlight that, regarding the methodological approaches of these papers, the majority are described as qualitative (26 out of 30). This fact points to the lack of empirical studies on AV in the area of B&M, as well as the emergence of the topic.

Finally, the most cited words in the titles and abstracts of the articles were identified. By using the "Word Frequency Counter" application, Figure 5 presents the most recurrent keywords found in the abstracts and titles. The words were chosen for both their frequencies and relevance in related discussions and debates. It is worth mentioning some important terms in the figure, such as transport business, public, model, technology, policy, social, liability, or market. These words served as guidelines for the construction of the thematic categories for the integrative review and represent relevant study trends in the area.

Figure 5 - Recurrent Keywords in the Papers' Titles and Abstracts.



Recurrent word	Frequence	Recurrent word	Frequence
vehicle	49	driving	9
autonomous	48	public	9
car	45	modes	9
technology	43	policy	8
transport	40	trends	8
system	37	self-enhancement	7
model	21	manufacturers	7
automated	19	carsharing	7
mobility	16	innovation	7
future	16	driverless	7
AVs	16	accidents	7
development	15	services	7
traffic	14	anxiety	7
social	14	levels	7
liability	12	market	7
industry	12	relationship	6
business	11	service	6
driving	11	legal	6
control	11	taxi	6
automotive	10	user	6
self-driving	9	law	6

Source: Prepared by the authors.

4.2 Integrative review

To categorize the articles, analyses on each of the 30 papers were carried out, considering subjects related to the research problem, objectives, scope, methodological approach, main contributions, conclusions, and recommendations. Regarding the integrative review, a common point observed while creating the synthesis matrix is the consensus among all analyzed papers that AV will be part of our future society, whether in the short, medium, or long term, as "the era of self-driving vehicles is undeniably upon us" (Attias, 2017:p.107).

Uncertainties permeate various aspects of this innovation, that is, the search for solutions on several questions and the focus of the papers among the identified categories seem to be still under development. It is also worth noting there is a strong relationship among all categories and, in many cases, the papers identified as belonging to one category broaden their discussions to other categories, leading to the understanding that this topic is not clearly delineated.

We also highlight that the main criterion for the inclusion of an article in a given category was the identification of the strongest present topic in its scope. The main themes categorized and detailed in the following sections of this study are: Ethics/Moral/Liability (9 papers); Policy Issues–Law (3 papers); Transport Planning (7 papers); Consumer Behavior (4 papers), and Business Models for AVs (7 papers). Although there is a higher incidence of papers in certain categories than in others, we understand that the quantitative metric does not

infer a bigger or smaller influence of a conceptual framework formulation for AV from the B&M perspective. We also highlight that a given paper might present aspects of one or more categories of analysis; however, we chose to allocate the papers in the category of their central research topic. Namely, it is assumed that all identified categories here are necessary, in a synergistic movement, for the description of the field. Table 1 presents the 30 papers divided within the four categories created for the integrative review.

Table 1 -Analyzed Papers and Categories.

Category	Paper	Authors	Year
Ethics/Morals/Liability	Responsibility for Crashes of Autonomous Vehicles: An Ethical Analysis	Hevelke, A; Nida-Rümelin, J	2015
	Self-driving Cars and the Chilling Effect of Liability Law	Schellekens, M	2015
	Fault-y Reasoning: Navigating the Liability Terrain in Intelligent Transportation Systems	JLederman, J; Garrett, M; Taylor, B.D.	2016
	Autonomous Driving: Technical. Legal and social aspects (Product liability issues in the U.S. and associated risk management)	Wu, S.S.	2016
	Who Should Decide How Machines Make Morally Laden Decisions?	Martin, D.	2016
	Engineering Social Justice into Traffic Control for Self-Driving Vehicles?	Mladenovic, M.N; McPherson, T.	2016
	Autonomous Cars: In Favor of a Mandatory Ethics Setting	Gogoll, J; Müller, J. F.	2016
	Ethical Ripples of Creativity and Innovation (Driverless cars: Driven to extinction?)	Mlodozeniec, T.	2016
	Autonomous Driving: Technical. Legal and Social Aspects (Why Ethics Matters for Autonomous Cars)	Lin, P.	2016
Policy Issues (Law)	Intelligent Vehicle-Highway Systems: U.S. activities and policy issues	Chen, K; Ervin, R.D.	1990
	Autonomous Driving: Technical. Legal and Social Aspects (Autonomous Driving—Political, Legal, Social, and Sustainability)	Schreurs, M.A, Steuwer, S.D.	2015
	Autonomous Driving: Technical. Legal and social aspects (Fundamental and special legal questions for autonomous vehicles)	Gasser, T.M.	2016
Transport Planning	Is the Transport System Becoming Ubiquitous? Socio-Technical Roadmapping as a Tool for Integrating the Development of Transport Policies and Intelligent Transport Systems and Services in Finland	Tuominen, A; Ahlqvist, T.	2010
	Transcultural Marketing for Incremental and Radical Innovation (Self-Driving Cars: Radical Innovation in the Transportation Industry)	Poorsartep, M.	2013
	How a Rapid Modal Convergence Into a Universal Automated Taxi Service Could Be the Future for Local Passenger Transport	Enoch, M.P.	2015
	Planning for Cars that Drive Themselves: Metropolitan Planning Organizations, Regional Transportation Plans, and Autonomous Vehicles	Guerra, E.	2016
	The Automobile Revolution: Towards a New Electro-Mobility Paradigm (The Autonomous Car, A Disruptive Business Model?)	Attias, D.	2017
	Self-Driving Cars Will Change Cities	Zakharenko, R.	2016
	Autonomous Vehicles and Automated Driving Status, Perspectives and Societal Impact	Schoitsch, E.	2016
Consumer Behavior	Applied Artificial Intelligence and Trust—The Case of Autonomous Vehicles And Medical Assistance Devices	Hengstler, M; Enkel, E; Duelli, S.	2016
	Autonomous Driving: Technical. Legal and social aspects (Consumer perceptions of automated driving technologies: An examination of use cases and branding strategies)	Woisetschläger, D.M.	2016
	Not Fearless, but Self-Enhanced: The Effects of Anxiety on the Willingness to Use Autonomous Cars Depend on Individual Levels of Self-Enhancement	Hohenberger, C; Spörrleb, M; Welpe, I.M.	2017
	Data-enabled public preferences inform integration of autonomous vehicles with transit-oriented development in Atlanta	Lu, Z; Du, R; Dunham-Jones, E; Park, H; Crittenden, J.	2017
Business Models for AV	Innovating in intelligent automobile transportation: towards an industry-wide consortium?	Chanaron, J.	2001
	Autonomous Driving: Technical, legal and social aspects (Implementation of an automated mobility-on-demand system)	Beiker, S.	2016

Requirements Towards Sustainable Future Urban Mobility in Germany	Geldmacher, W., Kopia, V. J. J; Bussian, A.	2016
SWOT Analysis and Evaluation of a Driverless Carsharing Model	Geldmacher, W; Pleșea, A. D	2016
The Relationship Between Technology, Business Model, And Market in Autonomous Car and Intelligent Robot Industries	Yun, J.J; Won, D; Jeong, E; Park,K; Yang, J; Park, J.	2016
Optimizing the Service Area and Trip Selection of an Electric Automated Taxi System Used for the Last Mile of Train Trips	Liang, X; G. H.A; Van Arem, B.	2016
Tailored Automotive Business Strategies in the Context of Digitalization and Service-Oriented Models	Kompalla, A., Geldmacher, W., Just, V; Lange, S.	2017

4.2.1 Ethics/moral/liability

This category is centered on the pre-defined functioning of AV. That is, AV decision-making will be previously introduced and "many or all of those decisions will have to be programmed into the car" (Ong, 2017:p.36); therefore, there is the fundamental role of the engineering department, responsible for programming AV and, consequently, its dissemination. Mladenovic and McPherson (2016) state that decision-making power should not be concentrated solely in a small group of experts, especially if financial interests have exclusive influence. This group should not have exclusive rights to decide on all moral aspects of these machines' behaviors (Martin, 2016). In this sense, Gogoll and Müller (2006) state that rather than including personal ethics settings—that is, concentrating such machine behavior decisions in small groups of people—mandatory policies would be more efficient on a larger scale.

One of the biggest challenges for AV manufacturers is the risk of product liability lawsuits if, in the event of accidents, AV operation may result in deaths and catastrophic injuries (Wu, 2016). Hevelke and Nida-Rümelin (2015) ask who should be made responsible in case of a crash. The authors conclude that AV users should be collectively responsible for any damage caused by such vehicles—even if they had no way of influencing the car's behavior—and agreed that a tax or a mandatory insurance seems to be the easiest and most practical means to achieve that. Further, Schellekens (2015) states that the chilling effect of product liability on innovation can be further mitigated by adequate obligatory insurance. For instance, companies such as Tesla, Mercedes, BMW, and most recently Audi, are all currently selling cars with imbedded levels 2 and 3 automation capabilities and, to protect themselves against liability issues, they all make the terms of use of such vehicles very clear. It is worth noting that in vehicles with such automation levels, the driver is required to always keep his hands on the steering wheel, even in the stand-alone mode.

Finally, we cannot eliminate the need for a public and democratic discussion on the societal values that technology shapes. As a result, it is necessary to transparently engage relevant corporate groups in critical discussions and decision-making (Mladenovic &McPherson, 2016). Disruptions imply changes and such changes are not necessarily a bad thing, but further damage caused by those changes must be anticipated and avoided whenever possible. This is the role of ethics in innovation policy: it can pave the way for a better future while enabling beneficial technologies. Without considering ethics, we are “driving with one eye closed” (Lin, 2016:p.82).

4.2.2 Policy issues: Law

This category presents perspectives based on the lack of clarity about who is responsible for the operation of such vehicles, the major point of confusion among manufacturers, consumers, and lawyers: "The liability issue is the biggest one of them all" (Adee, 2016:p26). This lack of clarity may be impacting the way in which public policy has been leading issues related to AV legislation.

However, several countries worldwide are stimulating, by governmental policies, the dissemination of AVs. Autonomous driving is not just about the automobile industry but includes many other industrial branches that will benefit from a greater degree of automation, such as component suppliers. That is why there is a growing interest in promoting local advantages and the reason political commitments are beginning to be made in some countries to support certain development paths (Schreurs & Steuwer, 2015).

In this sense, this study considers that policies will act in two stages: 1) to stimulate companies and investments to provide technological advances and the consequent dissemination of AV (current AV stage); and 2) to develop public policies or adequate laws for AV. It is understood that this latter stage will also follow local factors, which would allow an assessment of how the corresponding legal framework should be designed to create a real "road traffic system" involving autonomous vehicles (Gasser, 2016).

4.2.3 Transport planning

When it comes to the future of mobility, there is consensus among the papers in this category that changes will occur in all the transportation systems (e.g., automated systems, traffic control and demand predictions, congestion, travel behavior). In this context, we are witnessing a modal convergence from traditional transportation modes such as car, bus, and taxi to intermediate modes such as shared taxis, lift-sharing schemes, demand-responsive

transport services, and car clubs. Further, AVs will directly impact or act as accelerators of this process (Enoch, 2015; Nikitas et al., 2017). The development of the society is driving these transportations system changes: these developments are being driven by both technology-push and demand-pull factors(Hojnik & Ruzzier, 2016).In view of the digitization context, many industries are gradually being transformed, with AVs as the translation of the digitization of the automotive industry, including the arrival of new players such as Google and Uber (Attias, 2017).

Under a gradually changing scenario, Tuominen and Ahlqvist (2010) point to three changes in the future of transport: (1) actor roles and stakeholder networks in the system will be pluralized and the transport system will increasingly be composed of public parties, private entities, contributing end-users, and the complex networks formed by these actors; 2) a new type of business and service layer will be formed in the system because of new dynamic interconnections among actors; and 3) a layer of services will be createdusing the concept of "technology service," which would be a flexible and adapted combination of technologies and services. Enoch (2015) proposes that these changes will converge from intermediate modes of transport, which will replace traditional transport (cars, buses, and taxis). The author believes that AVs will be accelerated in this process to a single autonomous universal service of higher quality and cheaper. Attias (2017) proposes that,overthe mediumterm, this evolution will not stop at AVs, opening the field for the design of similar technical objects (e.g., trucks, buses) and, subsequently, boats and autonomous planes.

Finally, Poorsartep (2014) proposes, in addition to a scenario of gradual change, a more radical perspective, which will provide a unique opportunity for the market leader to establish an indisputable position, possibly leading to monopoly. In fact, although there is consensus regarding the benefits of AVs(Fagnant & Kockelman, 2015), the uncertainties and questions that permeate them are still barriers to long-range transportation plans (Guerra, 2016).

4.2.4 Consumer behavior

The main themes addressed here are the market perception regarding AVs and how to measure population and potential consumers' acceptance of AVs byspecifically a) discussing if firms have enhanced trust in applied artificial intelligence (Hengstler, Enkel& Duelli, 2016), b) examining how positive cognitive evaluations and anxiety-related affects, and the interplay between these two factors influence the willingness to use AVs (Woisetschläger,

2016), c) identifying consumer acceptance and branding consequences in the AV context (Hohenberger, Spörrleb &Welpe, 2017), and d) presenting discussions on innovative means to analyze social preferences, demand for AVs, and the potential to resolve community concerns with integrated solutions (Luet al., 2017).

When we address issues related to AV from the consumer's standpoint, we clearly perceive that "the main roadblock is human acceptance"(Webb, 2007:p.5). We cannot fall into the fallacy of a simple analysis of benefits brought to and/or perceived by the consumer. The feelings of attachment, possession, freedom, and the sensations acquired by consumers as drivers/passengers should be thus considered.

In fact, rather than presenting solutions and conclusions, these papers introduce preliminary research that opens the discussion onto a new theme to be explored when considering the human element, its reactions, preferences, and perspectives in the dynamics of AVs, as well as the various factors that can influence consumer behavior and willingness to adopt AVs. The main research gaps in this category refer to studies that relate different business models (ownership, car-sharing, etc.) to the expectations of different consumer groups, as well as comparing the cost effectiveness and sustainability of individual ownership versus public-operated AVs. Future studies should also address questions about new ways for the customers to use their time while traveling in the vehicles, considering the creation of an in-car environment as well as new opportunities of "infotainment" (information + entertainment) that can be offered to consumers by these vehicles. Additionally, the investigation of individual values and their influence on AV adoption has yetto be explored (Hohenberger, Spörrleb & Welpe, 2017).

4.2.5 Business models for AVs

This final category deals with aspects related to the business models proposed for AVs. The presented key factors refer to the economic implications (including sale options for these vehicles), as well as discussions about service-oriented business models (e.g., car-sharing), their strengths, opportunities, threats, and weaknesses as an option for AV deployment (Kompallaet al., 2017).

The business models associated with AVs consider different scenarios of ownership and use—manufacturers, distributors, fleets, and public sector—which are important to ensuringthe introduction and sustainability of AVson the market. The main research gaps in this category point to a link between innovation theories and approaches as to propose models

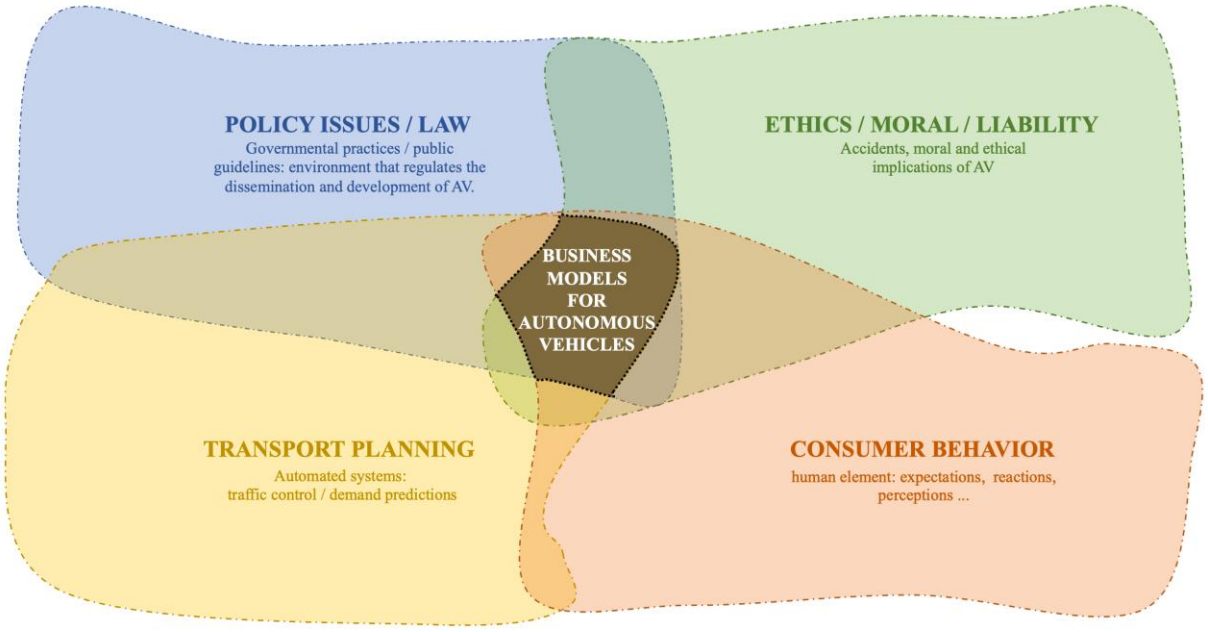
associated with disruptive innovation; that is, this refers to breaking and redefining existing models so that it would be possible to understand and anticipate disruptive business and process strategies and contribute to the construction of a consistent theoretical basis for the new businesses associated with AVs.

It is worth mentioning that, among all analyzed categories, this was the most incipient. That is, more studies are needed to better understand the evolution and dynamics of business models for autonomous vehicles. However, the incipience of this category is understandable, since AVs are not yet a market reality and, therefore, much of what is discussed today in terms of business is based on projections and speculation.

4.3 Overall discussion and framework

After identifying the relevant aspects of each discussed category, we propose a theoretical framework as an attempt to unify the discussion. Figure 6 illustrates the categories developed in this study, as well as the main issues related to each of them.

Figure 6 – Theoretical Framework of Autonomous Vehicles within Business and ManagementResearch.



Source:Prepared by the authors.

As shown in Figure 6, several aspects and macro-environments permeate AV. Currently, the vast majority of studies related to such vehicles, tend to focus on the more

technological aspects related to the vehicle's characteristics. As pointed out by Gandia et al. (2018), although there is a predominance of sciences related to AVs' technical evolution, there is a growing presence of other science branches in the field.

In this sense, the categories drawn in this study point to the main trends of the studies related to other knowledge areas, thus raising important questions on the perspectives and implications of AV introduction. From Figure 6, until AV can be implemented on a large scale, there are several aspects related to "policy issues and law," "ethical and moral issues," as well as discussions regarding "transportation planning" and "consumer behavior" that need to be addressed.

The advancement of technological innovations permeating the AV field is part of the dynamic relationship established between technology, business model, and market (Yun et al., 2016). In this sense, to establish business models for AV, it is first necessary to understand aspects related to "policy issues—law," "ethics/morals/liability," "transport planning," and "consumer behavior," because such areas will directly impact the business models to be created. In this, sense, this category points to the need to think about and elaborate new AV models and market standards.

Given the aspects discussed in each category and drawn in Figure 6, it is possible to outline four implications for the construction of AV business models:

1. The business model for AV is fluctuates among the five categories. There cannot be a rigid standard when defining business models, as the development of each category, over time, will yield better definitions that are still uncertain todayfor each of these categories. These definitions will, in turn, be incorporated into the AV business model.

2. There is a need to understand the convergent and divergent points among the five categories. This is because changes in one category can have both positive and negative effects in another category. For instance, public policy issues may be negatively correlated with ethical issues. On the other hand, transport planning issues can be positively correlated with consumer behavior issues, and so on. Understanding these relationships becomes a key factor in defining AV business models.

3. The complexity of business models in the AV field creates the need to establish interfaces between the five identified categories, since there should be negotiations between the various components of these categories as points of divergence/convergence may occur. For instance, the establishment of public policies needs to be negotiated in view of ethical

issues. On the other hand, transport planning needs to consider the human aspects involved in consumer behavior.

4. Consequently, there is a need to raise questions about the governance of these business models: (i) who will be responsible for bringing together these various interests, (ii) will it be the government's role to do the intermediation between the various public and private agents; (iii) whose will be the role of translating the desires of one player to another; or (iv) can we consider that governance will be defined as the various private initiatives are introduced on the market and, from there, a re-accommodation of the other players in the ecosystem to these changes will take place?

As such, the results of this research may include difficult-to-solve implications, but these will be answered from the perspective of B&M as pre-definitions in each of these categories and incorporated into AV business models.

5 CONCLUDING REMARKS

AVs stand out as a technological innovation that will translate the yearnings of a new era into our society. As the evolution of the AV study field is characterized as pluridisciplinary (Gandia et al., 2018), the first query conducted for this paper yielded more than 35,000 papers; however, when search parameters were refined for B&M categories, the query yielded significantly fewer works. This result might indicate a possible gap between the technological advances on R&D and its eventual market insertion and consolidation as business models play an extremely important role in the events that precede AV market introduction, according to Yun et al. (2016).

To reduce these uncertainties, this study identified five knowledge categories, implying a synergistic orientation among them, which contributes to the field’s disruptive appeal. It was observed that businesses models should be consumer oriented and also aligned with the society’s ethical and moral precepts, as well as with government policies for future transport planning. Namely, the automotive industry must understand the need to establish technological advances that do not neglect social impact over profitability. In the opposite direction, entities opposed to this advance should keep in mind that such technological evolution is inevitable, and they must make efforts to reconcile this advance, which required governmental support for balance.

Finally, many uncertainties permeate this research theme, and this study sought to identify the academic efforts that could result in a favorable advancement of the field.

Consequently, the joint evolution of the categories that permeate the AV field in B&M will likely determine a positive innovation result that will configure the future of our society in detriment of a disorderly advancement that can cause irreparable damage.

Regarding future studies, it would be interesting to carry out other integrative studies using different databases, specific journals in the B&M area, as well as studies that aim to update their present research to enable a comparison of the evolution of the theme in view of the rapid change of pace in both the AV and B&M research fields.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

REFERENCES

Adee, S. (2016) 'Who is in control', *New Scientist*. September 24 – 30. Issue 3092. pp.26.

Akram, H. (2015) '*Function of Business and Management Resea*rch' [online] https://www.linkedin. com/pulse/function-business-management-research-hamza-akram-msm-mba (accessed 9 July 2018).

Attias, D. (2017) 'The Autonomous Car, a Disruptive Business Model?. In *The Automobile* Revolution'. Chapter 7. pp. 99-113. Springer International Publishing. Gewerbestrasse - Switzerland.

Bimbraw, K. (2015) 'Autonomous cars: past, present and future a review of the developments in the last century, the present scenario and the expected future of autonomous vehicle technology', in *Informatics in Control, Automation and Robotics* (ICINCO), Vol. 1, pp.191–198, IEEE.

Botelho, L.L.R., Cunha, C.C.A. and Macedo, M. (2011) 'O método da revisão integrativa nos estudos organizacionais', *Gestão e Sociedade*, Vol. 5, No. 11, pp.121–136.

Brookhuis, K., de Waard, D. and Janssen, W. (2001) 'Behavioural impacts of advanced driver assistance systems – an overview', *European Journal of Transport and Infrastructure Research*, Vol. 1, No. 3, pp.245–253.

Chanaron, J. J. (2001) 'Innovating in intelligent automobile transportation: towards an industry-wide consortium?', *International Journal of Automotive Technology and Management*, Vol. 1, No. 2-3, pp. 358-368.

Chen, K., and Ervin, R.D. (1990) 'Intelligent vehicle-highway systems: US activities and policy issues', *Technological Forecasting and Social Change*, Vol. 38, No. 4, pp.363–374.

Christensen, C.M., Baumann, H., Ruggles, R. and Sadtler, T.M. (2006) 'Disruptive innovation for social change', *Harvard Business Review*, Vol. 84, No. 12, p.94.

Christensen, C. M., Bartman, T., & Van Bever, D. (2016). The hard truth about business model innovation. *MIT Sloan Management Review*, Vol. 58, Fall 2016 Issue, pp. 31.

de Winter, J., Happee, R., Martens, M.H. and Stanton, N.A. (2014) 'Effects of adaptive cruise control and highly automated driving on workload and situation awareness: a review of the empirical evidence', *Transportation Research Part F: Traffic Psychology and Behaviour*, Vol. 27, November 2014, pp.196–217.

Easterby-Smith, M., Thorpe, R., Jackson, P.R. (2008) '*Management Research'*, 3rd ed., Sage, London.

Enoch, M.P. (2015) 'How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport', *Technology Analysis & Strategic Management*, Vol. 27, No. 8, pp.910–924.

Fagnant, D.J. and Kockelman, K. (2015) 'Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations', *Trasponrtation Research Part A: Policy and Practice*, Vol. 77, July 2015, pp.167–181.

Fernandes, L.C., Souza, J.R., Pessin, G., Shinzato, P.Y., Sales, D., Mendes, C., Prado, M., Klaser, R., Magalhães, A.C., Hata, A., Pigatto, D., Branco, K.C., Grassi Jr., V., Osorio, F.S. and Wolf, D.F. (2014) 'CaRINA intelligent robotic car: architectural design and applications', *Journal of Systems Architecture*, Vol. 60, No. 4, pp.372–392.

Frazzoli, E., Dahleh, M.A. and Feron, E. (2002) 'Real-time motion planning for agile autonomous vehicles', *Journal of Guidance, Control, and Dynamics*, Vol. 25, No. 1, pp.116–129.

Gandia, R.M., Veroneze, R.B., Antonialli, F., Cavazza, B.H., Sugano, J.Y., Castro, C.C., Zambalde, A.L., Miranda Neto, A. and Nicolaï, I. (2017) 'The quintuple helix model and the

future of mobility: the case of autonomous vehicles', in *25th Gerpisa International Colloquium, R/Evolutions. New Technologies and Services in the Automotive Industry*, Paris.

Gandia, R.M., Antonialli, F., Cavazza, B.H., Neto, A.M., Lima, D.A.D., Sugano, J.Y., Nicolaï, I. and Zambalde, A.L. (2018) 'Autonomous vehicles: scientometric and bibliometric review', *Transport Reviews*, Vol. 38, Issue 1, pp.1–20.

Gasser, T.M. (2016) 'Fundamental and special legal questions for autonomous vehicles', in *Autonomous Driving: Technical, Legal and Social Aspects*, pp.523–551, Springer Berlin Heidelberg.

Geiger, A., Lenz, P. and Urtasun, R. (2012) 'Are we ready for autonomous driving? The KITTI vision benchmark suite', in *IEEE Conference on Computer Vision and Pattern Recognition* (CVPR), IEEE, June, pp.3354–3361.

Gerónimo, D., López, A.M., Sappa, A.D. and Graf, T. (2010) 'Survey of pedestrian detection for advanced driver assistance systems', *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 32, No. 7, pp.1239–1258.

Gogoll, J. and Müller, J.F. (2016) 'Autonomous cars: in favor of a mandatory ethics setting', *Science and Engineering Ethics*, Vol. 23. No. 3, pp.1–20.

González, D., Pérez, J., Milanés, V. and Nashashibi, F. (2016) 'A review of motion planning techniques for automated vehicles', *IEEE Transactions on Intelligent Transportation Systems*, Vol. 17, No. 4, pp.1135–1145.

Guerra, E. (2016) 'Planning for cars that drive themselves: metropolitan planning organizations, regional transportation plans, and autonomous vehicles', *Journal of Planning Education and Research*, Vol. 36, No. 2, pp.210–224.

Guizzo, E. (2011) 'How google's self-driving car works', *IEEE Spectrum Online*, Vol. 18, No. 7, pp. 1132-1141, 2011.

Hawes, N. (2016) *Driving the Revolution* [online] https://www.birmingham.ac.uk/news/thebirminghambrief/items/2016/11/driving-the-revolution.aspx (accessed 5 July 2018).

Hengstler, M., Enkel, E. and Duelli, S. (2016) 'Applied artificial intelligence and trust – the case of autonomous vehicles and medical assistance devices', *Technological Forecasting and Social Change*, Vol. 105, April 2016, pp.105–120.

Hevelke, A. and Nida-Rümelin, J. (2015) 'Responsibility for crashes of autonomous vehicles: an ethical analysis', *Science and Engineering Ethics*, Vol. 21, No. 3, pp.619–630.

Hohenberger, C., Spörrle, M. and Welpe, I.M. (2017) 'Not fearless, but self-enhanced: the effects of anxiety on the willingness to use autonomous cars depend on individual levels of self-enhancement', *Technological Forecasting and Social Change*, Vol. 116,March 2017, pp.40–52.

Hojnik, J. and Ruzzier, M. (2016) ‘What drives eco-innovation? A review of an emerging literature’, *Environmental Innovation and Societal Transitions*, Vol. 19,June 2016, pp.31–41.

Kompalla A., Geldmacher W., Just V. and Lange S. (2017) Tailored Automotive Business Strategies in the Context of Digitalization and Service-Oriented Models. *Quality Management*, Vol.18, Iss.156, pp.77-84.

Lima, D.A. and Pereira, G.A.S. (2013) ‘Navigation of an autonomous car using vector fields and the dynamic window approach’, *Journal of Control, Automation and Electrical Systems*, Vol. 24, Nos. 1–2, pp.106–116.

Lima, D.A. (2015) *Sensor-based Navigation Applied to Intelligent Electric Vehicles*, Doctoral thesis, Université De Technologie De Compiègne, Compiègne, France.

Lin, P. (2016) ‘Why ethics matters for autonomous cars’, in *Autonomous Driving: Technical, Legal and Social Aspects*, pp.69–85, Springer, Berlin, Heidelberg.

Lu, Z., Du, R., Dunham-Jones, E., Park, H. and Crittenden, J. (2017) ‘Data-enabled public preferences inform integration of autonomous vehicles with transit-oriented development in Atlanta’, *Cities*, Vol. 63, pp.118–127.

Martin, D. (2016) ‘Who should decide how machines make morally laden decisions?’, *Science and Engineering Ethics*, Vol. 23, No. 4, pp.1–17.

Milakis, D., Van Arem, B. and Van Wee, B. (2017) ‘Policy and society related implications of automated driving: a review of literature and directions for future research’, *Journal of Intelligent Transportation Systems*, Vol. 21, No. 4, pp.324–348.

Mladenovic, M.N. and McPherson, T. (2016) ‘Engineering social justice into traffic control for self-driving vehicles?’, *Science and Engineering Ethics*, Vol. 22, No. 4, pp.1131–1149.

Nascimento, S., Salvador, A. and Vilicic, F. (2017) ‘A era da autonomia’, Revista Veja, November, Vol. 2554, No. 44, pp.76–87.

Nikitas, A., Kougias, I., Alyavina, E. and Njoya Tchouamou, E. (2017) ‘How can autonomous and connected vehicles, electromobility, BRT, hyperloop, shared use mobility and mobility-as-a-service shape transport futures for the context of smart cities?’, *Urban Science*, Vol. 1, No. 4, p.36.

Ong, S. (2017) ‘Auto correct’, *New Scientist*. January 7, Issue 3107, pp. 36-39.

Piao, J. and McDonald, M. (2008) ‘Advanced driver assistance systems from autonomous to cooperative approach’. *Transport Reviews*. Vol. 28, No. 5, pp.659–684.

Poorsartep, M. (2014) ‘Self-driving cars: radical innovation in the transportation industry’, in *Transcultural Marketing for Incremental and Radical Innovation*, Chapter 5. pp.96–105, IGI Global.Hershey, Pennsylvania.

Remenyi, D., Williams, B., Money, A. and Swartz, E. (2003) Doing Research in Business and Management: An Introduction to Process and Method, 3rd ed., Sage, London.

SAE International (2016) *Surface vehicle recommended practice*: (R) Taxonomy and Definitionsfor Terms Related to Driving Automation Systems for On-Road Motor Vehicles, USA.

Schellekens, M. (2015) 'Self-driving cars and the chilling effect of liability law', *Computer Law & Security Review*, Vol. 31, No. 4, pp.506–517.

Schoitsch, E. (2016) 'Autonomous vehicles and automated driving status, perspectives and societal impact', *Information Technology, Society and Economy Strategic Cross-Influences* (IDIMT-2016) 24th Interdisciplinary Information Management Talks, Vol. 45, No. 1, pp.405–424.

Schreurs, M.A. and Steuwer, S.D. (2015) 'Autonomous driving – political, legal, social, and sustainability dimensions', in *Autonomous Driving: Technical, Legal and Social Aspects, pp.149–171, Springer, Berlin, Heidelberg.*

Shladover, S.E. (1995) 'Review of the state of development of advanced vehicle control systems (AVCS)', *Vehicle System Dynamics*, Vol. 24, Nos. 6–7, pp.551–595.

Shladover, S.E. (2005) 'Automated vehicles for highway operations (automated highway systems)', Proceedings of the Institution of Mechanical Engineers, Part I: *Journal of Systems and Control Engineering*, Vol. 219, No. 1, pp.53–75.

Stanton, N.A. and Young, M.S. (1998) 'Vehicle automation anddriving performance', *Ergonomics*, Vol. 41, No. 7, pp.1014–1028.

Sun, Z., Bebis, G. and Miller, R. (2006) 'On-road vehicle detection: a review', *IEEE Transactions on Pattern Analysis and Machine Intelligence*, Vol. 28, No. 5, pp.694–711.

Thomopoulos, N. and Givoni, M. (2015) 'The autonomous car – a blessing or a curse for the future of low carbon mobility? An exploration of likely vs. desirable outcomes', *European Journal of Futures Research,* Vol. 3, No. 1, p.14.

Tuominen, A. and Ahlqvist, T. (2010) 'Is the transport system becoming ubiquitous? Socio-technical roadmapping as a tool for integrating the development of transport policies and intelligent transport systems and services in Finland', *Technological Forecasting and Social Change*, Vol. 77, No. 1, pp.120–134.

Turner, J.D. and Austin, L. (2000) 'A review of current sensor technologies and applications within automotive and traffic control systems', *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering*, Vol. 214, No. 6, pp.589–614.

Vahidi, A. and Eskandarian, A. (2003) 'Research advances in intelligent collision avoidance and adaptive cruise control', *IEEE Transactions on Intelligent Transportation Systems*, Vol. 4, No. 3, pp.143–153.

Webb, J. (2007) ‘No driver required. What’s to stop us sitting back and letting the car drive itself?’, *New Scientist*. Editorial, pp.5.

Whittemore, R. and Knafl, K. (2005) ‘The integrative review: updated methodology’, *Journal of Advanced Nursing*, Vol. 52, No. 5, pp.546–553.

Woisetschläger, D.M. (2016) ‘Consumer perceptions of automated driving technologies: an examination of use cases and branding strategies’, in *Autonomous Driving: Technical, Legal and Social Aspects*, pp.687–706, Springer, Berlin, Heidelberg.

Wu, S.S. (2016) ‘Product liability issues in the US and associated risk management’, in *Autonomous Driving: Technical, Legal and Social Aspects*, pp.553–569, Springer, Berlin, Heidelberg.

Xiao, L. and Gao, F. (2010) ‘A comprehensive review of the development of adaptive cruise control systems’, *Vehicle System Dynamics*, Vol. 48, No. 10, pp.1167–1192.

Yun, J.J., Won, D., Jeong, E., Park, K., Yang, J. and Park, J. (2016) ‘The relationship between technology, business model, and market in autonomous car and intelligent robot industries’, *Technological Forecasting and Social Change*, Vol. 103,February 2016, pp.142–155.

Zakharenko, R. (2016) ‘Self-driving cars will change cities’, *Regional Science and Urban Economics*, Vol.61, pp.26-37.

Ziegler, J., Bender, P., Schreiber, M., Lategahn, H., Strauss, T., Stiller, C., Dang, T., Franke, U., Appenrodt, N., Keller, C., Kaus, E., Herrtwich, R., Rabe, C., Pfeiffer, D., Lindner, F., Stein, F., Erbs, F., Enzweiler, M., Knöppel, C., Hipp, J., Haueis, M., Trepte, M., Brenk, C., Tamke, A., Ghanaat, M., Braun, M., Joos, A., Fritz, H., Mock, H., Hein, M. and Zeeb, E. (2014) ‘Making bertha drive – an autonomous journey on a historic route’, *Intelligent Transportation Systems Magazine*, Vol. 6, No. 2, pp.8–20, IEEE.

ARTICLE 02 -Critical Success Factors for the insertion of Autonomous Vehicles as a Product Service System in a country

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ABSTRACT

This paper aimed at identifying the critical success factors (CSFs) and propose a theoretical model of the innovation radar for the insertion of autonomous vehicles (AVs) as a Product-Service System (PSS) in a country. The research design adopted in this study was characterized as empirical, of exploratory-descriptive in nature based on quantitative-qualitative analysis. In terms of nature, first, through a systematic literature review, it was possible to map the main CSFs for a country.From this gathering,it was developed questionnaires to filter key CSFs that could be usefull in AVs scope and context. The compilation resulted infour key dimensions that work like anchors: (1) Technology and Innovation, (2) Social and Political Environments (3) Consumer and Market, (4)Infrastructure and Patters. Among these anchors, was imbedded 12 factors of the innovation system that can serve as pursuit avenues. These outputs was transformed in inputs to a focus group that had as main purpose the organization and validation of CSFs in an Innovation Radar's framework. As a result, the proposition of a theoretical framework allowed the mapping of the innovative capacity of a country. Hence, the main contribution of this work is the integration of data and information from different sectors (social, political, economic, technological, and structural) of a given country, making it possible to map, discuss, and dive deeper on the real panorama for AVs' insertion.

1 INTRODUCTION

Autonomous Vehicles (AVs), also known as Automated Driving Systems (ADS), self-driving vehicles, driverless cars, and robotic cars, are vehicles that don't require any sort of conductor or teleoperation control (Frazzoli, Dahleh & Feron, 2002). These are considered an integral part of the new forms of mobility (Attias, 2016) and have become focus of many R&D projects of differents stakeholders such as governments, industries, universities, and other research centers.

Being considered by many authors as the greatest disruptive innovation in the automotive industry (Attias, 2016; Attias &Mira-Bonnardel, 2016; Enoch, 2015; Fagnant &Kockelman, 2015; Mutz et al., 2016; Poorsartep, 2014; Schellekens, 2015; Schreurs &Steuwer, 2015), AVs are belived as an important innovation that promises to have impacts on several spheres. Therefore, it is essential to comprehend these impacts in depth.

The fact is that there is a long way to go from the current concept of having / owning a vehicle - including here symbolic, instrumental and affective factors (Steg, 2005) to this new configuration with autonomous vehicles. In this sense, complementary trends in shared rides and vehicles may lead us from vehicles as a privately-owned asset to an on-demand service (Fagnant & Kockelman, 2015). In fact, with the emergence of issues related to Mobility as a Service (MAAS) it is consistent to think that the deployment of these vehicles will occur in a

model that combines a bundled offer of product and service, that is a Product-Service System (PSS) in order to provide value to society (Johnson &Mena, 2008).

When facing several changes that will occur from the insertion of AVs as PSS, specially regarding a macro scenario, it is essential to consider aspects according to specificities. The optimal AV future may differ depending on countries' patterns. However, there are basic standards that "*will need to be put in place across countries and potentially entire continents*" (KPMG, 2018, p.7). In this sense, to become a successful innovation, key aspects related to AVs must be considered, such as business, social, and legal system (KPMG, 2018; Sawhney,Wolcott& Arroniz, 2006).

These aspects could be understood as the essential factors or dimensions that must be prioritized to achieve tactical and strategic goals, even if other aspects are neglected (Rockart, 1979) and are known as "*Critical Success Factors*" (CSF). These represent areas, activities, and organizational processes that use the resources available to increase the competitiveness of a given product, service, or organization (Nascimento, 2016).

Considering a country as a specific type of organization, we understand that the first step to design innovations associated with new models and business for AVs as a PSS is to consider what the main features and aspects of this vehicle are in order to promote the insertion and adoption in a country and also the shift to unexplored markets.

It is important to highlight that, even though there is large and growing literature on CSFs, there is a gap about pratical guidelines to base effective projects and implementations in wider systems (King& Burgess, 2008). As an option to fill this gap, the literature points out that CSFs can be represented on the radar chart (Innovation Radar) as a way to promote a broad focus about dimensions and its aspects considering these as a system that operationalizes the innovating process (Sawhney, Wolcott & Arroniz, 2006).

Given the aforementioned, some questions emerged as guidelines to this work such as: What is the connection between AVs and technology, market, infrastructure, political, and social spheres? What are the key critical success factors for a country and how do they relate to each other? Which ones will be present on an innovation radar?

Thus, the general objective of this paper is to identify the critical success factors and propose a theoretical model of the innovation radar for the insertion of autonomous vehicles as a Product-Service System in a country.

Theories and concepts about the subject 'Disruptive Innovation' have been widely discussed in management literature, but not yet in terms of its implications for innovation

policy design. In fact, the insertion of AVs in a country has numerous technical and social implications that must be, at least, acknowledged by the authorities, police makers and also, academics and practitioners. In this context, this paper seeks to offer useful insides and data to enable appropriate policy responses to emerging innovation needs, trends, and phenomena (Selhofer et al., 2012).

It is worth emphasizing that the fields of studies in AVs are still incipient. A previous study by Gandia et al. (2018) published at Transport Reviews, shows that there is a growing demand on this topic over the years. From 2012 it was observed that the number of publications exceeded the trend line, showing an exponential growth of the field in recent years.

Although there is a predominance of sciences more related to the technical evolution of AVs, a growing presence of sciences that permeates AVs was noted. We believe that the maturity reached by the studies in the technical fields raised important questions about how this technology could be implemented in the market, which are the agents involved (government, industry, academia, civil society, and consumers) and what are the impacts and implications (social, economic, ethical, managerial, environmental, legal, political) that such vehicles will cause on urban mobility. Although there are studies related to business, economics, and management, there is a slight evolution of these domains related to AVs (Gandia et al., 2018).

2 THEORETICAL BACKGROUND

2.1 Managing Disruptive Innovation in countries

In his seminal work, *"The Innovator's Dilemma"*, Christensen (1997) states that disruptive technologies bring to market a very different value proposition than those previously available; which generally by being technologically straightforward, offer different packages of attributes that are not often considered important to mainstream customers.

When we start to analyze the disruptive innovation in a macro concept, considering its adoption and management in a country, it is necessary to consider some specificities. In fact, "*Christensen's framework has been widely discussed in management literature, but not yet in terms of its implications for innovation policy design*" (Selhofer et al., 2012, p.5). It's important to consider that governments and policy makers need to explore whether and how innovation policy should pay specific attention to disruptive innovation developments in order

to give policy responses properly to emerging innovation needs, trends, and phenomena (Selhofer et al., 2012).

Innovations in the automotive industry are usually guided by macro- and micro-environmental developments such as scarcity of raw materials, discussions on traffic growth, gas emissions and pollution, climate change, among others. This context makes the challenges of this sector exceed the technological level, also covering planning and logistics issues, as well as social and economic aspects (Selhofer et al., 2012; WEF, 2019).

In the technological scope, "*Information and communication technology (ICT) is a key enabler of innovation in the transport and logistics service industry*" (Selhofer et al., 2012, p.10). According to the Global Review of Innovation Policy Studies (p.10), there are 03 important innovation trends triggered by ICTs that must be considered by the governments and policy makers:

- **New e-services:** the integration of traditional services with new, innovative information services facilitated by the internet. However these enhanced services do not have a significant disruptive potential.
- **New players:** ICT has facilitated the market entry of a new intermediary: different types of transportation e-marketplaces. They may have a disruptive impact on several aspects of the industry; for instance, they tend to alter the role of traditional transport intermediaries (e.g. freight forwarders) and the relationships between these firms and other actors in the supply chain.
- **New alliances:** Another innovation resulting from the diffusion of ICT and web technologies is the formation of new types of alliances between third-party logistics providers (3PLs) and companies operating in other service sectors such as financial services, management consulting, and ICT vendors. Some of these alliances have given rise to the creation of a new category of service provider called fourth-party logistics provider (4PL). This can be seen as a disruptive trend in service provision and business models, as the 4PL model enables customers to outsource to a single organization the entire re-engineering of their supply chain processes.

In this sense, a strategic response for policy must address the cross-sectorial nature of disruptive innovations, as well as to manage some 'business case conflicts' – considering that desired and expected externalities from accelerating disruptive innovation deployment do not

coincide with the industry's business case as well as to anticipate unwanted side-effects of interventions and disruptive innovation in service sectors (Selhofer et al., 2012).

Considering current trends in major economies, especially in China, promoting the development of AVs is to be advised, in spite of the uncertainty. The risk of "backing the wrong horse" has to be weighed against the risk of losing competitiveness in the emerging technology (KPMG, 2018; Selhofer et al., 2012).

In fact, if innovation policy decides to support the insertion of AVs the best approach is therefore probably to encourage the move to 'mobility as a service'. This could have positive side-effects such as reducing emissions and freeing up parking space in cities. In order to better understand how this technology can be seen and used in the context of mobility as a service, the following topic addresses the main concepts and characteristics of AVs as a product service system.

2.2 Autonomous Vehicles as a Product Service System

By representing a potentially disruptive and beneficial change to the current transportation business model AVs are bound to change the future of urban mobility, and such transformation will not only affect the means of transport but society as a whole, in a sense that the traditional transport model (dominated by private cars, taxis, and buses) is likely to suffer an exponential decline in the coming years, giving rise to "intermediaries" means of transport – mostly designed in the form of shared vehicles (Attias, 2016; Enoch, 2015;Mutz et al., 2016; Schreurs & Steuwer, 2015).

Nevertheless, there are many issues that still need to be addressed such as the possible impacts of autonomous driving on mobility behaviors and human-machine interactions, as well as consumer acceptance, regulatory and liability frameworks (Schellekens, 2015; Schreurs & Steuwer, 2016). Therefore, due to their disruptive nature, AVs are likely to change the structure of cities (Zakharenko, 2016), however it is still complex to understand how life will be affected by this disruptive innovation in a sense that the timing, scale, and direction of the AVs' impacts are uncertain and the opportunities to influence investment decisions are limited (Guerra, 2016).

Thus, the traditional business model of selling cars as products is losing ground to alternative forms of commerce. As pointed out by Johnson and Mena (2008) manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer and more profitable business relationships.

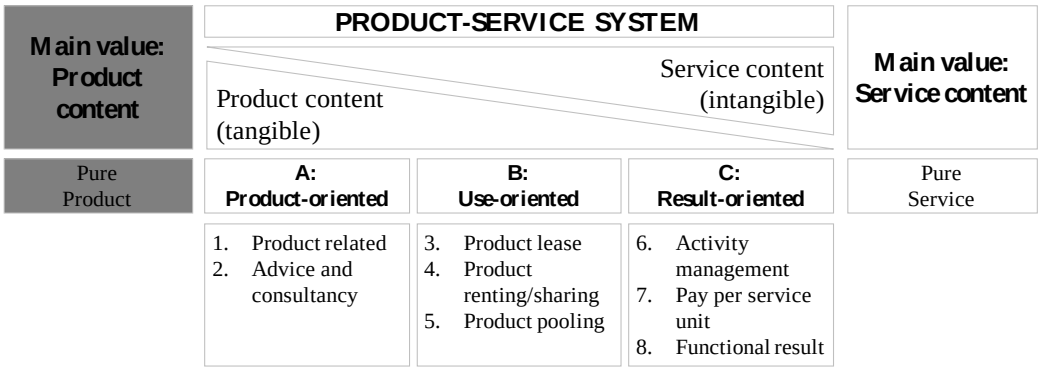
A Product-Service System (PSS) can be defined as consisting of tangible products and intangible services designed and combined with the aim of fulfilling users' needs or of a given function (Poulain, 2017; Tukker, 2004). In other words, PSS may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality and expected benefits (Manzini &Vezzoli, 2003; Wong, 2004).

Considering PSS as an integration of resources, skills, and knowledge (Kowalkowski, 2010), it is important to consider business model aspects to fit into these premises of this new approach based on customers, businesses, and the value chain (Barquet et al., 2013). In this sense, a business model in which cars are offered as services is gaining strength and it is being tackled by many companies and scholars. As Burns, Jordan and Scarborough (2013, p.101) stated: "*an analysis by Larry Burns, the former Vice President of GM, estimates 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*".

Schuh, Schittny, and Gaus (2009) highlight that the operations, strategy, and networks are success factors of a company and, in this sense, the business model is adequate to support the PSS. Here upon, considering that radical changes are characterizing the automotive industry (Schoitsch, 2016), as pointed out by Attias and Mira-Bonnardel (2016, p.69), it has been struggling to find the right positioning, in a sense that "*while cooperation with traditional players is necessary, OEMs find themselves obliged to form alliances with new entrants, often far removed from their core business*" such as Google, Uber, Apple, among other tech-companies.

Tukker (2004) drew a categorization of PSS by creating eight different types of Product-Service Systems that, according to the author, exist with quite diverging economic and environmental characteristics. As displayed on Figure 1, it can be noted that types of PSSs vary on a spectrum in which on one end the main value rests on product content (tangible) and on the other on service content (intangible).

Figure 1 - Categories of Product-Service Systems.



Source: Adapted from Tukker (2004, p.248).

There are three main categories of PSS within the spectrum (Tukker, 2004, p.248): the first one is product-oriented where the business model is still mainly geared towards sales of products, but some extra services are added; the second category is use-oriented**,** here the traditional product still plays a central role, but the business model is not geared towards selling products. The product is owned by the provider, and is made available in a different form, and sometimes shared by a number of users. Finally, the third category is result-oriented where the client and provider in principle agree on a result, and there is no pre-determined product involved.

Within each main category, there are PSSs with quite different characteristics, and based on Tukker's (2004, p.248-249) framework AVs as a PSS is likely to be positioned on the middle category, that is, use-oriented PSSs in which, according to the author, is composed of three different PSSs:

- **Product lease:** The provider has ownership, and is also often responsible for maintenance, repair, and control. The lessee pays a regular fee for the use of the product; in this case, normally he/she has unlimited and individual access to the leased product.
- **Product renting or sharing:** Here, the product in general is also owned by a provider, who is likewise responsible for maintenance, repair, and control. The user pays for the use of the product. The main difference to product leasing is, however, that the user does not have unlimited and individual access; others can use the product at other times. The same product is sequentially used by different users.
- **Product pooling:** This greatly resembles product renting or sharing. However, here there is a simultaneous use of the product.

Thus, it can be inferred that PSS represents a new sight to vehicles, building a context where different companies are involved in the transformation of resources into value beyond the product ownership. In this sense, considering more stakeholders, relationships and transactions are the mainstream in PSS (Vargo & Lusch, 2004).

Therefore, it can be considered that the AVs as a PSS is a disruptive innovation in terms that it represents an innovation in products, services, and business models that offer different solutions and alternatives to the market, and are mainly directed at non-traditional consumers and to an unmet need (Nogami& Veloso, 2017). Hence, AVs as PSS change social practices and ways of living, working, and interacting (Christensen, 2001).

AV as the PSS could arise as a promising business model (both in business and national contexts). In this sense, it is essential to establish and design which the most important aspects that must be observed are, that is, what would be the critical success factors for the insertion of these vehicles. The following topic addresses the main concepts found in the literature on CSF as well as presents a theoretical framework that can be used to organize and measure this kind of information.

2.3 Critical Success Factors and Innovation Radar

There are several definitions and concepts for the term Critical Success Factors (CSF) in the literature. Initially, Rockart (1979) states that CSF are the:

> "Limited number of areas in which results, if satisfactory, will ensure successful competitive performance for the organization. They are the few key areas where "things must go right" for the business to flourish. If results in these areas are not adequate, the organization's efforts for the period will be less than desired"(Rockart, 1979, p.9).

For Brotherton and Shaw (1996) CSFs can be understood as the essential aspects that must be achieved by an organization or areas that produce the greatest competitiveness. They are not goals, but actions or processes that can be controlled and affected by management to achieve organizational objectives. In addition, Grunert and Ellegard (1992) point out that these skills or resources explain most of the observable differences in perceived value and relative costs. So, one can consider CSFs as the areas, activities, or organizational processes that should be prioritized as "*one or more competitive factors that use the resources available to increase the competitiveness of an organization*" (Nascimento, 2016, p.36).

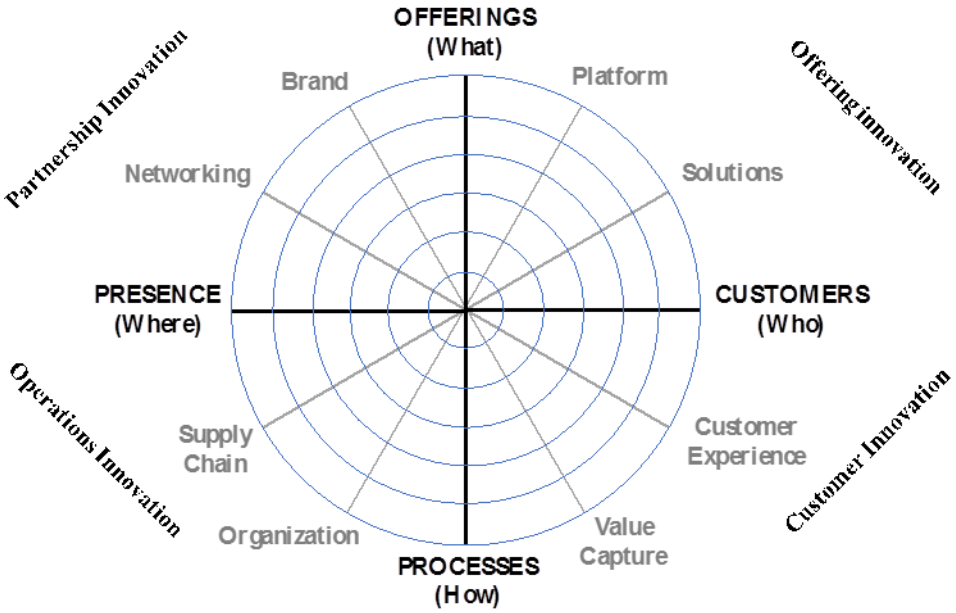
The identification of CSFs can be effective for 1) determining where management attention should be directed; 2) developing success measures; 3) identifying the key information as well as the main characteristics of an organization and thus limiting gathering unnecessary data, and 4) assisting the definition of knowledge and technologies essential for the survival and competitive advantage of the analyzed object (Colautoet al., 2004, Nascimento, 2016; Rockart, 1979).

Thinking about methods and measures for important aspects of an organization or country, an important tool to have disruptive products or services creating and delivering value is the Innovation Radar proposed by Sawhney, Wolcott and Arroniz (2006). According to the authors "*successful business innovation requires careful consideration of all aspects of a business*" and thus "*when innovating, a company must consider all dimensions of its business system*", p.36).

In this sense, there are three basic premises or characterizations related to business innovations: a) business Innovation is about the creation of new value (for customers and consequently for the firm), not new things; b) business Innovation can occur in any dimension of a business system; c) business innovation is systemic and requires careful consideration of all aspects of a business(Sawhney, Wolcott & Arroniz, 2006).

Starting from these three basic statements, the framework radar of innovation was proposed (Figure 2). It highlights 12 key dimensions for business innovation and explore the relation among them. The framework presents four key dimensions that work like a business anchor: (1) the offerings a company creates, (2) the customers it serves, (3) the processes it employs and, (4) the points of presence it uses to take its offerings to market. Between these four anchors, they embed eight other dimensions of the business system that can serve as avenues of pursuit (Sawhney, Wolcott & Arroniz, 2006;Sawhney & Chen, 2010).

Figure 2 - Innovation Radar.



Source: Adapted from Sawhney, Wolcott and Arroniz (2006).

Next, Table 1 presents a short description of all the 12 dimensions originally proposed by the authors:

Table 1 - Dimensions of the Innovation Radar.

Dimension	Definition	Examples
Offerings	Develop innovative new products or services.	Gillette Mach3Turbo razor / Apple iPod music player and iTunes music service
Platform	Use common components or building blocks to create derivative offerings.	General Motors OnStar telematics platform / Disney animated movies
Solutions	Create integrated and customized offerings that solve end-to-end customer problems.	UPS logistics services Supply Chain Solutions / DuPont Building Innovations for construction
Customers	Discover unmet customer needs or identify underserved customer segments.	Enterprise Rent-A-Car focus on replacement car renters / Green Mountain Energy focus on "green power"
Customer Experience	Redesign customer interactions across all touch points and all moments of contact.	Washington Mutual Occasio retail banking concept / Cabela's "store as entertainment experience"
Value Capture	Redefine how company gets paid or create innovative new revenue streams.	Google paid search / Blockbuster revenue-sharing with movie distributors
Processes	Redesign core operating processes to improve efficiency and effectiveness.	Toyota Production System for operations / General Electric Design for Six Sigma (DFSS)
Organization	Change form, function or activity scope of the firm.	Cisco partner-centric networked virtual organization / Procter & Gamble front-back hybrid organization for customer focus
Supply Chain	Think differently about sourcing and fulfillment.	Moen ProjectNet for collaborative design with suppliers / General Motors Celta use of integrated supply and online sales

Presence	Create new distribution channels or innovative points of presence, including the places where offerings can be bought or used by customers.	Starbucks music CD sales in coffee stores / Diebold RemoteTeller System for banking
Networking	Create network-centric intelligent and integrated offerings.	Otis Remote Elevator Monitoring service / Department of Defense Network Centric Warfare
Brand	Leverage a brand into new domains.	Virgin Group “branded venture capital” / Yahoo! as a lifestyle brand

Source: Sawhney, Wolcott and Arroniz (2006, p.76).

The Innovation Radar presents itself as a significant tool for discussing and structuring a field based on trends in a targeted way (Golovatchev,Kellmereit& Budde, 2008). However, while working on a holistic picture, Sawhney, Wolcott and Arroniz's (2006) proposal addresses broader issues in an organizational context and does not deal with aspects of heterogeneity in sectors, contexts, and objectives.

Thus, innovation being an indisputably relevant factor in the present era for all contexts, it is important to consider it beyond the local level, expanding the focus to regional as well as national aspects, as approached in the context of the European Union by De Prato, Nepelski and Piroli (2015). Thus, an Innovation Radar, as a way of guiding innovation, demands adaptations (Oliveira et al., 2014). As adapted from Mansell and When (1998), this study will focus on the national context for the development of an Innovation Radar.

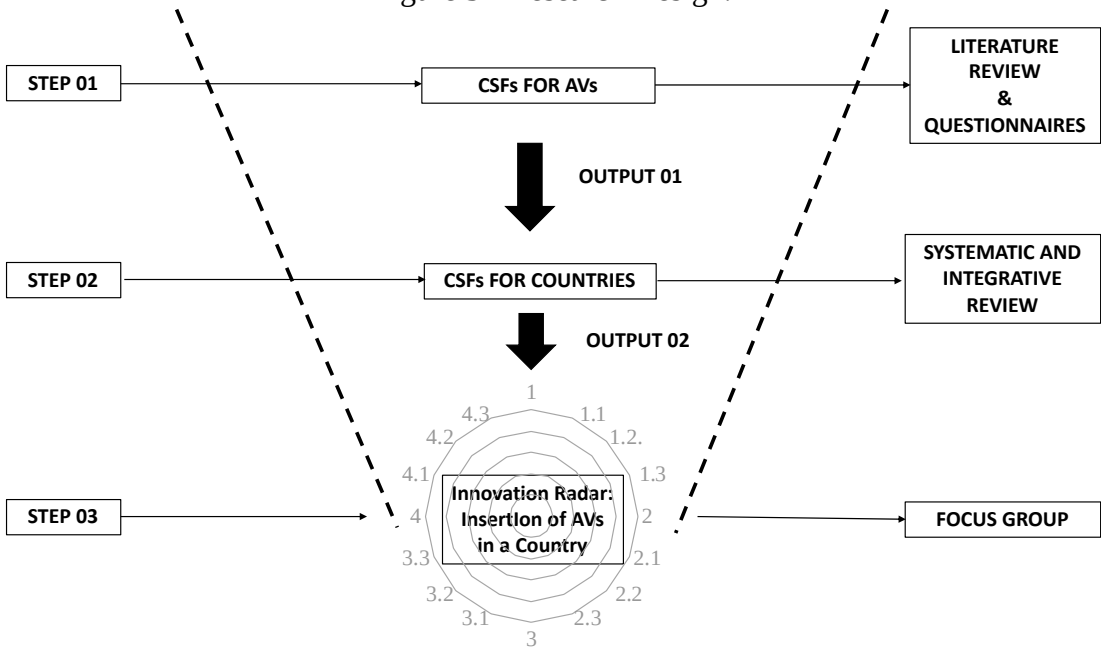
3 METHODOLOGY

With the aim of identifying the critical success factors and propose a theoretical model of the innovation radar for the insertion of Autonomous Vehicles as a Product-Service System in a country, this study adopted research design was characterized as empirical, quantitative-qualitative of exploratory-descriptive nature.

According to Gil (2008), it is exploratory because it seeks to identify the factors that determine or contribute to the occurrence of phenomena and due to the existence of few theoretical and empirical research in the field of AVs, especially in the study area of business and management (Cavazza et al., 2017; Gandia et al., 2018).

In terms of nature of the research, first, via a systematic literature review, it was possible to map the main CSF for a country found in the literature (descriptive), next, we used questionnaires as qualitative anchors to filter key CSF that could be used in AVs’ scope and context. Figure 3 details the research design adopted in this study.

Figure 3 - Research Design.



Source: Elaborated by the authors.

On **Step 01**, the data collection was firstly performed via secondary data, using academic literature and grey literature such as technical reports, news articles, magazines, documentaries (Cavazza et al., 2017; KPMG, 2018). Via this literature review it was possible to define key dimensions and to list a series of general CSFs that could fit the AVs scope. This data served as pre-defined categories of analysis to be used on the next step. Thus, we were able to select 18 factors that were organized in a questionnaire, containing their labels and a guideline, so that the respondents could rank them in order of importance from 0 (lowest importance) to 5 (highest importance). The methodological intent of the step 03 was to map and realize a general verification about CSFs that are closely relatedto the insertion of AVs as PSS in a country.

The questionnaires (Appendix I) were submitted to pre-tests with professors and doctoral students from Federal University of Lavras - Brazil before conducting the primary data collection. After this they were applied to experts in urban mobility at the 26th International Colloquium of Gerpisa from June 11th to June 14th 2018.

Next, all the questionnaires were tabulated in order to comprehend which CSFs are more and less important in terms of AVs as PSS. These outputs were transformed in an extra input to generate a matrix for data analysis and categorization.

On **Step 02** a systematic integrative review was developed to cover all the possible critical success factors (in a macro level) for countries found in the literature. The articles for the integrative review were searched on Web of Science (WoS) and Science Direct (SD) databases, in a single search, looking for articles published between, the very first year available in the databases - 1945 to 2018. For the search, the Boolean Operator "AND" was used and the following terms were selected in the title, abstract, and keywords of the articles: *critical_success_factor** and *country*.

The first stage of this search resulted in 352 articles (133 from WoS and 219 from SD). These were collected based on the filters: language (English), document type (articles, proceedings papers and review), categories (management, business, economics, econometrics, planning development, public administration, transportation, urban studies, transport science technology, environmental studies, environmental sciences, multidisciplinary sciences, social sciences interdisciplinary, and political science). As a result, 154 articles were selected and, of these, 30 duplicate and unavailable articles were excluded.

With a sample of 124 articles, a scope analysis to verify the CSFs listed in each one was performed. The goal was to select articles with CSFs related to the context of countries rather than firms. Doing this, as final sample, 36 articles were selected and these were organized in a content matrix to be analyzed in terms of title, journal, type of publication, author, year, country, CFSs, CSFs' categories, and general observation.

On **Step 03** another round of information acquisition was performed in order to validate the outputs of the previous analysis and to cross check them with the ones identified via the questionnaires. Using this set of information, we were able to conduct a focus group with professors and doctoral students from the Terrestrial Mobility Laboratory from Federal University of Lavras – Brazil. With the focus group, it was expected to validate the categories previously established according to the questionnaires and the integrative review. As result from the focus group we were able to design a theoretical framework for the innovation radar in the context of AVs as PSS.

It is important to highlight that, similar to the application made by Sawhney, Wolcott, and Arroniz (2006) where the authors based the definition of the radar on interviews and academic review, this paper used the stages related to the data collection as fundamental basis for the definition of the Innovation Radar.

4 RESULTS AND DISCUSSION: THE FRAMEWORK

As mentioned in the methodological steps, using the secondary data obtained through a literature review we were able to define 4 key dimensions that served as categories of analysis and guidelines. These dimensions are: 1) infrastructure and patterns; 2) social and political environment; 3) consumer and market and, 4) technology and innovation.

Next, we were able to list a series of CSFs (platform, solutions, customer experience, value capture, organization, supply chain, networking, brand, public polices, technology and innovation, infrastructure, consumer acceptance, sustainability, ethics & moral, transport planning, cybersecurity, law & liability, and partnerships) that composed the questionnaire. The main objective of that step was to test and filter these factors so that we could reach a final list of CSFs that were strictly aligned with the scope of the AVs.

As for the outputs of the query, 37 responses were obtained, being these from 8 different countries: U.S.A (1), Norway(1), Germany(1), England(1), Colombia(1), Mexico(2), France(7) and Brazil(23). At the end of this phase, we had 4 dimensios and a final set of 12 CSFs.

In order to refine and to align the CSFs with the national context, a systematic and integrative review was carried out. Analyzing the 36 selected articles, all the indicators found in the search[2] that could be relate to our scope were identified and distributed into the key dimensions and their corresponding CSFs (Table 2).

[2] The numbers in front of each indicator correspond to the article identification

Table 2 - CSFs for the Innovation Radar.

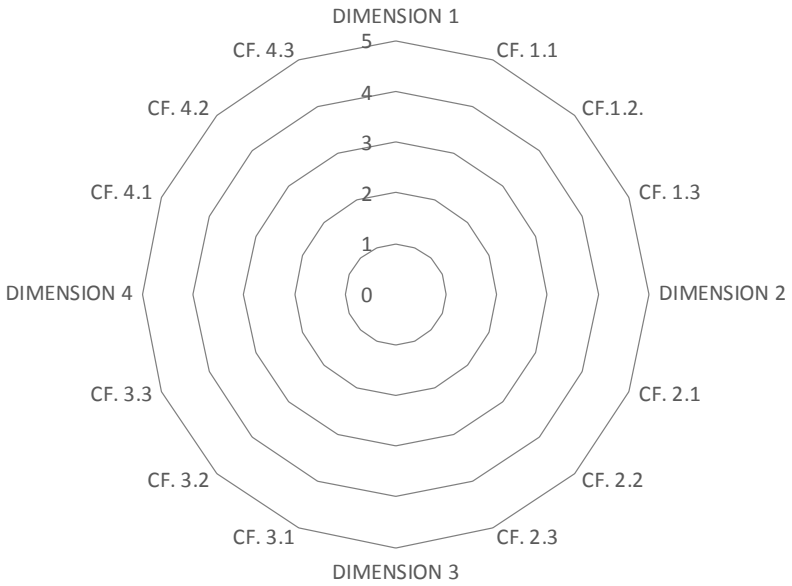
KEY DIMENSIONS	INDICATORS FOUND IN THE LITERATURE	CRITICAL SUCCESS FACTORS	INDICATORS FOUND IN THE LITERATURE
INFRASTRUCTURE AND PATTERNS	Structure (Soltanzadeh, et al 2014).	**CITIES INFRASTRUCTURE**	**Country Infrastructure Standarts** (Al-Kaabi, 2010)
		ROADS INFRASTRUCTURE	**Physical infrastructure**(Pfoser, Treiblmaier, & Schauer, 2016)
		MOBILITY AND TRANSPORT PLANNING	**Sophisticated planning**(Pfoser, Treiblmaier, & Schauer, 2016)
SOCIAL AND POLITICAL ENVIROMENT	Policy based factor (Soltanzadeh, et al 2014); External Enviromental (29); Legal and Governance Eviroment (32)	**PUBLIC POLICES**	**Internal political** (Al-Kaabi, 2010);**governement investment** (KMPG); **Government vision & strategy** (Al-Kaabi, 2010);**Governement Guarantee** (Chan et al, 2010); **strong governemnt support**(Chan et al, 2010); **Stable and transparent political / social situation**(Chan et al, 2010); **Stable political and social enviroment**(Chou & Pramudawardhani, 2015); **Judicious Government control**(Chou &Pramudawardhani, 2015); **Pressures from governments**(Gopal & Thakkar 2016); **The role of government** (Kifle et al, 2004);**political support**(Osei-Kyei & Chan,2015); **goverment providing guarantees**(Osei-Kyei & Chan,2015) (Osei-Kyei & Chan 2017); **political stability**(Osei-Kyei & Chan,2015) (Osei-Kyei & Chan 2017); **well organize and comitted public agency**(Osei-Kyei & Chan,2015) (Osei-Kyei & Chan 2017); **good governance**(Osei-Kyei & Chan,2015); **strong governmnet comittement and support** (21); **Political/Government support**(20); **Government providing financial support**(Osei-Kyei & Chan 2017); **governement responsiveness to business** (32)
		ETHICAL & MORAL	**Cultural Background** (Calebrese et al, 2014); **culture** (Syed et al, 2018); **social cultural** (36)
		LAW & LIABILITY	**Legal framework by government**(Gopal & Thakkar 2016); **favorable legal framework**(Osei-Kyei & Chan,2015); **Favourable legaland regulatory framework** (Osei-Kyei & Chan 2017); **legal / political framework**(Pfoser, Treiblmaier, & Schauer, 2016); **law and regulation** (Soltanzadeh, et al 2014); **legal requirements related to data protection** (27)
CONSUMER AND MARKET	Market (Soltanzadeh, et al 2014).	**MACROECONOMIC ENVIROMENT**	**Macroeconomic Enviroment** (Chou & Pramudawardhani, 2015)(Osei-Kyei & Chan,2015)(32)/ **sound economic policy**(Osei-Kyei &Chan,2015) (Osei-Kyei & Chan 2017); **Stable macroeconomic indicators**Osei-Kyei & Chan 2017); **economic viability**(Zhang,2005); **economic** (Zhang,2005)
		CONSUMER BEHAVIOR	**Pressures from consumers**(Gopal & Thakkar 2016); **public/community support** (Osei-Kyei & Chan,2015); trust (Osei-Kyei & Chan,2015); **Public/Community support**(Osei-Kyei & Chan 2017); **High level of enthusiasm and willingness(**Osei-Kyei & Chan 2017);**strong community supoort and relationship** (Osei-Kyei & Chan 2017)**awareness / mental shift**(Pfoser, Treiblmaier, & Schauer, 2016); **end user involviment**(Standing & Cripps 2015); **custumer** (28); **enlisting custumer and stakeholder support-involvement**(Syed et al, 2018)
		STAKEHOLDERS RELATIONSHIPS	**Stakeholder involviment**(8) (Standing & Cripps 2015); **Networking; Stakeholder relationship and communication**(Cepeda, Sohail & Ogunlowo 2018**); good partners'relationship** (Chan et al, 2010); Supply **chain integration**(Gopal & Thakkar 2016); **customer and supplier relationships**(Gopal & Thakkar 2016); **role of stakeholders**(Gopal & Thakkar 2016); **foreign alliances** (Kifle et al, 2004); **Higher instituins** (Kifle et al, 2004);**strong private consortium** (Osei-Kyei & Chan,2015; 2017); **Clarity of roles and responsibilities** (Osei-Kyei & Chan 2017);**Transparent PPP process**(Osei-Kyei & Chan 2017); **Clear goals and mutual benefit objectives**(Osei-Kyei & Chan 2017); **Enlisting custumer and stakeholder support-involvement**(Syed et al, 2018)
TECHNOLOGY AND	Technology (Soltanzadeh, et al	**IT STANDARTS (Hardware and Software)**	**Country IT Standarts** (Al-Kaabi, 2010); consideration of IT infrastructure (Standing & Cripps, 2015); **ICT infrastructure**(Syed et al, 2018); **IT hardware infrastructure**(Yang, Zheng, & Huang 2012)

INNOVATION	2014); Technological (Ziembra et al, 2015)	**TECHNOLOGICAL CAPABILITY**	Technology (Al-Kaabi, 2010);; technology transfer (Chan et al, 2010); (Osei-Kyei & Chan 2017); IT leadership (Nfuka & Rusu 2011); engage key stakeholders (Nfuka & Rusu 2011); technology innovation (Osei-Kyei & Chan,2015); Technology innovation(Osei-Kyei & Chan 2017);ICT/ITS Technologies(Pfoser, Treiblmaier, & Schauer, 2016); innovation (Rocha et al, 2012)
		DATA MANAGEMENT $ SECURITY	Data management(Azimi & Manesh 2012)

Source: Elaborated by the authors

The next step was to validate the CSFs and insert these in the Innovation Radar framework based on the pluridisciplinary knowledge. For this, we conduct a focus group composed by six participants from several areas of knowledge such as business, production engineering, mechanical engineering, and, systems engineering and computing. Each participant received two documents to guide the meeting: i) a chart in which each CSF was described, and ii) a basic framework of the Innovation Radar that should be completed (Figure 4) considering the individual's knowledge.

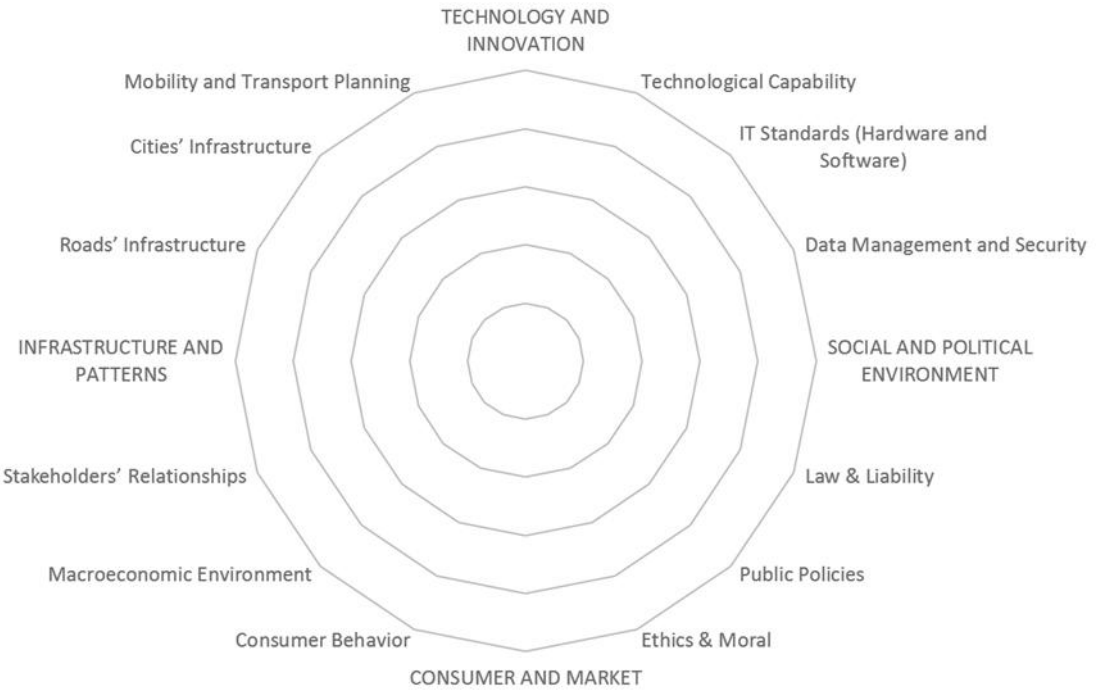
Figure 4 -Basic Framework for the Innovation Radar.



Source: Elaborated by the authors.

After a conducted discussion, the focus group resulted in the definition of the CSFs disposed in the Innovation Radar for the insertion of AVs as PSS in a country. The framework is represented in the Figure 5.

Figure 5 - Innovation Radar for the Insertion of AVs as PSS in a Country.



Source: Elaborated by the authors.

The CSFs allocated in the Innovation Radar for the insertion of AVs as PSS in a country is discussed based on the qualitative analysis from focus group and in the previous steps.

Technology and Innovation: in knowledge-based economy, technology is an important resource to create innovation. In this sense, considering technological assets and requirements, it is fundamental to pay attention to policies and patterns in order to achieve the goals and benefit society. The main aspect related to this dimension's CSFs is competences and creation of standards of certification and homologation as a source of the perfect functioning of AVs as PSS (Al-Kaabi, 2010; Azimi& Manesh, 2012; Cavazza et al., 2017; KPMG, 2018; Rocha et al., 2012; Soltanzadeh, Taghavifard &Sahebjamnia, 2014).

- Technological capability: it is referred to technology knowledge and competences, technology transfer, IT leadership, technology innovation and ICT/ITS technologies related with hardware, software systems, specific management processes, standards and policies. The intent is to create, arrange, and offer technology to AVs as PSS.

- IT standards (hardware and software): considering that in these related equipment and data systems to PSS, So, IT standards for hardware and software must be

developed as a way to guarantee the PSS's function. This function is referred to the automated system inserted into AVs, the AV itself, the intelligence of cities and roads, and others that must be certified and regulated.

- Data management and security: quality and standard are some aspects related to data sharing and exchanging. However, considering the existence of different stakeholders in the new era, to create, improve, and to ensure a PSS is essential to implement management systems in order to provide data security and protection. Specially in terms of confidentiality, integrity, availability, and authenticity of the information.

Reported as an important source of prosperity creation and sustainability, innovative capacity, when related to AVs, refers to knowledge and competences in information and communication technologies (ICTs). ICTs base innovation on technical and market aspects. In this sense, political actions should encourage technological solutions as a means of promoting benefits to society as a whole (Selhofer et al., 2012).

Related to ICTs and AVs as PSS are the data. Much of this revolution involves the collection and use of mobility data. These need to be managed as a way to ensure user and provider security. Thus, policies need to consider the specificities and include in their projects questions of ownership, responsibility, and privacy (KPMG, 2018).

Guiding questions may be in the sense of: Who owns the data? What warranty is offered for cyber attacks? How is data privacy worked out? How is it used as a way to improve transport demand?"(BCG, 2016).

4.1 Social and Political Environment: the presence of different stakeholders increases the complexity of a system. In this sense, it is essential to manage questions related to the social context and to the political context. Political support, social support, and governance are needed to determine legal and political conditions and are indispensable to establish a functional PSS (Al-Kaabi, 2010; Cavazza et al., 2017; Chou & Pramudawardhani, 2015; Gopal &Thakkar, 2016; KPMG, 2018; Osei-Kyei & Chan, 2017; Soltanzadeh, Taghavifard &Sahebjamnia, 2014; Syed et al., 2018).These aspects are translated into CSFs:

- Law and liability: harmonized regulations are essential for the functioning of AVs as PSS. Specific laws must be structured in order to address legal issues and promote a favorable legal framework. One of these issues is liability that needs to be clear. Other aspects are services agreements, data sharing, relation between the stakeholders. Basically, legal framework is a fundamental source of security in the new context promoted by the PSS.

- Public policies: government has a fundamental role in regulating and standardizing structure needed. Public policies are related to governmental practices that work as guidelines to promote a regulation's environment to support the implementation of AVs as PSS successfully, such as economic incentives and tax advantages. An important example of necessary public policies is related to certification and homologation. Governments should treat public policies as a crucial strategy's asset that ensures the attractiveness to investors to the economy and improve competitiveness.
- Ethics and moral: considering the culture as the background that is related to a value system based on shared norms and beliefs that are differentiate in contextual terms, ethics and moral must be guaranteed as a way to offer trust and benefits including aspects as privacy, inclusion, and accessibility.

Policymakers are aware of the benefits and impacts of AVs. The US Department of Transportation, for example, has promoted a program to rescue ideas about easy, dependable, and safe transportation. Sweden has been working on innovation strategies in business models. Germany and Finland worked on legal issues regarding AV testing. However, there is still a need to include AV issues in legal planning, as it has been done in Austria, France, the Netherlands, the United Kingdom and the USA (BCG, 2016).

Policy and social implications related to AVs as PSS are very broad and demand urgency in the formulation of policies to ensure a future of maximization of benefits. The related legislation should include adaptations related to, for example, ownership, responsibility, documentation, traffic laws, and issues (KPMG, 2018).

4.2Consumer and Market: market is an aspect that is embedded by several factors because it is related to many and different stakeholders, whichi s complex because these have different goals and activities. The main ideas are: stakeholders need to be managed, macroeconomic objectives must be aligned in order to develop a viable and attractive environment, and the cultural background must be considered in strategies to promote and improve consumers' behavior that benefit the project of the insertion of AVs as PSS (Cavazza et al., 2017; Gopal& Thakkar, 2016; KPMG, 2018; Osei-Kyei & Chan, 2017; Pfoser,Treiblmaier &Schauer, 2016; Soltanzadeh, Taghavifard & Sahebjamnia, 2014; Syed et al., 2018).

- Stakeholders' relationships: in a national context there is a broader stakeholders' involvement because the extent of projects demands different partnerships among them:

public sector, private sector, society, and academy. Thus, stakeholders, its relationships, and its management must be included in the scope of the different governance variation as a source of success.

- Macroeconomic market: based on the idea of a stable macroeconomic condition, the literature pointed out that it is related to economic policy and favorable legal framework as a way to designate an appropriate risk allocation and sharing providing sources of benefits for multiple objectives characterizing the environment as available in financial terms and, doing so, transforming the project of implementation of AVs as economically viable.
- Consumer behavior: related to the consumer's openness (willingness to riding a car without a driver and / or share a car with other people, mental shift, and trust), this CSF considers the acceptance and understanding of AVs as PSS by the public community either through the media, civil societies, non-governmental organizations as a way to ensure the progress and success of the project.

Suppliers, OEMs, technology companies, mobility providers, research institutions, regulators, and governments are already studying and working on issues related to AVs. Tests, programs, and goals announce that a future where AVs are moving on roads - which would seem like a distant future - may already become a reality in years. Dubai, for example, has already announced a project where, by 2030, 25% of travelling will be in vehicles without a driver (BCG, 2016).

However, it is vital that projects like this one in Dubai, faced with numerous related factors, consider consumer acceptance, as these are specific and varied. As an example, Asia, the continent where the largest cities in the world are located, there are the most prepared consumers for the disruptive innovation of AVs. 85% of Indian consumers and 75% of Chinese consumers consider themselves able to ride on AVs. However, it must be considered that its traffic conditions and infrastructure are more precarious and there is a high accident rate. Thus, the expectation of benefits turns out to be greater. On the other hand, consumers from Japan (36%), the Netherlands (41%) and Germany (44%) are more reluctant (BCG, 2016). Thus, it is essential that the conditions are treated as specific and are studied in depth in order to benefit social, economic, environmental, and market aspects.

4.3 Infrastructure and Patterns: AV as a PSS will connect with its surrounding ecosystem and infrastructure, that is: other transportation models, users' devices and other systems and services. In this sense, considering that changes and adaptations in different aspects of

infrastructure will be necessary for the operation of AVs, countries must pay attention in physical and technological patterns to supply the new demands. The core premise related to this dimension's CSFs is necessary to develop a systems' network (Al-Kaabi, 2010; Cavazza et al., 2017; KPMG, 2018; Pfoser, Treiblmaier & Schauer, 2016; Soltanzadeh, Taghavifard & Sahebjamnia, 2014).

- Roads' infrastructure: one of the basics prerequisites for AVs' operation is the existence of a connected environment. Roads must be prepared to offer data for the intelligent systems inserted on AVs.
- Cities' infrastructure: based on the same idea of roads, cities must offer an intelligent context (smart cities) by building structures for transport flows based on synchro modal streams. AVs as a PSS will play a fundamental role in the context of a smart city and, within this context, the interaction with the infrastructure and other modes of transport can not only make the last mile typology but also the typologies involving cargo transport something very attractive for the users.
- Mobility and transport planning: it is essential to plan transport and mobility based on a dynamic and integrated view. To do this, transport routes must be simulated in order to create synchro modal transport network considering customer's preferences, routes and available resources from data to ways of transport.

Changes related to AVs, in terms of infrastructure, include physical issues as well as business issues. With regard to business, changes in the business models of public transportation, parking, vehicle sharing, among others, are involved. Physical issues refer to changes in cities, roads, highways, road signs and other structural factors. Thus, focus on planning and investment in infrastructure as a means of directing adequate efforts and ensuring delivery of benefits to society becomes paramount (KPMG, 2018).

The BCG report (2016) stresses that one of the UN's sustainable development goals is to transform cities into spaces of inclusion, security, flexibility, and sustainability. In this sense, policymakers should study local issues and other specificities to determine investments in infrastructure and standardization considering technologies for the operation and management of intelligent ecosystems. Thus, it is argued that approaches must be forward-looking in order to ensure an adequate mobility strategy (WEF, 2019).

5 CONCLUDING REMARKS

The development of AVs is considered as an important innovation that promises to have great impact on the issues of urban mobility and on several spheres. In fact, discussions about AVs show that these are embedded in the most significant historical change to the automobile and transportation industry, which have impacts to the whole society.

Complementary trends are related to business models that are given in the sense of transforming the car into service as well as product. This perspective is referred to PSS that has as main premise to offer solutions by sales that involves both a product and a service element. Thus, the delivery is about functionality and expected benefits.

However, considering the role of innovations for a country's competitiveness, for the AVs, as a radical innovation to become a successful project, there are some key aspects to be considered and prioritized, such as the market, technology, social, political and legal system. These aspects, in this work, are associated with critical success factors and are represented in the form of a radar framework, divided into dimensions and factors.

The literature review, the questionnaires, the integrative review, and the focus group were used to identify the critical success factors and propose a theoretical model of the innovation radar for the insertion of autonomous vehicles as a product service system in a given country. Each methodology's stage was used as input to the next one and provided reliability and validity to the research.

We identified 4 key dimensions of the Innovation Radar e 12 related CSFs: i) **Technology and Innovation:** related to Technological Capability, IT Standards (Hardware and Software), and Data Management and Security; ii) **Social and Political Environment**: related to Law & Liability, Public Policies, and Ethics & Moral; iii) **Consumer and Market:** composed for consumer behavior, macroeconomic environment and stakeholders' relationships and, iv) **Infrastructure and Patterns**: composed by factors related to roads infrastructure, cities infrastructure, and mobility and transport.

We sought to fill a gap in the literature, related to the definition, adequacy and application of an artifact to support the insertion and management of a disruptive innovation in a country. Finally, there is a proposal for methodological advancement, associated to critical success factors, with an empirical approach and easy adaptation and application around the world. A radar framework to identify CSF to be used in order to contribute to processes related to innovative capacity, governance and market reach efficiency and effectiveness in the current and real context of the countries.

`Given that CSFs are the essential aspects that must be achieved by an organization or areas that produce the greatest competitiveness (Brotherton& Shaw, 1996) we suggest that the Radar of Innovation proposed in this paper can contribute to the process of insertion of AVs as PSS in a country considering that the CSFs identified can guideactions and projects. From the operationalization of the CSFs arranged in the Radar of Innovation, it is possible to determine priorities. However, it is important that stakeholders' actions are aligned as a way to ensure that basic market demands, public policies, legal and social issues are supported.

As for research limitations, we point out the novelty and complexity of the theme, in a sense that since AVs are not yet a reality in the market, carrying out research on the topic is challenging due to lack of information as well as due to high speculations. Also noteworthy is the difficulty in obtaining answers to the questionnaires and contact people involved in the industry, since discussions regarding AVs in the business environment are still mainly being kept confidential, therefore we were not able to get as many answers as we desired.

As future studies, the next step is to fulfill the Radar considering points of view from different stakeholders from different countries. This will ensure de validity of the identified CSFs.

REFERENCES

Al-Kaabi, R. (2010). Critical success factors of egovernment: A proposal model for e-Government implementation in Kingdom of Bahrain. *Proceeding of the 6th International Conference one-Government (ICEG)*, 1-9.

Al-Fadhli, S. (1970). Critical success factors influencing E-Commerce in Kuwait. *The Journal of Internet Banking and Commerce*, *16*(1), 1-7.

Attias, D. (2016). *The Automobile Revolution: Towards a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Attias, D., &Mira-Bonnardel, S. (2016). Extending the Scope of Partnerships in the Automotive Industry Between Competition and Cooperaiton. In: Attias, D. (2016). *The Automobile Revolution: Towards a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Azimi, A., & Manesh, F. S. (2012). A New Model to Identify and Evaluate Critical Success Factors in the IT Projects; Case Study: Using RFID Technology in" Iranian Fuel Distribution System". *International Journal of Information Science and Management (IJISM)*, 99-112.

Barquet, A. P. B., de Oliveira, M. G., Amigo, C. R., Cunha, V. P., & Rozenfeld, H. (2013). Employing the business model concept to support the adoption of product–service systems (PSS). *Industrial Marketing Management*, *42*(5), 693-704.

BCG. Self-Driving Vehicles, Robo-Taxis, and the Urban Mobility Revolution. The Boston Consulting Group and the World Economic Forum. 2016. From: https://www.bcg.com/pt-br/publications/2016/automotive-public-sector-self-driving-vehicles-robo-taxis-urban-mobility-revolution.aspx.

Brotherton, B., & Shaw, J. (1996). Towards an identification and classification of critical success factors in UK hotels plc. *International journal of hospitality management*, *15*(2), 113-135.

Burns, L., Jordan, W. & Scarborough, B., (2013). *Transforming personal mobility*, Broadway NY: Columbia University.

Calabrese, A., Capece, G., Di Pillo, F., & Martino, F. (2014). Cultural adaptation of web design services as critical success factor for business excellence: A cross-cultural study of Portuguese, Brazilian, Angolan and Macanese web sites. *Cross Cultural Management*, *21*(2), 172-190.

Cavazza, B. H., Gandia, R. M., Antonialli, F., Nicolaï, I., Zambalde, A. L., Sugano, J. Y., Miranda Neto, A. (2017). Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. *Proceedings of the European Conference on Innovation and Entrepreneurship*, [ECIE]. Paris, France, 12.

Cepeda, D. M., Sohail, M., & Ogunlowo, O. O. (2018). Understanding the critical success factors for delivery of megaprojects in Colombia. *Proceedings of the Institution of Civil Engineers-Management, Procurement and Law*, *171*(2), 45-57.

Chan, A. P., Lam, P. T., Chan, D. W., Cheung, E., & Ke, Y. (2010). Critical success factors for PPPs in infrastructure developments: Chinese perspective. *Journal of Construction Engineering and Management*, *136*(5), 484-494.

Chou, J. S., & Pramudawardhani, D. (2015). Cross-country comparisons of key drivers, critical success factors and risk allocation for public-private partnership projects. *International Journal of Project Management*, *33*(5), 1136-1150.

Christensen, C. M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Boston: Harvard Business School Press.

Christensen, C. M. (2001). The past and future of competitive advantage. *Sloan Management Review*, *42*(2), 105–109.

Colauto, D., Gonçalves, C. M., Beuren, I., & Santos, N. (2004). Os fatores críticos de sucesso como suporte ao sistema de inteligência competitiva: o caso de uma empresa brasileira. RAM. *Revista de Administração Mackenzie*, *5*(2).

De Prato, G., Nepelski, D., & Piroli, G. (2015). Innovation radar: identifying innovations and innovators with high potential in ICT FP7, CIP & H2020 projects. *Seville: JRC-IPTS*.

Enoch, M. P. (2015). How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport. *Technology Analysis & Strategic Management*, *27*(8), 910-924.

Fagnant, D. J., Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Trasponrtation Research Part A: Policy and Practice, 77,* 167-181.

Frazzoli, E., Dahleh, M. A., Feron, E. (2002). Real-time motion planning for agile autonomous vehicles. *Journal of Guidance, Control, and Dynamics*, *25*(1), 116-129.

Gandia, R. M., Antonialli, F., Cavazza, B. H., Neto, A. M., Lima, D. A. D., Sugano, J. Y., Nicolaï, I. & Zambalde, A. L. (2018). Autonomous vehicles: scientometric and bibliometric review. *Transport Reviews*, 38, 1-20.

Gil, A. C. (2008). Métodos e técnicas de pesquisa social. 6. ed. Editora Atlas SA.

Golovatchev, J., Kellmereit, D., &Budde, O. (2008, September). Innovation radar-a strategic approach for an innovation development and profitable launch of new product and services. In *Management of Innovation and Technology, 2008. ICMIT 2008. 4th IEEE International Conference on* (pp. 993-996). IEEE.

Gopal, P. R. C., & Thakkar, J. (2016). Analysing critical success factors to implement sustainable supply chain practices in Indian automobile industry: a case study. *Production Planning & Control*, *27*(12), 1005-1018.

Grunert, K. G., &Ellegaard, C. (1992). The concept of key success factors: theory and method (pp. 1-28). MAPP.

Guerra, E. (2016). Planning for cars that drive themselves: Metropolitan Planning Organizations, regional transportation plans, and autonomous vehicles. *Journal of Planning Education and Research*, *36*(2), 210-224.

Johnson, M., Mena, C. (2008). Supply Chain Management for Servitized Products: a multi-industry case study. *International Journal of Production Economics, 114*(1), 27-39.

Kifle, M., Solomon, A., Okoli, C., & Mbarika, V. (2004). Critical success factors for telemedicine in Ethiopia. In *International Conference IT Management in Healthcare', In Information Resources Management Association (IRMA 2004). International Conference, New Orleans*.

King, S. F., & Burgess, T. F. (2008). Understanding success and failure in customer relationship management. *Industrial Marketing Management*, 37(4), 421-431.

Kowalkowski, C. (2010). What does a service-dominant logic really mean for manufacturing firms? *CIRP Journal of Manufacturing Science and Technology*, *3*(4), 285–292.

KPMG(2018). *Autonomous Vehicles Readiness Index.* Assessing countries' openness and preparedness for autonomous vehicles. KPMG International.

Mansell, R., &Wehn, U. (1998). Knowledge societies: Information technology for sustainable development. United Nations Publications.

Manzini, E., &Vezzoli, C. (2003). A strategic design approach to develop sustainable product service systems: Examples taken from the "environmentally friendly innovation" Italian prize. Journal of Cleaner Production, 11(8), 851–857.

Mutz, F., Veronese, L. P., Oliveira-Santos, T., Aguiar, E., Cheein, F. A. A., & Souza, A. F. (2016). Large-scale mapping in complex field scenarios using an autonomous car. *Expert Systems with Applications*, *46*, 439-462.

Nascimento, A. L. S. (2016). Proposta de framework para avaliação de fatores críticos de sucesso de parques científicos e tecnológicos. Master thesis, Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, Brazil.

Nogami, V. K. C., Veloso, A. R. (2017). Disruptive innovation in low-income contexts: challenges and state-of-the-art national research in marketing. *RAI Revista de Administração e Inovação*, *14*(2), 162-167.

Nfuka, E. N., & Rusu, L. (2011). The effect of critical success factors on IT governance performance. *Industrial Management & Data Systems*, *111*(9), 1418-1448.

Oliveira, M. R. G., Cavalcanti, A. M., de Paiva Junior, F. G., & Marques, D. B. (2014). Mensurando a inovação por meio do grau de inovação setorial e do característico setorial de inovação. *RAI-Revista de Administração e Inovação*, *11*(1), 115-137.

Osei-Kyei, R., & Chan, A. P. (2015). Review of studies on the Critical Success Factors for Public–Private Partnership (PPP) projects from 1990 to 2013. *International Journal of Project Management*, *33*(6), 1335-1346.

Osei-Kyei, R., & Chan, A. P. (2017). Empirical comparison of critical success factors for public-private partnerships in developing and developed countries: A case of Ghana and Hong Kong. *Engineering, Construction and Architectural Management*, *24*(6), 1222-1245.

Pfoser, S., Treiblmaier, H., & Schauer, O. (2016). Critical success factors of synchromodality: Results from a case study and literature review. *Transportation Research Procedia*, *14*, 1463-1471.

Poorsartep, M. (2014). Self-Driving Cars: Radical Innovation in the Transportation Industry. In: Christiansen, B., Yildiz, S., Yildiz, E. (2014). *Transcultural Marketing for Incremental and Radical Innovation.* (1st ed.). Hersey (Pennsylvania): IGIGlobal.

Poulain, B. (2017). State-of-the-art: Product and service systems modelling [Working Paper N° 01]. *École Centrale Paris*, Châtenay-Malabry, France.

Rocha, M. M, Lima, G. B. A., Lameira, V. D. J., & Quelhas, O. L. G (2012). Innovation as a Critical Success Factor: an Exploratory Study about the Partnership among University with

Pharmaceutical Industry in Brazil. *Journal of technology management & innovation*, *7*(3), 148-160.

Rockart, J. F. (1979). Chief executives define their own data needs. Harvard business review, 57(2), 81-93.

Sawhney, M., & Chen, J. (2010). Defining and measuring business innovation: the innovation radar. *MIT Sloan Management Review*, *1611264*.

Sawhney, M., Wolcott, R. C., &Arroniz, I. (2006). The 12 different ways for companies to innovate. *MIT Sloan Management Review*, *47*(3), 75.

Schellekens, M. (2015). Self-driving cars and the chilling effect of liability law. *Computer Law & Security Review*, *31*(4), 506-517.

Schoitsch, E. (2016). Autonomous Vehicles and Automated Driving Status, Perspectives and Societal Impact. Information Technology, Society and Economy Strategic Cross-Influences (IDIMT-2016). *24th Interdisciplinary Information Management Talks*, *45*(1), 405-424.

Schreurs, M. A., Steuwer, S. D., (2015). Autonomous Driving – Political, Legal, Social, and Sustainability Dimensions. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.) (2015). *Autonomous Driving: technical, legal and social aspects*. Berlin: Springer. pp. 149–171.

Schuh, G., Schittny, B., &Gaus, F. (2009). Differentiation through industrial product-service-systems in the tooling industry. POMS 20th Annual Conference (pp. 1–26) (Orlando, Florida U.S.A.).

Selhofer, H., Arnold, R., Lassnig, M., & Evangelista, P. (2012). Disruptive Innovation: Implications for Competitiveness and Innovation Policy. *INNO-Grips–Global Review of Innovation Policy Studies http://www. proinnoeurope. eu/innogrips2. Retrieved: January*, *9*, 2017.

Soltanzadeh, J., Taghavifard, M. T., & Sahebjamnia, N. (2014). Critical success factors in S&T policymaking using confirmatory factor analysis and DEMATEL: a case study. *International Journal of Technology, Policy and Management*, *14*(4), 305-326.

Standing, C., & Cripps, H. (2015). Critical success factors in the implementation of electronic health records: A two-case comparison. *Systems Research and Behavioral Science*, *32*(1), 75-85.

Steg, L. (2005). Car use: lust and must. Instrumental, symbolic and affective motives for car use. *Transportation Research Part A: Policy and Practice*, 39(2-3), 147-162.

Syed, R., Bandara, W., French, E., & Stewart, G. (2018). Getting it right! Critical Success Factors of BPM in the Public Sector: A Systematic Literature Review. *Australasian Journal of Information Systems*, *22*.

Tukker, A. (2004). Eight types of product– service system: eight ways to sustainability? Experiences from suspronet. *Business Strategy and the Environment*, *13*, 246-260.

Vargo, S. L., & Lusch, R. F. (2004). Evolving to a new dominant logic. *Journal of Marketing, 68*, 1–17.

WEF - World Economic Forum - (2019). Mapping Global Transformation - Brazil. Available in https://toplink.weforum.org/knowledge/insight/a1Gb0000000LPqYEAW/explore/summary. Access in: 4th February, 2019

Wong, M. T. N. (2004). Implementation of innovative product service systems in the consumer goods industry. Doctoral dissertation, University of Cambridge, Cambridge, United Kingdom.

Yang, H. S., Zheng, L., & Huang, Y. (2012, December). Critical success factors for MES implementation in China. In *Industrial Engineering and Engineering Management (IEEM), 2012 IEEE International Conference on* (pp. 558-562). IEEE.

Zakharenko, R. (2016). Self-driving cars will change cities. *Regional Science and Urban Economics*, *61*, 26-37.

Zhang, X. (2005). Critical success factors for public–private partnerships in infrastructure development. *Journal of construction engineering and management*, *131*(1), 3-14.

Ziemba, E., Papaj, T., Żelazny, R., & Jadamus-Hacura, M. (2015). Building and evaluating classification framework of critical success factors for e-government adoption. In *Proceedings of 15th European Conference on eGovernment", University of Portsmouth, Portsmouth*.

Appendix I

Name (or initials):_____

E-mail:_____

Country:_____

Please answer the questionnaire in one of the following languages: English; French; Spanish; Portuguese.

Part 1

In order to answer this questionnaire, you should consider the Autonomous Vehicles (higher levels of automation) as a Product-Service System.

Product-Service System (PSS): Is a solution combining product(s) and service(s) aiming at the fulfilment of user's needs or of a given function (Poulain, 2017). In other words, product Service-Systems (PSS) may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality (Wong, 2004). For example: product leasing; sharing or pooling.

Considering that Critical Success Factors are determinant for the insertion of a product / service in the market, what would be the critical success factors for insertion of AVs as a PSS in your country?

Critical Success Factor	Guidelines (please use them to better understand the critical success factors)	Importance (Low → High)
Platform	Set of common components, assembly methods or technologies that serve as building blocks for a portfolio of products or services. E.g.: airbnb; uber; blablacar …	0 1 2 3 4 5
Solutions	To have integrated and customized offerings that solve end-to-end customer mobility problems. (ease of going from point A to point B)	0 1 2 3 4 5
Customer Experience	The car is designed for riding not driving (no steering wheel; internet of things, infotainement…)	0 1 2 3 4 5
Value Capture	Consumers' choice for AVs as a PSS instead of other private and public transportation means.	0 1 2 3 4 5
Organization	How the AV service provider structures itself, and its employee roles and responsibilities.	0 1 2 3 4 5
Supply Chain	The sequence of activities and agents that move AVs and information from the source to delivery	0 1 2 3 4 5
Networking	AVs connections to customers through a network that can sometimes become part of the firm's competitive advantage.	0 1 2 3 4 5
Brand	Importance of the brand for AVs' insertion	0 1 2 3 4 5
Public Polices	Governmental practices and subsides / public guidelines: environment that regulates the dissemination and development of AVs, certification and homologation	0 1 2 3 4 5
Technology and Innovation	P&D; hardware; software…	0 1 2 3 4 5
Infrastructure	Physical and technological infrastructure of the country (roads; electric grid; 3G coverage…)	0 1 2 3 4 5
Consumer Acceptance	Consumer's openness (willingness to riding a car without a driver and / or share a car with other people	0 1 2 3 4 5
Sustainability	Car sharing; reduction of cars on the road; more acces and lower prices	0 1 2 3 4 5
Ethics & Moral	Ethical dilemma; Robot x human interactions	0 1 2 3 4 5
Transport planning	Automated systems: traffic control and demand predictions, congestion, travel behavior	0 1 2 3 4 5
Security	Dataprivacy; hackers attacks …	0 1 2 3 4 5
Law and Liability	Specific legislation	0 1 2 3 4 5
Partnerships	Partnerships among: public sector; private sector and academy	0 1 2 3 4 5

ARTICLE 03 - Innovation Radar for Disruptive Technology Insertion: The Case of Autonomous Vehicles in Brazil and France

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Paper presented on 28th International Colloquium of GERPISA; PARIS -2019 – final candidate to the Young Author Prize

ABSTRACT
This paper seeks to map and discuss the innovation context of Brazil and France, using, for this, the Innovation Radar's framework. Fundamentally, it seeks to address the gap between the development of AVs, the differences between two national contexts, and the lack of specific knowledge about how to manage disruptive innovation in countries. The adopted research design was based on a qualitative approach and characterized as exploratory-descriptive. As for the research development, the case study (Brazil and France) was used as method to investigate a current phenomenon inserted in its natural context, using, for this, questionnaires as a data source (Yin, 2015). The results obtained in Brazil and in France were crossed with official data and statistics as a way to corroborate the use of the Innovation Radar.France has better metrics in all the dimensions when comparing to Brazil. This is not a surprising outcome, being corroborated by studies and reports that seek to map the macroeconomic, political, and social conditions of these countries. On the other hand, we must ponder the Brazilian importance and influence when it comes to the international automotive scenario: the country auto market stands out on the world stage and can be considered as the gateway of Latin America given that, currently, Brazil is the fifth largest auto industry consumer market in the world, also accounting for more than half of the vehicles sold in Latin America.

1 INTRODUCTION

Industries, markets, and governments worldwide are experiencing several trends that will fundamentally change our business ecosystems and the way that value is generated (DUP, 2016; McKinsey, 2018).

This trends includes changes in customer expectations and value generation with the digitalization of channels and interfaces; big dataand analytics becoming new sources of value generation, the increasing importance of professionally managed fleets and the rise of emerging markets and a new service mindset; the rise of next-generation vehicles with electrification shrinking the profit pool, the increasing importance of software requiring new competencies, autonomous driving leading to fewer accidents but shorter maintenance intervals as well as connected vehicles enabling predictive maintenance; shifts in competitive power with new players entering the market and the further acceleration of industry consolidation and integration. These changes have some key impacts: a disruption along the value chain, a change in end customer access, and a shift in profit pools (McKinsey, 2018).

In this context, we can highlight the automotive industry – which, for decades, has been mainly stable and traditional in terms of business models and incremental in terms of innovation shifts - as one of the major areas of disruption. The imminent arrival of

autonomous technologies and systems has stirred up industry giants and key stakeholders all over the world.

Autonomous Vehicles (AVs) – also known as Automated Driving Systems (ADS); self-driving vehicles; driverless cars or even; robotic cars – are vehicles that don't require any sort of conductor or teleoperation control (Frazzoli, Dahleh & Feron, 2002), they have several technological elements which includes the vehicles performance system; cloud features, perception and object analysis, drive control, decision making, localization and mapping; analytical platform, middleware or operating system, computer hardware and sensors (McKinsey, 2018).

Furthermore, AVs are considered an integral part of the new forms of mobility (Attias, 2016) and have become focus of many R&D projects, being considered by many authors as the greatest disruptive innovation in the automotive industry (Attias, 2016; Attias & Mira-Bonnardel, 2016; Enoch, 2015; Fagnant & Kockelman, 2015; Mutz et al., 2016; Poorsartep, 2014; Schellekens, 2015; Schreurs & Steuwer, 2015).

In fact, considering the dynamics and the rhythm of innovations today, "*full autonomy is likely to be taken up quickly, both by fleets and consumers, and to rapidly establish itself as a new technology platform for innovative businesses and applications, some of which we cannot yet imagine*" (McKinsey, 2018, p.19). It is worth noting that, besides industries, several other areas will be affected. Consumers and markets will shift the whole innovative capacity of the countries. In this sense, policy makers and urban planners will have to adapt and rethink mobility in this new panorama.

It's essential to consider that a disruptive innovation such as AVs which are expected to have an impact in the economy also require a special 'disruptive innovation policy'. The literature about disruptive innovation presents approaches related to impacts of this on management practices (Yu, 2010). However, policy's implications need to be more discussed in terms of the design of innovation (Cavazza et al. (artigo 3 da tese);Selhofer et al., 2012). On the other hand, it would be possible to determine policies prepared to 'react' to disruptive trends (Selhofer et al., 2012).

A strategic response of economic and innovation policy should consist in creating positive framework conditions for innovation in a given country with the objective to strengthen thenational innovative capacity. In other words, to make countries able to produce and commercialize a flow of innovative technology over the long term (Proksch, Haberstroh & Pinkwart, 2017; Wu, Ma & Zhuo, 2017).

As pointed out by Wu, Ma and Zhuo (2017, p.2), the "*national innovative capacity depends in part on the overall technological sophistication of an economy and its labor force, but also on an array of investments and policy choices by both the government and the private sector".* In this sense, it is worth to comprehend national competencies that are important to promote disruptive innovations and include them in the policies programs.

In this context, by using the theoretical model of the Innovation Radar for the insertion of Autonomous Vehicles as a PSS in a country (Cavazza et al., artigo 3 da tese), this paper seeks to map and discuss the innovation context of Brazil and France. Fundamentally, it seeks to address the gap between the development of AVs, the differences between two national contexts, and the lack of specific knowledge about how to manage disruptive innovation in countries.

Besides this introduction, this paper presents four more sections: in the theoretical background, first we present an overview of the subject of this paper: the autonomous vehicles as a product service system, its main aspects and characteristics as well as the typologies that could emerged when considering AVs as a PSS (Antonialli et al., 2018). Next, we discuss how to manage disruptive innovations such as the AVs in a national context. Finally the theoretical framework of the Innovation Radar for the insertion of AVs in a country is presented (Cavazza et al., 2017). In the next section, the methodological steps of the research are presented and in section four we present and discuss the main outputs of this work. At last, in section 05, we develop some conclusion and guidelines for future studies.

2 THEORETICAL BACKGROUND

2.1 Autonomous Vehicles as a Product Service System

By representing a potentially disruptive and beneficial change to the current transportation business model, autonomous vehicles (AVs) are bound to change the future of urban mobility, and such transformation will not only affect the means of transport but society as a whole, in a sense that the traditional transport model (dominated by private cars, taxis, and buses) is likely to suffer an exponential decline in the coming years, giving rise to "intermediaries" means of transport – mostly designed in the form of shared vehicles (Attias, 2016; Enoch, 2015; Mutz et al., 2016; Schreurs & Steuwer, 2015).

Nevertheless, there are many issues that still need to be addressed such as the possible impacts of autonomous driving on mobility behaviors and human-machine interactions, as

well as consumer acceptance, regulatory and liability frameworks (Schellekens, 2015; Schreurs & Steuwer, 2015).

Therefore, due to their disruptive nature, AVs are likely to change the structure of cities (Zakharenko, 2016), however it is still complex to understand how life will be affected by this disruptive innovation in a sense that the timing, scale, and direction of the AVs impacts, are uncertain and the opportunities to influence investment decisions are limited (Guerra, 2016).

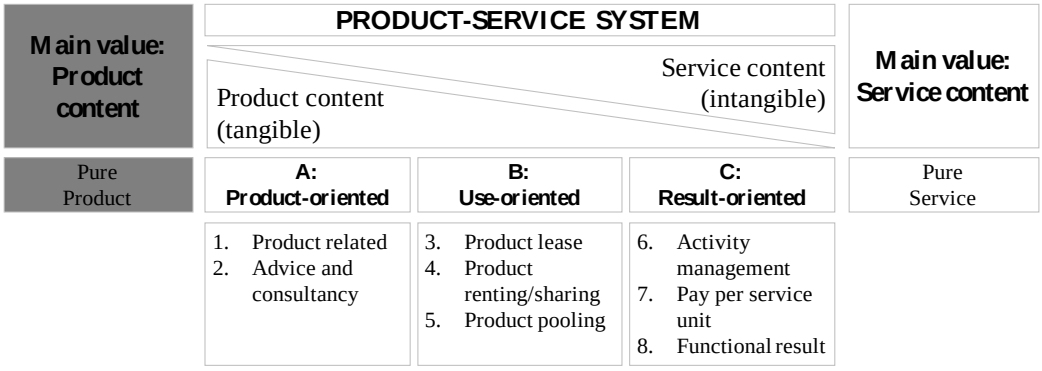
Hence, the traditional business model of selling cars as products is losing ground to alternative forms of commerce. As pointed out by Johnson and Mena (2008) manufacturers are combining products and services in order to provide greater value to the customer and to facilitate longer more profitable business relationships.

In this sense, a Product-Service System (PSS) can be defined as consisting of tangible products and intangible services designed and combined with the aim of fulfilling users' needs or of a given function (Poulain, 2017; Tukker, 2004). In other words, PSS may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality and expected benefits (Manzini & Vezzoli, 2003; Wong, 2004).

Considering PSS as an integration of resources, skills, and knowledge (Kowalkowski, 2010), it is important to consider businesses model aspects to fit into the premises of this new approach based on customers, business, and the value chain (Barquet et al., 2013). Hereupon, a business model in which cars are offered as services is gaining strength and it is being tackled by many companies and scholars. As Burns, Jordan, and Scarborough (2013, p.101) stated: "*an analysis by Larry Burns, the former Vice President of GM, estimates 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*".

Tukker (2004) drew a categorization of PSS by creating eight different types of Product-Service Systems that, according to the author, exist with quite diverging economic and environmental characteristics. As displayed on Figure 1, it can be noted that types of PSSs vary on a spectrum in which on one end the main value rests on product content (tangible) and on the other on service content (intangible).

Figure 1 - Categories of Product-Service Systems.

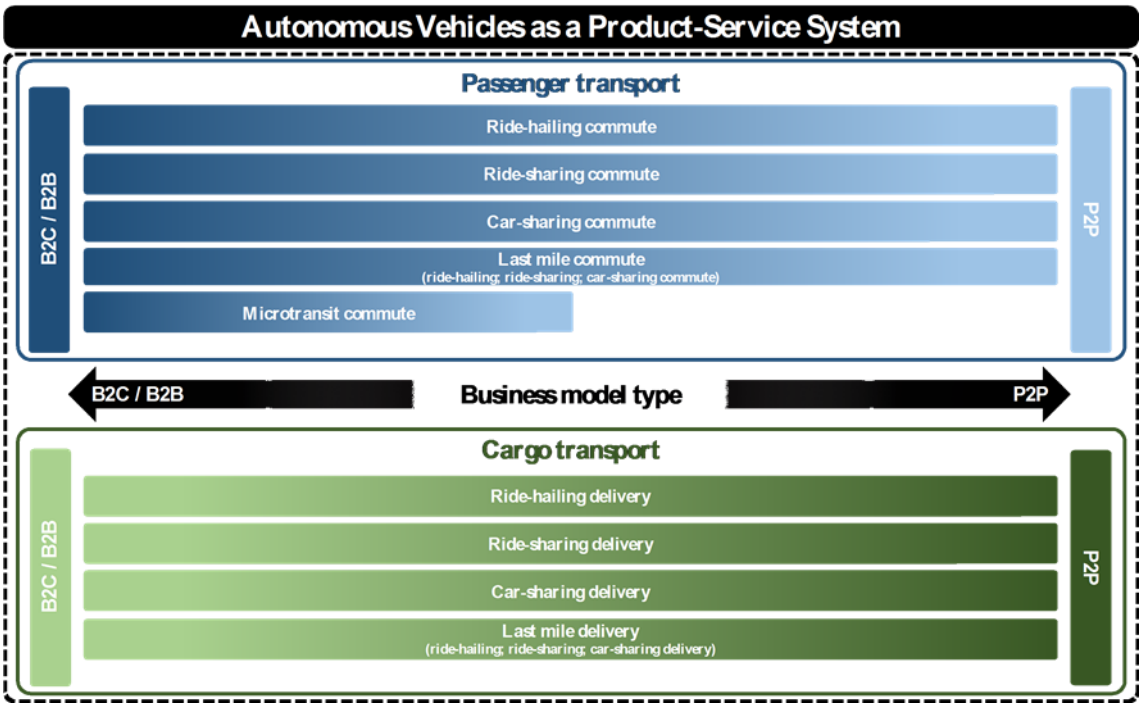


Source: Adapted from Tukker (2004, p.248).

There are three main categories of PSS within the spectrum (Tukker, 2004, p.248): the first one is product-oriented where the business model is still mainly geared towards sales of products, but some extra services are added; the second category is use-oriented, here the traditional product still plays a central role, but the business model is not geared towards selling products. The product stays in ownership of the provider, and is made available in a different form, and sometimes shared by a number of users. Finally, the third category is result-oriented where the client and provider in principle agree on a result, and there is no pre-determined product involved.

As an advancement in this area, in our previous work, *Typologies of uses for Autonomous Vehicles as a Product-Service* we were able to design a set of use typologies for the AVs as a PSS. As detailed on Figure 2, AVs are better fitted on the "use oriented" category of Tukker's (2004) PSS model, that is: the traditional product (AV) still plays a central role, however the business model is not geared towards sales, in this sense, the product is not in the ownership of the service provider consumer, instead it stays in the ownership of a service provider (or even other ownership forms), and is made available to the service provider's consumers in different forms (typologies).

Figure 2 - Typologies for Autonomous Vehicles as a PSS.



Source: Antonialli et al. (2018).

As for the typologies, two main groups were identified: 1) passenger transport (in blue), and 2) cargo transport (in green). Within each group two set of business models arose; a) Business-to-Consumer (B2C) and/or Business-to-Business (B2B) where the service provider (or its partners) owns the fleet of vehicles and not only is in charge of managing the rides, the application, and the algorithm of the service, but is also responsible for all fleet costs (maintenance, storage, parking, insurance, and fuel), and b)Peer-to-peer (P2P) - also known as C2C (consumer to consumer) or O2O (owner to owner) - in which the individual can offer the transportation service by him/herself or opt to rent his/her vehicle to a service provider to handle the transportation service. Furthermore, within each set of business model, three main sub typologies were identified: 1) car-sharing; 2) ride-sharing and 3) last mile

issue – which can be further subdivided into car-sharing and ride-sharing as well (Antonialli et al., 2018).

For each type of the afore mentioned business models, we were able to divide them even further into different usage sub-typologies. For passengers' transport (both B2C/B2B and P2P) we extracted five: 1) ride-hailing; 2) ride-sharing; 3) car-sharing; 4) last mile; and 5) microtransit commute. As for cargo transport (both B2C/B2B and P2P as well) we identified the same typologies as for passengers, except for microtransit, however, instead of focusing on passengers' commute, the focus is on logistics, freight, and goods delivery.

In fact, AVs as a PSS can be considered a relevant innovation that promises to have great impact on the urban mobility, thus, it is crucial for governments and policy makers worldwide to consider all the aspects of this innovation and its relation with governance and public policies. This next topic seeks to discuss disruptive innovation with a view to its relevance for innovation policy.

2.2 Disruptive Innovation, AVs-PSS and Countries

The concept of innovation is quite varied, mainly depending on its application. In general ways, it is related to insertion in the market and society of something new and also it is about generating value in this context. Many authors base the concept of innovation by relating it to Schumpeter's approach to creative destruction (1942; 2009). For this author innovation could be related to a) the introduction of a new good; b) the introduction of a new method of production or commercialization of existing assets; c) the opening of new markets; d) the conquest of a new source of raw materials; and e) the breaking of a monopoly. Following this path, the OECD's Oslo Manual states that innovation could be related to a) a product, b) a process, c) the organization, and d) the marketing (OECD, 2005).

Considering that different value proposition emerges from different innovations than those previously available, Christensen (1997) states – in his seminal work: "The Innovator's Dilemma" – that, generally by being technologically straight forward, innovations come in two types: 1) incremental (sustaining) technologies and, 2) radical (disruptive) technologies. In the former, products are made better over time to meet the demands of costumers who are willing to pay more for better products, in this sense, most technological advances in a given industry are sustaining in character; on the latter, the introduced products bring to market a very different value proposition than had been previously available (Christensen & Raynor, 2003; Enoch, 2015; Markides & Geroski, 2005). In this sense, it is important to understand

the concept of a disruptive innovation because it offers different packages of attributes that are not often considered important to mainstream customers (Christensen, 1997).

It is worth highlighting that, although the term disruptive technology is widely used, disruptive innovation seems more appropriate since few technologies are intrinsically disruptive; rather, it is the business model that the technology enables that creates the disruptive impact (Christensen, 2001). That is, few technologies or business ideas are intrinsically sustaining or disruptive in character; rather, their disruptive impact must be molded into strategy as managers shape the idea into a plan and then implement it.

As pointed in the *Global Review of Innovation Policy Studies:*

> "in a nutshell, the notion of 'disruptive' innovation refers to the impact which an innovation has (on markets, industries and the players acting in them) rather than on the mere novelty of the innovated products, services, processes or management techniques" (Selhofer et al., 2012, p.13).

Also, it is important to consider that disruptive innovation can have a totally different meaning in services than in manufacturing. While in manufacturing the emphasis is in the product itself, in services, disruptive innovation is typically linked to new business models that have been made possible by innovative uses of technologies provided by other sectors, notably ICT, rather than conducting R&D. In this context, if we consider the bundle of characteristics of AVs as a PSS the implications for innovation policy are therefore quite different.

In fact, AVs are being piloted in a number of countries and are running on public roads, whilst only in a handful of locations such as Phoenix in the US State of Arizona and in Singapore, even though this innovation could take 10 or 30 years to effectively 'reach the market', the social and political implications "*are so far-reaching that policymakers need to start planning now for our AV future*" (KPMG, 2018, p.6).

As pointed out by the *KPMG Autonomous Vehicles Readiness Index,* there are many implications beyond the technological spectrum:

> "Regulations on vehicle insurance will need to adapt, including who is responsible for a driverless vehicle's actions. Driving licenses could become redundant, although many countries use them as an identity card. Road traffic regulations, designed for use by humans, will ultimately be replaced by protocols, determining priority at junctions and giving way to emergency vehicles" (KPMG, 2018, p.6).

In this context, many public policymakers are already focusing their attention on autonomous transportation and on understanding its potential impact (BCG, 2016). It's worth mentioning that policy making and policy implementation do not occur in a vacuum. "*Rather, they take place in complex political and social settings, in which individuals and groups with unequal power interact within changing rules as they pursue conflicting interests*" (World Bank, 2017, p.29).

Thus, a strategic response for policy must address the cross-sectoral nature of disruptive innovations, as well as to manage some 'business case conflicts' – considering that desired and expected externalities from accelerating disruptive innovation deployment do not coincide with the industry's business case as well as to anticipate unwanted side-effects of interventions and disruptive innovation in service sectors (Selhofer et al., 2012).

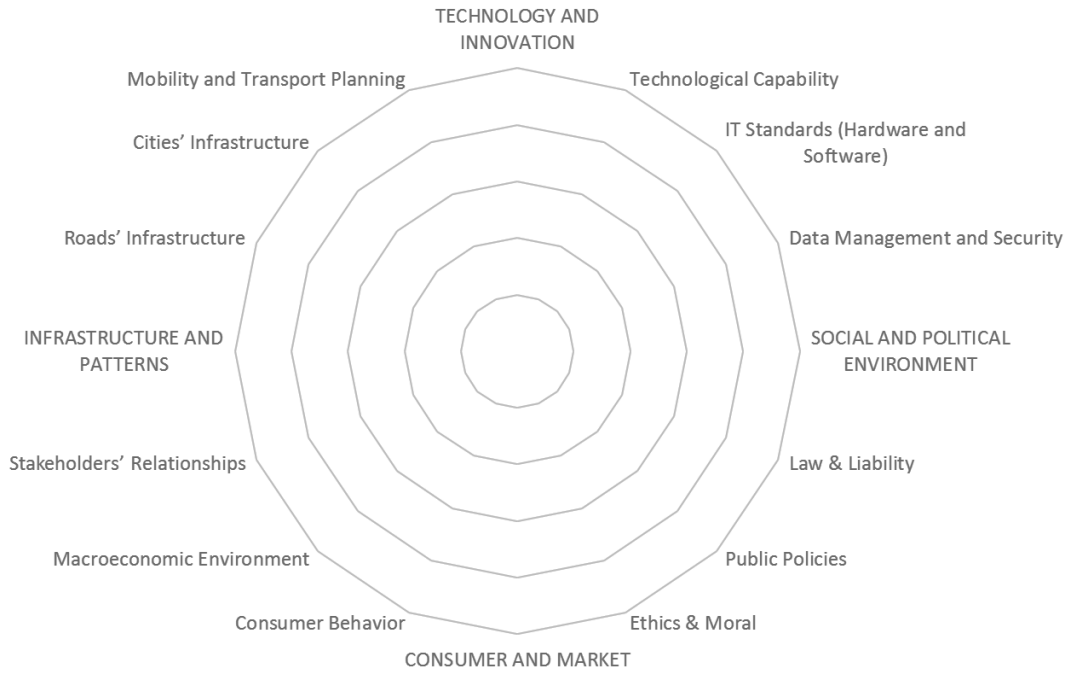
Due to the complexity and relevance of the theme, some studies have been carried out in order to develop tools and methods to assess the openness and readinessof countries for autonomous vehicles (KPMG, 2018), as well as to map and analyze the critical success factors for insertion of AVs into different national contexts (Cavazza et al. (artigo 3 da tese); WEF, 2019). The following topic presents the theoretical framework used in this study to identify / measure CSFs for the insertion of AVs in a country.

2.3 Innovation Radar for the Insertion of AVs in a Country

The Innovation Radar is a useful tool proposed by proposed by Sawhney, Wolcott and Arroniz (2006) to have disruptive products or services creating and delivering value. According to the authors "*successful business innovation requires careful consideration of all aspects of a business" and thus "when innovating, a company must consider all dimensions of its business system*" (Sawhney, Wolcott & Arroniz, 2006, p.36).

Based on this seminal work (Sawhney, Wolcott & Arroniz, 2006), in our previous paper *Critical Success Factors for the insertion of Autonomous Vehicles as a Product Service System in a country* we were able to design a theoretical model of the Innovation Radar for the insertion of Autonomous Vehicles (AV's - higher levels of automation – 4 and 5) as a Product Service System (PSS) based on the Critical Success Factors (CSF) as shown in Figure 3.

Figure 3 - Innovation Radar for the Insertion of AV's as a PSS in a Given Country.



Source: Cavazza et al.(artigo 3 da tese).

The framework Radar AVs-PSS presents 4 key dimensions that work like anchors: (1) Technology and Innovation, (2) Social and Political Environment (3) Consumer and Market, (4) Infrastructure and Patters. Between these four anchors, we embed 12 factors of the innovation system that can serve as avenues of pursuit. All the Radar's dimensions, as well as a brief concept explanation about its concepts and factors, is presented in Table 1.

Table 1 - Dimensions of the Innovation Radar.

KEY DIMENSIONS	GUIDELINES	DIMENSIONS	GUIDELINES
TECHNOLOGY AND INNOVATION (T&I)	In a knowledge-based economy, technology is an important resource to create innovation. In this sense, considering technological assets and requirements, it is fundamental to pay attention to knowledges and competences and policies and patterns of hardware (equipment) and software in order to achieve specific knowledge domain and scandalization and to benefit the society. Finally, data management and security are very important, especially in terms of confidentiality, integrity,availability, and authenticity of the information.	TECHNOLOGICAL CAPABILITY (TC)	It is referred to knowledge and competences to technology transfer, Information and Technology leadership, technology innovation and Information and Communication Technology (ICT)/Information Technology System (ITS) technologies
		IT STANDARDS - HARDWARE AND SOFTWARE (IT-S)	Considering that in the related hardware and software system that configure AVs as PSS, are resources that need to be written and read frequently with accuracy.
		DATA MANAGEMENT AND SECURITY (DM &S)	Data management and security have to be based on quality and standard as main aspects to data sharing and exchange. Specially in terms ofconfidentiality, integrity availability, and authenticity.
SOCIAL AND POLITICAL ENVIRONMENT (S&P)	The presence of different stakeholders increases the complexity of a system. In this sense, it is essential to manage questions related to the social and political context. Political support, social support and governance are needed to determine legal and political conditions of a country as well as political-economic initiatives (financial and non-financial?).	LAW & LIABILITY (L&L)	Harmonized regulations are essential for the functioning of AVs as PSS. Basically, legal framework is a fundamental source of security in the new context promoted by the PSS.
		PUBLIC POLICES (PP)	The government has a fundamental role in regulating and standardizing the structure needed for AVs' insertion. Governments should treat public policies as crucial strategical assets that ensure investors' attractiveness as well as to improve the competitiveness of the country.
		ETHICS & MORAL (E&M)	Culture is a background related to a value system based on shared norms and beliefs which are variable according to the context
CONSUMER AND MARKET (C&M)	Market is an aspect that is embedded by several factors because it is related to many different stakeholders, which have different goals and activities. Here, the main idea is: stakeholders need to be managed, macroeconomic objectives must be aligned in order to develop a viable and attractive environment, and the cultural background must be considered in strategies to promote and improve consumers' behavior that benefits from the insertion of AVs as PSS.	CONSUMER BEHAVIOR (CB)	Related to the consumers' openness (willingness to ride a car without a driver and / or share a car with other people, mindset shift and trust).
		MACROECONOMIC MARKET (MM)	A stable macroeconomic condition is related to the existence of economic policies and a favorable legal framework as a way to designate an appropriate risk allocation providing sources of benefits for multiple objectives.
		STAKEHOLDERS' RELATIONSHIPS (SR)	In a national context there is broader stakeholders' involvement because the extent of projects demands different partnerships among them. We highlight here specially the public sector; private sector, society, and academy.
INFRASTRUCTURE AND PATTERNS (I&P)	AV as a PSS will connect with its surrounding ecosystem and infrastructure, that is, other transportation models, users' devices and other systems and services. In this sense, considering that changes and adaptations in different aspects of infrastructure will be necessary for the operation of AVs, countries must pay attention to physical and technological patterns to supply these new demands. The core premise related to this dimension's critical success factors is that is necessary to develop a systems' network.	ROADS' INFRASTRUCTURE (RI)	An intelligent environment is characterized by places with intensive use of technology and communication through three main areas: 1) internet of things (IoT); 2) path management and planning based on actions built by algorithms applied to the context; and 3) processing and analysis of a large amount of information (Big Data).
		CITIES' INFRASTRUCTURE (CI)	
		MOBILITY AND TRANSPORT PLANNING (M &TP)	For the success of mobility projects, it is essential to plan transport and mobility based on a dynamic and integrated view.

Source: Cavazza et al. (artigo 3 da tese).

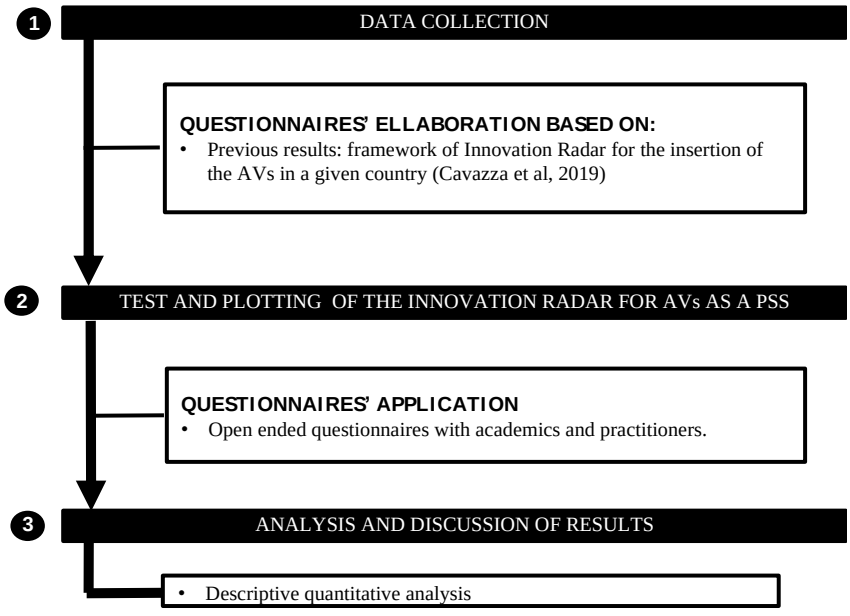
These parameters enable to identify CSFs for the insertion of AVs in a country. From this conception this study proposes that the CSFs be measured and plotted in an Innovation Radar considering the AVs as PSS. This effort will be developed using the methodology presented below.

3 METHODOLOGY

With the aim of testing a theoretical model of the Innovation Radar for autonomous vehicles as a PSS based on the critical success factors (Cavazza et al. (artigo 3 da tese), the adopted research design was characterized as a qualitative approach of exploratory-descriptive nature.

It is qualitative because it searches through the collected data to understand a phenomenon (insertion of a disruptive innovation in a country) and its complexity as a whole (Godoy, 1995). Based on this approach, the research is exploratory-descriptive because it provides an overview about a certain fact: the key performance indicators regarding autonomous vehicles as a PSS, issues that are not clearly addressed in the literature (Cavazza et al., 2017; Gandia et al., 2017; Gil, 2008; King & Burgess, 2006). As for the research development, the case study was used as method to investigate a current phenomenon inserted in its natural context, using, for this, questionnaires as a data source (Yin, 2015). Figure 4 describes the stages of the research.

Figure 4 - Research Design



Source: Elaborated by the authors.

As described in Figure 04,on Stage 1 we have the elaboration of the questionnaires used in the data collection, we first resorted to accessing and reading secondary data, such as: technical reports from governments, car-manufacturers, consulting companies as well as academic literature on the field (journal and conference papers, thesis and dissertations). It is worth to highlight that, the main source for the questionnaire elaboration was the outputs of the previous paper elaborated by the authors: *Critical Success Factors for the Insertion of Autonomous Vehicles as a PSS in a Country.*

Next, on Stage 2 data after the gathering of secondary data, we were able to formulate the open ended questionnaires (Appendix I). This instrument was submitted to pre-tests with 05 specialists related to the 04 key dimension of the framework. To test and plot the framework of the Innovation Radar, on Stage 2, open ended questionnaires were sent via GoogleDocs within the Automotive Industry and Urban Mobility fields in Brazil and in France. We were able to reach 20 specialists from Brazil and 09 from France.

On the questionnaire, the respondent had a brief explanation for each of the 12 factors presented, and next it was presented two conceptual phrases that described the ideal situation for this factor in a country. Thus, considering that Critical Success Factors are determinant for the insertion of a product/service in the market, the respondent was invited to choose if he/she disagree (1) or agree (5) with the statements specified in the following tables according to the following scale:

1. Strongly disagree (SD)
2. Disagree (D)
3. Neither agree nor disagree (ND/D)
4. Agree (A)
5. Strongly agree (SA)

On stage 3all questionnaires were tabulated and quantitatively organized, therefore, generating a descriptive qualitative analysis as well as the final plotting of the Innovation Radar. The index of each factor was calculated through the average of all respondents in the country. After analyzing each dimension’s results, we were able to discuss the relevance of the critical success factors for AVs as a PSS, emphasizing their main characteristics in both countries.

4 RESULTS AND DISCUSSION

This topic displays the plotting of the Innovation radar for Brazil and France, also, it discusses the main aspects and differences between the outputs as well and its context relation. Table 2 and Figure 5present the results of the data collection.

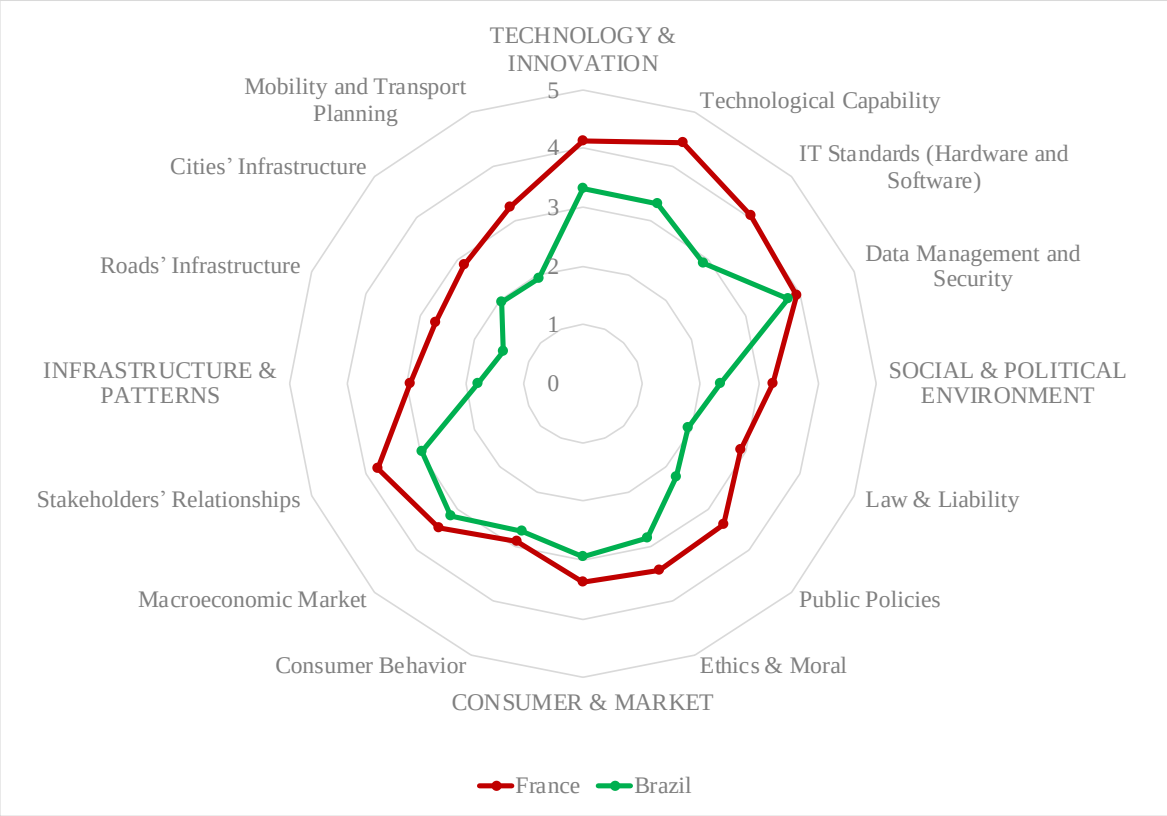
The indices for each dimension were obtained through the average response of the participants. France indicators are displayed by the red line and Brazil's indicators by the green one.

Table 2 – Key Dimensions and CSFs Index.

Dimensions	France	Brazil
Technology & Innovation	**4,13**	**3,33**
Technological Capability	4,43	3,33
IT Standards (Hardware and Software)	4,05	2,90
Data Management and Security	3,93	3,78
Social & Political Enviroment	**3,23**	**2,34**
Law & Liability	2,90	1,93
Public Policies	3,38	2,25
Ethics & Moral	3,43	2,85
Consumer & Market	**3,38**	**2,95**
Consumer Behavior	2,90	2,70
Macroeconomic Market	3,45	3,18
Stakeholders' Relationships	3,78	2,98
Infrastructure & Patterns	**2,93**	**1,79**
Roads' Infrastructure	2,70	1,48
Cities' Infrastructure	2,85	1,95
Mobility and Transport Planning	3,25	1,95

Source: Elaborated by the authors

Figure 5 - Innovation Radar – Brazil x France.



Source: Elaborated by the authors.

As we can observe, France has better metrics in all the dimensions when comparing to Brazil. This is not a surprising outcome, being corroborated by studies and reports that seek to map the macroeconomic, political, and social conditions of these countries (KPMG, 2018; WEF, 2019). One must also consider that, because it is a developed country, France has at its disposal a series of material and human resources that have been employed in this "race" to put autonomous vehicles on the road. In fact, France plays a significant role in global affairs thanks to its political, economic, and cultural influence (WEF, 2019).

As pointed out by Bertrand Vigner, partner at the Strategy Group of KMPG in the country, "France has large companies including Renault, PSA- Opel, Transdev, Valeo, and Safran as well as startups such as Navya and Easymile investing heavily in AV. Although it has been slow to develop awareness, the French government is now proactively working to regulate and promote development, with an ambitious strategic plan expected soon" (KPMG, 2018, p.29).

As from Brazil, one can consider that this country faces challenges as large as its territorial extension:

> Brazil boasts the largest economy in Latin America, and its potential to further diversify and better utilize vast natural resources represent substantial opportunities. Recently, however, Brazil has faced domestic and external challenges that have hindered economic growth. Measures that stimulate greater private sector investment in infrastructure will be crucial for safeguarding the social progress achieved by Brazil in recent decades (WEF, 2019).

On the other hand, we must ponder the Brazilian importance and influence when it comes to the international automotive scenario. In an article written by Muller (2012) for Forbes Magazine, what carmakers see when they look at Brazil is South America's largest consumer market, a still-bustling economy- and a lot of potential customers. Besides it is, in the world, the fifth-largest country and only 14% of its roads are paved, in economic terms, incomes are rising, lifting almost 40 million more Brazilians into the middle class since 2003 and putting a vehicle purchase within their reach for the first time.

In this sense, the Brazilian auto market stands out on the world stage and can be considered as the gateway of Latin America given that, currently Brazil is the fifth largest auto industry consumer market in the world, also accounting for more than half of the vehicles sold in Latin America (ICCT, 2015; SEBRAE, 2015).

The results of both countries for each key dimension are discussed in more detail below.

4.1 Technology and Innovation (T&I)

As highlighted in the introduction of this study, in a country, the national innovative capacity depends on commitment to innovation projects, the innovation environment, the strength of relation between infrastructure and industrial side, the intensity of financial and human resources, and technological capacity (Furman & Hayes, 2004; Porter & Stern, 2002).As national innovative capacity is one of the main drivers for long-term economic growth, several countries have heavily invested in high-tech strategy and policies in order to try to increase it (Proksch, Haberstroh & Pinkwart, 2017).

Regarding T&I, France has its greatest scores (4,13), which could be partly explainedby the institution of the public-private VedeCom Institute which aimed to deliver an available autonomy by 2020.Also,Renault, one of the leading companies in the automotive sector, has a local project in Rouen with public and private authorities. Transdev, a transport operator, through this project, “aims to establish an on-demand mobility service on pre-set

routes and PSA Group joined in activities with start-ups AIMotive and nuTonomy.France ranks the 10 position on the Technology & Innovation pillar of KMPG Autonomous Vehicles Readness Index. The country is well rated on research and development hubs and in the World Economic Forum ratings (KPMG, 2018) and, also, in a recent rank published in the Journal Transport Reviews regarding the total number of academic publications on the scope of AVs, the country ranks the fourth position (Gandia et al., 2018).

As for Brazil results, that, similarly to France, the country also reaches its greatest scores (3,33) on this dimension. On the KPMG Index, Brazil shares the bottom spot with Russia on market share of electric cars which are not generally available, although hybrid cars are starting to be imported. It received the lowest scores on research and development hubs, AV technology company headquarters, patents and investments (KPMG, 2018, p.33). The World Economic Forum's Global Competitiveness Report (WEF, 2018) named Brazil as best in its region in terms of innovation capability - though it noted that the country remains below its potential.

It is worth remembering that this dimension also contemplates the issue of data management and security, a topic that has been widely discussed. Nowadays, the vehicle is becoming the fourth screen for information, entertainment and communications, generating increasing amounts of data, raising questions about ownership and security (WEF, 2019). Vehicle security is a real issue; such systems will need to be much more robust than those offered in today's vehicles. Hackers could gain access to the vehicle's control system and cause a vehicle to accelerate, brake, or maneuver unexpectedly causing a vehicle crash. Today's vehicles are designed to protect against these types of intrusions. However, the hardware does not consistently protect against threats such as hackers. The mean time between failure (MTBF), a measure of the reliability of a hardware component, for security systems is far too high to be commercially viable today.

4.2 Social and Political Environment (S&P)

Regarding the relationship between AVs and the social and political environment surrounding it, there are some important questions to discuss such as "How disruptive will these vehicles actually be in transforming the city of today?" And "how can city governments take advantage of autonomous technology to achieve broader goals with regard to urban mobility and livability?" And also "How much control and regulatory influence does the city

take in shaping mobility flows and shifting the modal mix?" "Which data sets are needed to make the right investment decisions?" (WEF, 2018, p.26).

AVs have the potential to catalyze the greatest transformation in urban mobility since the creation of the automobile. However, their social benefits can be unlocked only if governments understand and implement the appropriate policies and governance structures "*Cities, nations, and the world will need to embrace a regulatory and governance framework for AVs that nudges us towards an "AV heaven" scenario and away from "AV hell*" (WEF, 2018, p.5).

Regarding the framework's scores, the dimension 'Social and Political Environment' is one of the weakest, for both countries. (Brazil – 2,34 / France – 3,23)

According to the World Economic Forum's Global Competitiveness Report (WEF, 2018) Brazil ranked 111th out of 140 countries in terms of reliability of police services, 124th in terms of the efficiency of its legal framework in settling disputes, 83rd in terms of freedom of the press, 133rd in terms of homicide rate, and last in terms of the burden of government regulation. Brazil's government was also deemed among those least "future-ready" according to the report, and overall the country slipped three places compared to the prior iteration of the ranking, to 72nd place.

In this sense, as stated by Mauricio Endo, head of Government & Infrastructure, KPMG in Brazil,

> "In terms of specific regulation, we haven't seen discussions on AV but there is a new automotive sector regulation called 'Rota 2030' being discussed by government, which may include some initial related topics. AV discussions are starting in forums and events related to the automotive and telecom industries, but we still haven't seen city authorities or governments planning around it"(KPMG, 2018, p.33).

France has a legal framework adopted to allow the testing of driverless cars on public roads in 2015, which was broadened the following year. Along with Germany, the French government has announced plans to test self-driving vehicles on a cross-border road from Metz in France to Merzig in Germany. However, the country is rated poorly for government capabilities by KPMG's Change Readiness Index. In fact, the dimension "Law & Liability" is the one with the lowest score (2,90) between all the 16 dimensions for this country.

4.3 Consumer and Market (C&M)

The dimension Consumer and Market presents the second highest rate for both countries (Brazil – 2,95 / France - 3,38).

Consumer openness and acceptance is a potentially big barrier to the insertion of AVs. Consumers have their own perspective, centered on optimizing the balance of convenience, cost, and environmental impact when making mobility decisions. Questions such as "How can consumers understand and compare mobility alternatives and make integrated and informed decisions for their individual travel patterns?" or "How will society receive and react to such disruptive innovation that will fundamentally change the way we have mobility today?" make the consumer behavior a shrinking obstacle and one that will likely dwindle with experience and familiarity over time (BCG, 2016; DUP, 2016).

Brazil, a country of continental proportions, is internationally recognized by its population passion for cars. Indeed, the car is one of the most beloved items by Brazilians and goes much further than a simple transportation tool. When buying a car, it is also bought an idea linked to social status, glamour, and power; therefore, automakers have been investing heavily in this extremely promising market. In fact, consumer data from KPMG suggests that:

> "Brazilians are the keenest of all those in the 20 countries on AV technology, mobile phone penetration is more than 100 percent of the population and Brazilians are known for being early adopters of new technologies. Despite this, the country gets the lowest rating for people's use of technology in KPMG's Change Readiness Index, which measures specific factors including internet access in schools and the use of mobile phones to pay utility bills" (KPMG, 2018, p.33).

Similarly to KPMG's outcomes, on Brazil's Innovation Radar, the dimension Consumer Behavior is one of the highest scores (2,70), being almost equal than the French score (2,90). At the French side, consumers are fairly enthusiastic about AV technology, but the country has a middling score on people's technology use in KPMG's Change Readiness Index research (KPMG, 2018).

At this point, it is important to understand the difference between the concepts 'willingness' and 'awareness'. When we talk about the willingness to ride (that it is higher in Brazil), we are only considering if these consumers are keen to try the AVs, without measuring or considering their maturity and awareness about all the AVs implications. According to the BCG report, the relationship between knowledge (awareness) and openness

(willingness) is inversely proportional: the more conscious and mature the consumers are, the less open they will be to accept / test the AVs (BCG, 2016).

Another important dimension to be discussed refers to the necessary partnerships between the different types of stakeholders that are involved in the AVs insertion. "*In the new mobility ecosystem, value creation opportunities will likely require stakeholders to rethink their business models*" (DUP, 2016). In this context, WEF Report (2018) points out that policy makers, consumers and mobility providers are key stakeholders that have different interests and incentives, in this sense, it is essential to have a holistic view and a multi-stakeholder approach.

4.4 Infrastructure and Patterns (I&P)

It's a consensus that cities worldwide need to develop a strategy for moving towards an integrated mobility platform (WEF, 2018). Numerous trends, ranging from energy decentralization to the Internet of Things, are likely to come together to create drastic changes in mobility systems over the next 10 to 15 years.

I&P is responsible for Brazil's worst score (1,79).In this sense, as pointed out by Bagloee et al. (2016, p.290):

> "Third world countries struggle with a lack of transportation infrastructure, such as roads, bridges, and public transport, which is impeding their economic development. Adoption of AVs by these developing countries may spare them the costs associated with expanding capital-intensive infrastructure. A similar paradigm was seen when developing countries leap-frogged over to mobile phone technology which exempted them from expensive landline infrastructure."

In fact, the WEF report Mapping Global Transformation points out that the country's infrastructure gap as one of the key issues for analysis. However, the same report points out that Brazil serious infrastructure needs may be an attractive location for related investment (WEF, 2019).

Also, with regard to infrastructure, it should be noted that road modal in Brazil is the country's main logistics system. According to CNT Transportation Yearbook (CNT, 2016), the country has a network of 1,720,643.20 kilometers (1,069,157.79 miles) of national roads and highways (the fourth largest in the world), accounting for more than half (approximately 56%) of all cargo transported in Brazil, being also the system of highways the main means of passengers' transportation in the country.

Still based on CNT (2016) data, about 10,000 kilometers (6,213.71 miles) of the highway system are composed of motorways, mainly in the state of São Paulo. However, about 30% of the entire Brazilian road network is badly damaged by the lack of maintenance and only 210,618.80 kilometers (130,872.414 miles) are currently paved. As a way of supporting the infrastructure of the sector, according to the Petroleum, Natural Gas, and Biofuels Statistical Yearbook (ANP, 2016), there are 40,802 automotive fuel retailers spread around the country.

Still in terms of infrastructure, concerning the connection capacity, according to KPMG report, Brazil has a good coverage of 4G (more than 90 percent of cities are covered), but very few electric charging stations and only Russia has worse roads. Corroborating with these appointments, the IR dimension 'Roads Infrastructure' is responsible for the worst score.

Regarding France, this dimension is also responsible for the lowest score (2,93). This fact is corroborated by the outputs of KPMG report were the country is credited with having excellent roads and good road infrastructure, but poor 4G coverage and a low density of electric charging stations (KPMG, 2018).

Another important aspect to be discussed here is the standardization issue: the growth of automotive connectivity and electronics calls for new global standards in the country (WEF, 2019):

> "When shopping for cars, people are faced with a web of varying specifications that have resulted in different plug types for the charging of different electric vehicles, different data formats for points of interest on maps for different cars, and varying data security standards. This mix of standards hinders car buyers' interest in related features. The next generation of connected vehicles would therefore benefit from a common set of technical specifications. This will only become more imperative amid the evolution of technologies such as vehicle-to-vehicle communication, and hands-free calling" (WEF, 2019).

Thus, AVs and its background of infrastructure will require much more than contemporary vehicles and patterns. According to McKinsey (2018), this demand "will boost the uptake of vehicle-to-infrastructure technologies to enable aspects such as road pricing, traffic flow optimization, and accident prevention systems". In this sense, mobility infrastructure will be inserted in a broader system and its function will, increasingly, mix physical and software components, delivering value as a service.

5 CONCLUDING REMARKS

Obviously, no one can predict the future. However, the advancing of autonomous technology is fast and it brings complex and multifaceted impacts to many parties, such as markets, consumers, auto industry, technology industry, urban planners, governments, and policymakers. In this regard, taking a look into the future is necessary as a way to understand and plan improvements for urban life and for policy (BCG, 2016). In other words, even if the future is not set, we need to prepare for the outcomes, not wait for it (McKinsey, 2018).

Hence, the main contribution of this work is the integration of data and information from different sectors (social, political, economic, technological, and structural) of a given country, making it possible to map, discuss, and delve deeper about the real situation for the insertion of the AVs.

We sought to fill a gap in the literature, related to the definition, adequacy, and application of an artifact to support the insertion and management of a disruptive innovation in a country. Finally, there is a proposal for methodological advancement, associated to critical success factors, with an empirical approach and easy adaptation and application around the world. A radar framework to identify CSF to be used in order to contribute to processes related to innovative capacity, governance and market reach efficiency, and effectiveness in the current and real context of the countries.

Although some studies and research present - in a partial and generalized way - some determinant factors for the insertion of the AVs in a country, there is a need to obtain a clear and assertive diagnosis that allows the formulation of guidelines and actions for capacity development of a country. The results obtained in Brazil and in France were crossed with official data and statistics and corroborate the use of this tool.

As for future studies we suggest to extend the data collection to other countries and also, based on the outputs of this research, a future agenda must include the elaboration of key guidelines for AVs governance, including short, middle, and long term actions and requirements for the complete and successful insertion of AVs in the countries.

REFERENCES

ANP - Agência Nacional do Petróleo, Gás Natural e Biocombustíveis (2016). *Anuário Estatístico Brasileiro do Petróleo, Gás Natural e Biocombustíveis* [Statistical Report]. Available at: <http://anp.gov.br/wwwanp/images/publicacoes/Anuario_Estatistico_ANP_2016.pdf> Access in: 12/09/2016.

Attias, D. (2016). *The Automobile Revolution: Towards a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Attias, D., & Mira-Bonnardel, S. (2016). Extending the Scope of Partnerships in the Automotive Industry between Competition and Cooperation. In: Attias, D. (2016). *The Automobile Revolution: Towards a New Electro-Mobility Paradigm.* (1st ed.). Gewerbestrasse (Switzerland): Springer International Publishing.

Bagloee, S. A., Tavana, M., Asadi, M., & Oliver, T. (2016). Autonomous vehicles: challenges, opportunities, and future implications for transportation policies. *Journal of Modern Transportation*, *24*(4), 284-303.

BCG. Self-Driving Vehicles, Robo-Taxis, and the Urban Mobility Revolution. The Boston Consulting Group and the World Economic Forum. 2016. From: https://www.bcg.com/pt-br/publications/2016/automotive-public-sector-self-driving-vehicles-robo-taxis-urban-mobility-revolution.aspx.

Barquet, A. P. B., de Oliveira, M. G., Amigo, C. R., Cunha, V. P., & Rozenfeld, H. (2013). Employing the business model concept to support the adoption of product–service systems (PSS). *Industrial Marketing Management*, *42*(5), 693-704.

Burns, L., Jordan, W., & Scarborough, B., (2013). *Transforming personal mobility*, Broadway NY: Columbia University.

Cavazza, B. H., Gandia, R. M., Antonialli, F., Nicolaï, I., Zambalde, A. L., Sugano, J. Y., & Miranda Neto, A. (2017). Managment and Business of Autonomous Vehicles: a systematic integrative bibliographic review. *Proceedings of the European Conference on Innovation and Entrepreneurship*, [ECIE]. Paris, France, 12.

Christensen, C. M. (1997). *The Innovator's Dilemma*: When New Technologies Cause Great Firms to Fail. Boston: Harvard Business School Press.

Christensen, C. M., & Raynor, M. E. (2003). *The Innovator's Solution*: Creating and Sustaining Successful Growth. Boston: Harvard Busniess School Press.

CNT - Confederação Nacional do Transporte (2016). *Anuário CNT do Transporte: estatísticas consolidadas 2016* [Statistical Report]. Available at: <http://anuariodotransporte.cnt.org.br/Inicial>Access in: 12/09/2016

Enoch, M. P. (2015). How a rapid modal convergence into a universal automated taxi service could be the future for local passenger transport. *Technology Analysis & Strategic Management*, *27*(8), 910-924.

Fagnant, D. J., & Kockelman, K. (2015). Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations. *Trasponrtation Research Part A: Policy and Practice*, *77*, 167-181.

Frazzoli, E., Dahleh, M. A., & Feron, E. (2002). Real-time motion planning for agile autonomous vehicles. *Journal of Guidance, Control, and Dynamics*, *25*(1), 116-129.

Gandia, R. M., Antonialli, F., Cavaza, B. H., Miranda Neto, A., Lima, D. A., Sugano, J. Y., Zambalde, A. L., & Nicolai, I. (2017). Autonomous vehicles: Scientometric and bibliometric studies. In: *Gerpisa International Colloquium: R/Evolutions*. New technologies and services in the automotive industry. Paris. 25.

Gandia, R. M., Antonialli, F., Cavazza, B. H., Neto, A. M., Lima, D. A. D., Sugano, J. Y., Nicolaï, I. & Zambalde, A. L. (2018). Autonomous vehicles: scientometric and bibliometric review. *Transport Reviews*, 38, 1-20.

Gil, A. C. (2008). Métodos e técnicas de pesquisa social. 6. ed. Editora Atlas SA.

Guerra, E. (2016). Planning for cars that drive themselves: Metropolitan Planning Organizations, regional transportation plans, and autonomous vehicles. *Journal of Planning Education and Research*, *36*(2), 210-224.

ICCT - International Council on Clean Transportation – (2015). Brazil Passenger Vehicle Market statistics: international comparative assessment of technology adoption and energy consumption [White Paper]. Available at: <http://www.theicct.org/sites/default/files/publications/Brazil%20PV%20Market%20Statistics%20Report.pdf> Access in: 12/09/2016.

Johnson, M., Mena, C. (2008). Supply Chain Management for Servitized Products: a multi-industry case study. *International Journal of Production Economics*, *114*(1), 27-39.

King, S. F., & Burgess, T. F. (2008). Understanding success and failure in customer relationship management. *Industrial Marketing Management*, 37(4), 421-431.

Kowalkowski, C. (2010). What does a service-dominant logic really mean for manufacturing firms? *CIRP Journal of Manufacturing Science and Technology*, *3*(4), 285–292.

KPMG (2018). *Autonomous Vehicles Readiness Index.* Assessing countries' openness and preparedness for autonomous vehicles. KPMG International.

Manzini, E., &Vezzoli, C. (2003). A strategic design approach to develop sustainable product service systems: Examples taken from the "environmentally friendly innovation" Italian prize. *Journal of Cleaner Production*, *11*(8), 851–857.

Markides, C., & Geroski, P. (2005). *Fast Second*: How Smart Companies Bypass Radical Innovation to Enter and Dominate New Markets. San Francisco: Jossey-Bass.

McKinsey (2018). Self-driving car technology: When will the robots hit the road? Access in 31-01-2019 https://www.McKinsey.com/industries/automotive-and-assembly/our-insights/self-driving-car-technology-when-will-the-robots-hit-the-road#0

Muller, J. (2012). Why The World's Automakers Love Brazil. *Forbes Magazine*. Available at: <http://www.forbes.com/sites/joannmuller/2012/10/05/why-the-worlds-automakers-are-loving-brazil/#284dea0bc20f> Access in: 12/09/2016.

Mutz, F., Veronese, L. P., Oliveira-Santos, T., Aguiar, E., Cheein, F. A. A., & Souza, A. F. (2016). Large-scale mapping in complex field scenarios using an autonomous car. *Expert Systems with Applications*, *46*, 439-462.

OECD - Organization for Economic Cooperation And Development (2005). /Eurostat. *Guidelines for Collecting and Interpreting Innovation Data* — The Oslo Manual, 3rd ed. Paris: OECD.

Poorsartep, M. (2014). Self-Driving Cars: Radical Innovation in the Transportation Industry. In: Christiansen, B., Yildiz, S., Yildiz, E. (2014). *Transcultural Marketing for Incremental and Radical Innovation.* (1st ed.). Hersey (Pennsylvania): IGIGlobal.

Poulain, B. (2017). State-of-the-art: Product and service systems modelling [Working Paper Nº 01]. *École Centrale Paris*, Châtenay-Malabry, France.

Proksch, D., Haberstroh, M. M., & Pinkwart, A. (2017). Increasing the national innovative capacity: Identifying the pathways to success using a comparative method. *Technological Forecasting and Social Change*, 116, 256–270. doi:10.1016/j.techfore.2016.10.009

Sawhney, M., Wolcott, R. C., &Arroniz, I. (2006). The 12 different ways for companies to innovate. *MIT Sloan Management Review*, *47*(3), 75.

Schellekens, M. (2015). Self-driving cars and the chilling effect of liability law. *Computer Law & Security Review*, *31*(4), 506-517.

Schreurs, M. A., Steuwer, S. D., (2015). Autonomous Driving – Political, Legal, Social, and Sustainability Dimensions. In: Maurer, M., Gerdes, J.C., Lenz, B., Winner, H. (Eds.) (2015). *Autonomous Driving: technical, legal and social aspects*. Berlin: Springer. pp. 149–171.

Selhofer, H., Arnold, R., Lassnig, M., & Evangelista, P. (2012). Disruptive Innovation: Implications for Competitiveness and Innovation Policy. *INNO-Grips–Global Review of Innovation Policy Studies http://www. proinnoeurope. eu/innogrips2.* Retrieved: January, *9*, 2017.

SEBRAE- Serviço Brasileiro de Apoio às Micro e Pequenas Empresas (2015). *Mercado Automotivo no Brasil: panorama do setor* [Electronic Bulletin]. Available at:

<http://www.bibliotecas.sebrae.com.br/chronus/ARQUIVOS_CHRONUS/bds/bds.nsf/f9087ff9c7f6da378eb8fb1f151fc79e/$File/5792.pdf> Access in: 12/09/2016.

Schumpeter, J. A. (1942). *Creative destruction.Capitalism, Socialism and Democracy*, 825 p.

Schumpeter, J. A. (2009).*Can capitalism survive?: Creative destruction and the future of the global economy*. New York: Harper Perennial.

Tukker, A. (2004). Eight types of product– service system: eight ways to sustainability? Experiences from suspronet. *Business Strategy and the Environment*, *13*, 246-260.

Wong, M. T. N. (2004). Implementation of innovative product service systems in the consumer goods industry. Doctoral dissertation, University of Cambridge, Cambridge, United Kingdom.

World Bank. (2017). World Development Report 2017: Governance and the Law. Washington, DC: World Bank. doi:10.1596/978-1-4648-0950-7. License: Creative Commons Attribution CC BY 3.0 IGO

WEF - World Economic Forum - (2018). Reshaping Urban Mobility with Autonomous Vehicles Lessons from the City of Boston. Available in https://www.weforum.org/reports/reshaping-urban-mobility-with-autonomous-vehicles-lessons-from-the-city-of-boston. Access in: 4th February, 2019.

WEF - World Economic Forum - (2019). Mapping Global Transformation - Brazil. Available in https://toplink.weforum.org/knowledge/insight/a1Gb0000000LPqYEAW/explore/summary. Access in: 4th February, 2019.

Wu, J., Ma, Z., & Zhuo, S. (2017). Enhancing national innovative capacity: The impact of high-tech international trade and inward foreign direct investment. *International Business Review*, *26*(3), 502–514. doi:10.1016/j.ibusrev.2016.11.001.

Zakharenko, R. (2016). Self-driving cars will change cities. *Regional Science and Urban Economics*, *61*, 26-37.

Appendix I

Name (or initials):_____. E-mail: _____

Country:_____Working Area:_____

Occupation: _____

This research seeks to test a theoretical model of the innovation radar for the insertion of Autonomous Vehicles (AV's - higher levels of automation – 4 and 5) as a Product Service System (PSS) based on the Critical Success Factors (CSF).

This theoretical model highlight 16 Critical Success Factors for the insertion of AV's in a given country and explore the relation between each other. The framework presents 4 key dimensions that works like a anchor: (1) Technology and Innovation, (2) Social and Political Environment (3) Consumer and market, (4) Infrastructure and Patters. Between these four anchors, we embed 12 other dimensions of the innovation system that can serve as avenues of pursuit.

The figure below shows the proposed framework of the innovation radar:

KEY DIMENSION 01	TECHNOLOGY AND INNOVATION
GUIDELINES	In a knowledge-based economy, technology is an important resource to create innovation. In this sense, considering technological assets and requirements, it is fundamental to pay attention to policies and patterns in order to achieve specific goals and to benefit the society. We highlight certification and homologation as key aspects related to this dimension's Critical Success Factors in a sense that they can assure the perfect functioning of AVs) as a PSS.

1.1 Technological Capability (please, read the text above before answer this questions)
It is referred to knowledge and competences to technology transfer, Information and Technology leadership, technology innovation and Information and Communication Technology (ICT)/Information Technology System (ITS) technologies.

I. My country is capable of supplying demands related to knowledge and competences in hardware, software and especific management and processes.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

II. My country is capable of developing, creating, arranging or offering data and information in order to provide an optimized function to AVs as PSS.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

1.2 IT Standards (Hardware and Software) (please, read the text above before answer this questions)
Considering that in the related hardware and software system that configure AVs as PSS, are resource that needs to be written and read frequently with accuracy.

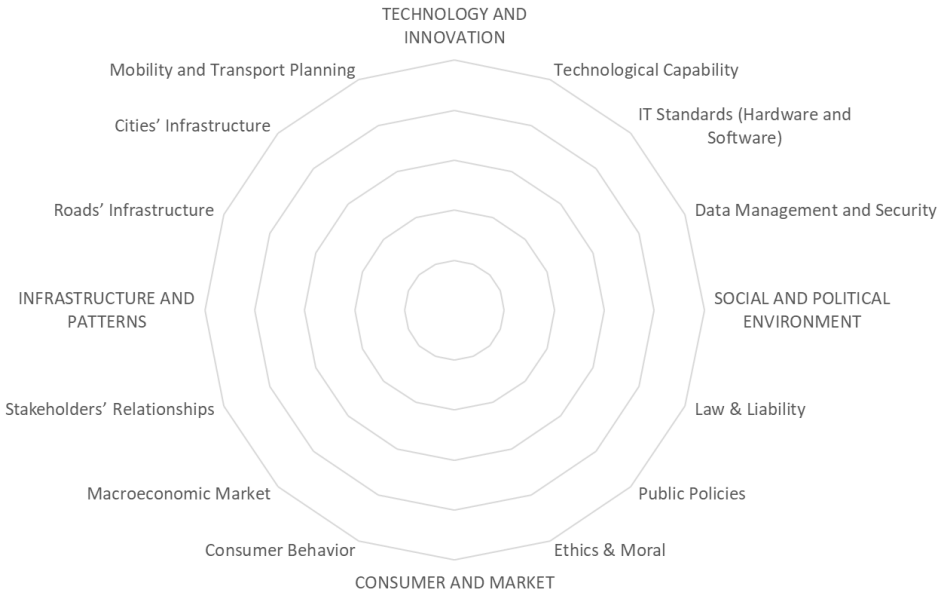
I. My country has been developing IT artefacts and standards for hardware (electronics and equipments) as a way to guarantee the PSS's function.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

II. My country has been developing IT artefacts and standards for software (computer systems) as a way to guarantee the PSS's function.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

1.3 Data Management and Security (please, read the text above before answer this questions)
Data management and security have to be based on quality and standard as main aspects to data sharing and exchange.

I. My country is able to implement management systems in order to provide data security and protection in terms of confidentiality and integrity.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

II. My country is able to implement management systems in order to provide data security and protection in terms of availability and authenticity
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )



Product-Service System (PSS) is a solution combining product (s) and service (s) aiming at the fulfilment of user's needs or of a given function (Poulain, 2017). In other words, product Service-Systems (PSS) may be defined as a solution offered for sale that involves both a product and a service element, to deliver a required functionality (Wong, 2004). For example: product leasing; sharing or pooling. Considering that Critical Success Factors are determinant for the insertion of a product/service in the market, how is the condition of these success factors related to the insertion of AVs as a PSS **in your country**?

KEY DIMENSION 02	SOCIAL AND POLITICAL ENVIRONMENT
GUIDELINES	The presence of different stakeholders increases the complexity of a system. In this sense, it is essential to manage questions related to the social and political context. Political support, social support and governance are needed to determine legal and political conditions of a country as well as political-economic initiatives (financial and non-financial?).
2.1 Law & Liability **Harmonized regulations are essential for the functioning of AVs as PSS. Basically, legal framework is a fundamental source of security in the new context promoted by the PSS.**	
I. My country has reviewed the current legal framework in order to verify to what extent it is adapted for the deploying AVs as a PSS. (Aspects as services agreements, data sharing, and the relation among stakeholders are encompassed in this legal framework). Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
II. The existing legislation in my country is sufficient to determine aspects of liability in cases of AVs as a PSS. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
2.2 Public Policies **The government has a fundamental role in regulating and standardizing the structure needed for AVs' insertion. Governments should treat public policies as crucial strategical assets that ensure investors' attractiveness as well as to improve the competitiveness of the country.**	
I. My country has public polices related to governmental practices, such as economic incentives and tax advantages, that work as guidelines to promote a regulatory environment to support the implementation of AVs as PSS. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
II. Questions related to certification and homologations have been addressed in these governmental practices. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
2.3 Ethics & Moral **Culture is a background related to a value system based on shared norms and beliefs which are variable according to the context**	

I. Ethics and moral aspects related to the insertion of AVs have been discussed by authorities, academics and practitioners in my country.	
KEY DIMENSION 03	**CONSUMER AND MARKET**
GUIDELINES	Market is an aspect that is embedded by several factors because it is related to many different stakeholders, which have different goals a activities. Here, the main idea is: stakeholders need to be managed, macroeconomic objectives must be aligned in order to develop a viable a attractive environment, and the cultural background must be considered in strategies to promote and improve consumers' behavior that bene from the insertion of AVs as PSS.
3.1 Consumer Behavior Related to the consumers' openness (willingness to ride a car without a driver and / or share a car with other people, mindset shift and trust).	
I. My country's society has enough information about AVs and all their implications and dynamics. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
II. The consumer market of my country is open to test/experience/adopt disruptive innovation such as AVs. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
3.2 Macroeconomic Market An stable macroeconomic condition is related to the existence of economic policies and a favorable legal framework as a way to designate an appropriate risk allocati providing sources of benefits for multiple objectives.	
I. The macroeconomic market is attractive to investments and initiatives related to the insertion of AVs. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	
II. Considering market barriers as a) factors' conditions, b) demands' conditions, c) related and supporting industries, and d) firm strategy, structure and rivalry, macroeconomic market is open to investments and initiatives related to the insertion of AVs. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )	

3.3 Stakeholders' Relationships In a national context there is broader stakeholders' involvement because the extent of projects demands different partnerships among them. We highlight here specially the pub sector; private sector, society and academy
I. There are initiatives that involves one or more of these stakeholders (public sector, private sector, society and academy) in order to promote the insertion of AVs in integrated way. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )
II. There are governance programs that includes management of these stakeholders' relationships. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )
II. My country has integrated ethical / moral issues into the regulation of AVs. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

KEY DIMENSION 04	INFRASTRUCTURE AND PATTERNS
GUIDELINES	AV as a PSS will connect with its surrounding ecosystem and infrastructure, that is, other transportation models, users' devices and other systems and services. In this sense, considering that changes and adaptations in different aspects of infrastructure will be necessary for the operation of AVs, countries must pay attention to physical and technological patterns to supply these new demands. The core premise related to this dimension's critical success factors is that is necessary to develop a systems' network.

4.1 Roads' Infrastructure
An intelligent environment is characterized by places with intensive use of technology and communication through three main areas: 1) internet of things (IoT); 2) path management and planning based on actions built by algorithms applied to the context; and 3) processing and analysis of a large amount of information (Big Data).

I. My country's roads are prepared to receive intelligent data systems related to AVs.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

II. In my country, there is an intelligent road environment (related to the capacity of communication between the infrastructure and the vehicle / persons, providing resources of the route - for example, state of the road, extended perception, speed limit, etc.)
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

4.2 Cities' Infrastructure
An intelligent environment is characterized by places with intensive use of technology and communication through three main areas: 1) internet of things (IoT); 2) path management and planning based on actions built by algorithms applied to the context; and 3) processing and analysis of a large amount of information (Big Data).

I. My country's cities are prepared to receive intelligent data systems related to AVs.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

II. In my country, there are cities with an intelligent environment.
Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

4.3 Mobility and Transport Planning
For the success of mobility projects, it is essential to plan transport and mobility based on a dynamic and integrated view.

I. In my country, the transport's routes are simulated in order to create a synchro-modal transport network. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )
II. This plan encompasses customer’s preferences, routes, and available resources from data obtained from transportation modes. Strongly disagree ( ) Disagree ( ) Neither agree nor disagree ( ) Agree ( ) Strongly agree ( )

Thank you! Any comments, suggestions or questions?