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Rodrigo Marçal Gandia, Ricardo B Veroneze, Fabio Antonialli, Bruna Habib Cavazza, Joel Yutaka Sugano, Cleber Castro, André Luiz Zambalde, Arthur Miranda Neto, Isabelle Nicolai

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## **The quintuple helix model and the future of mobility: The case of autonomous vehicles.**

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**Purpose:** 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 and have become focus of automotive industry R&D projects, being considered the most popular application in the recent history of such industry (Fan & Fang, 2016). Considering the rapid change imposed on such industry, and new players ready to shape the automotive industry of tomorrow (Attias, 2016), there are still a number of legal, ethical, social, environmental and market barriers to overcome. Within this perspective, the Quintuple Helix model emerges, aiming at broadening the synergy among social, industrial, academic, environmental and governmental interactions, to an extent that the sum of such actions should promote a system of knowledge cooperation in search of society's well-being. Quintuple Helix agents influence each other on knowledge sharing to promote sustainability by innovations that are pioneering and useful (Carayannis, Barth & Campbell, 2012). We realized that there is still a lack of coordination between companies, government, universities and even society so that these AVs bring economic, social and sustainable development for all. In this sense, Quintuple Helix model can fill up the gap among these agents. Thus, it remains to be known "when" and, most importantly, "how" this innovation will be disseminated. Therefore, this paper aims at understanding if the Quintuple Helix model can positively help in advancements of urban mobility from the insertion of AVs in the society. To this end, we drew five propositions: the relations among government (P1); companies (P2); academy (P3); society (P4) and; environment (P5), provide an advancement on urban mobility, based on the technological development of the AVs.

**Design:** We carried out a survey on academic articles, government and consulting firms reports, and various websites. The idea was to approach the mobility thematic based on the AVs and the Quintuple Helix. The intention was to seek a meaningful theoretical contribution that adds value to current thinking on the two themes, seeking to deepen knowledge and open research fields in both areas. Therefore, in addition to understanding and discussing both issues jointly, a framework will bring the results with the main practical implications found. From this framework, it was possible to see the real theoretical contribution of the Quintuple Helix in the urban mobility.

**Findings:** Considering mobility as an incisive aspect that impacts directly on people's routine, it is necessary to understand such concept from a more integrated and holistic perspective, in order to obtain strong and significant advances. We observed that governments of some countries offer fiscal support and create public policies to strengthen the relationship with the university and industry. As an example, some European countries are already dealing with regulation of incentives to the industry AVs. Regulation should ensure safety and monitor the development of such emerging industry, avoiding any market failures. These nations have created rules regarding prototypes that allow testing, licensing and operation of this technology on public roads. These changes, in turn, directly impact manufacturers in the automotive industry, as all actors must work together to implement a "common language" solution. Fournier (2014) showed that the automotive industry has entered a new era, in which the value creation relies entirely on the dynamic relations in an open ecosystem of innovation with moving boundaries in the

long-run. The automotive ecosystem sectors as diverse as consumers of electricity, society, other industries (software, telecommunications, financial services) and government (Rishi et al., 2008). This new era also includes the consumption perception that is different in each country, for instance in emergent nations (e.g. Brazil) the ownership of a car is perceived as status, independence and power. In this sense, it is also worth to understand the consumers' needs (Attias, 2016). AVs can reduce fuel consumption and pollution, moreover, this emerging technology promises several potential benefits, such as reducing collisions and deaths, reducing traffic congestion, improving mobility options for people incapable of driving and mitigating environmental impacts. Sustainability is a crucial desideratum for engineers and policy makers considering vehicle design, public versus private transportation, infrastructure manufacturing (Mladenovic & McPherson, 2016). In this regard, universities, in turn, may contribute to research on innovative prototypes in a collaborative development environment with companies. The academy plays a central role between the government and an industry, especially in car manufacturers. Universities from different countries are now cooperating with large programs involving both public and private actors for the development and application of automated mobility systems.

Practical Implications: We observed that the Quintuple Helix model contributes favorably to the future of urban mobility in which AVs' innovation is present. It is noteworthy that among projections and scenarios of the future of mobility (BCG, McKinsey, PWC) AVs are a key factor, even though this innovation is still surrounded by uncertainties. The synergy among agents proposed by Quintuple Helix model is essential for the impacts on the development of this innovation to be minimized, and although we observed the need for action of all agents, this was treated in a fragmented fashion on the documents and studies analyzed. It is understood that the technological development of AVs can be considered at a global level; however, in the case of urban mobility, local specificities should be taken into account, considering social and governmental particularities as determining factors for AVs dissemination. This study opens the discussions on the topic by demonstrating the importance of establishing the VAs' innovation in a synergistic way among all directly impacted agents (established by the Quintuple Helix model) in order to contribute positively to the future of mobility.