AUTONOMOUS VEHICLES FROM ANOTHER PERSPECTIVE – A LITERATURE ANALYSIS

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ABSTRACT

Autonomous vehicles are part of our everyday lives, but with the rapid development of technology, this will become more and more common. Research on self-driving cars will replace conventional vehicles not only in passenger transport but also in the transport of goods and industrial materials. Car companies and research institutes are conducting more and more research in the face of serious economic interests. This study analyses published papers on self-driving vehicles and their security issues. A more detailed analysis of the publication output of the last six years is also included. The analysis of the publications by country shows that the Asian region has invested considerable efforts in the research and development of self-driving cars and their safety issues in the last three years.

KEY WORDS

CLASSIFICATION

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INTRODUCTION

The mass emergence of self-driving cars will transform how we live and work. Related research suggests several positive consequences: shorter travel times, improved fuel economy, reduced traffic accidents and deaths, and fewer emissions. The world of self-driving cars is already here; only mass deployment is still to come. The world's leading car manufacturers are investing heavily to get this technology on the road as soon as possible. Of course, this expenditure is mainly in research and development, the results of which can be tracked in the publication of research results and publication output.

Self-driving cars and related fields have made significant progress in recent years. An increase in publications and a widening spectrum of research results have naturally accompanied this continuous development. By examining and analysing the scientific output on the subject, we can get an objective picture of the direction of research on autonomous cars and the importance of the topic. Research on self-driving vehicles examines the potential impact of the phenomenon from different angles and the consequences of the spread of autonomous cars.

The following change in research forecasts illustrates the evolution of technology and the pace of autonomous vehicle deployment. Prognoses in 2018 predicted sales of 8 million semi-autonomous (SAE Level 3, 4, and 5) vehicles by 2025 [1]. Statista's 2022 report predicts 10,5 million autonomous vehicles at Level 3 or above will be sold by 2025. Figure 1 shows Statista's forecast for the period 2019-2030. The report forecasts 58 million autonomous vehicles sold by 2030 [2].
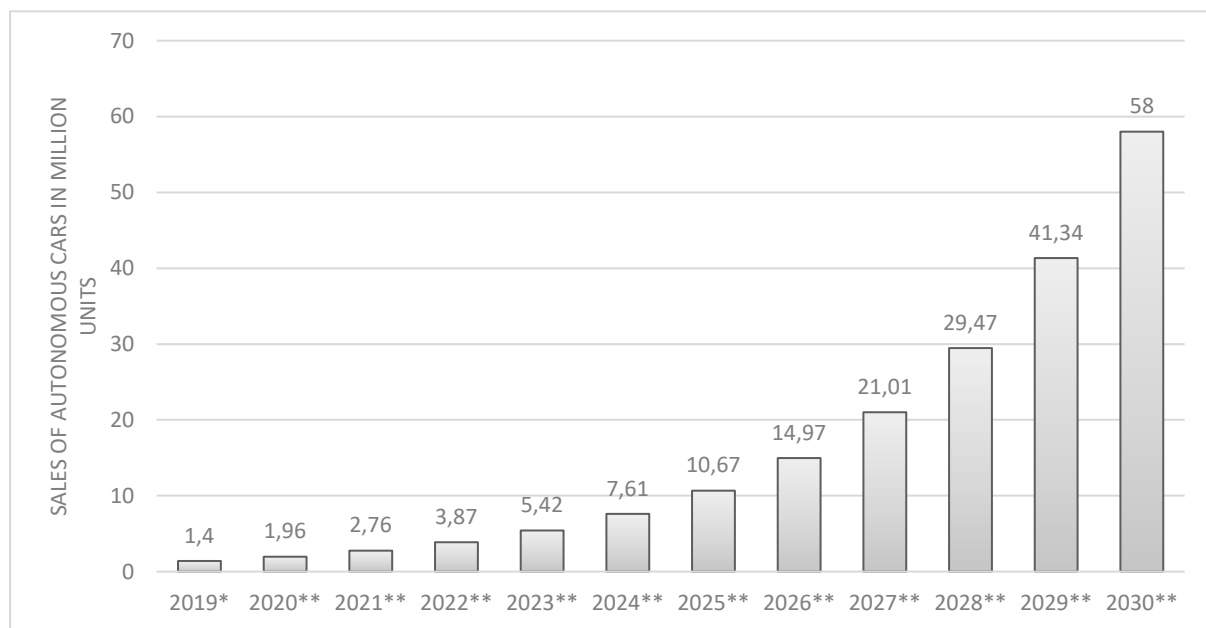

Figure 1. Projected sales of autonomous vehicles worldwide from 2019 to 2030 [2].

Several studies are looking at the issue of autonomous vehicles for transport and public transport. In this area, mass deployment of self-driving vehicles would make all aspects of transport much simpler and less polluting. In public transport, driverless subways, trains, and trams are already in operation in many countries, and an increasing number of city buses also carry passengers without drivers. The research has raised the following questions [3, 4]: Who are the current manufacturers of such vehicles? Is it possible to completely abandon traditional modes of transport? Where are driverless vehicles used today?

There is a growing amount of research into the development and evolution of autonomous vehicles, not independently but linked to each other and the related technologies. Cooperative

driving uses vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication technologies to implement cooperative functions such as sensing and manoeuvring. Researchers in this area are investigating the feasibility and development opportunities for the safe implementation of intelligent car parking, route changing and connecting, and crossroad management in the context of self-driving car cooperation [5, 6].

In recent years, several studies have focused on the potential impact of the spread of autonomous cars on the urban environment. These research directions are not only related to the effects on urban traffic rules or pedestrian traffic but also to urban planning, car sharing, or possible changes in the daily life of urban citizens. Autonomous vehicles are expected to revolutionise urban mobility with their improved sensing and navigation capabilities. Despite the expected benefits, this emerging technology has some implications for their use in mixed traffic flows in cities. A systematic literature review has also been published to map the research field. Some researchers have examined the impact of the spread of autonomous cars on urban planning, urban infrastructure and through this, the daily lives of people living in cities [7-9].

Research is being carried out in some related areas to assess the public perception of self-driving vehicles. The results of a 2018 survey showed that autonomous cars are perceived as a low risk means of transport. However, autonomous cars were also perceived as riskier than autonomous trains already in use. The research looked at how gender and age affect attitudes toward self-driving cars [10]. Attitudes toward self-driving vehicles were also examined in a survey in 2021. The outcomes showed that around 47 % of respondents would be willing to use a semi-autonomous car, while around 44 % of respondents expressed a willingness to use a fully autonomous car, Figure 2 [11].
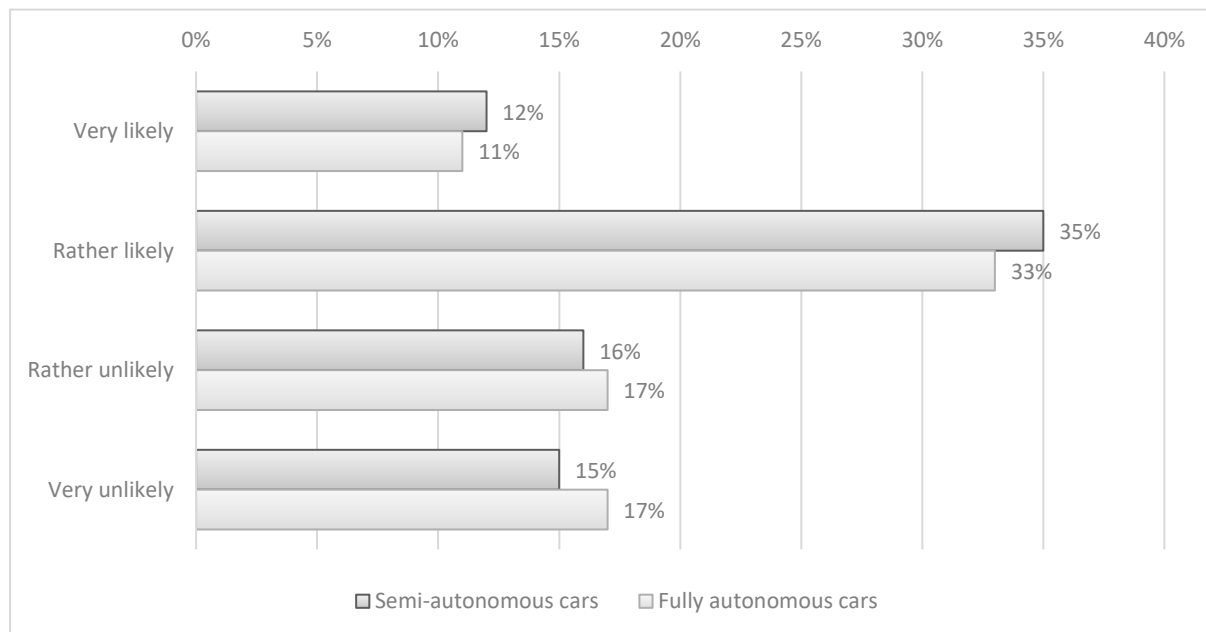

Figure 2. Willingness among customers worldwide to use fully autonomous or semi-autonomous cars in 2021 [11].

Several research projects have been launched to address the problems faced by some segments of society concerning self-driving vehicles. Some research in the field of autonomous vehicles, including self-driving cars, addresses the travel problems of people with disabilities. One example is a systematic literature review in which the authors examined the grey and academic literature on autonomous vehicles for people with disabilities [12].

MATERIALS AND METHODS

The research is based on a bibliometric analysis of the literature using scientific and statistical database and the Zotero reference management software. The primary data source used in the study was the Scopus database, where two search queries were conducted.

CRITERIA AND LIMITATIONS

The search was conducted in Scopus, one of the largest scientific bibliographic databases. For further analysis, the related data analysis platform SciVal was used.

As a first approach, the entire literature was examined, regardless of publication date. The following comparisons have been conducted for the last six years. Data for 2017-2019 and 2020-2022 were queried and analysed. The search queries were conducted on 9 February 2023.

The search in Scopus did not exclude conference proceedings or book chapters. All content indexed in Scopus was included in the analysis.

Several keywords (autonomous car, autonomous vehicle, unmanned vehicle, self-driving, and vehicle-to-vehicle) were defined to obtain relevant publications for this study. Additional keywords (car, cars, automobile) have been used to exclude possible erroneous results. In the second search query, keywords (safety, security, risk, data privacy, accident, pedestrian) related to safety and security were added to the term..

SEARCH QUERIES

The structure of the search queries was started by mapping the keywords most frequently used in the literature. The following search queries were used to conduct the analysis.

Scopus search query #1
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) PUBYEAR < 2023

Scopus search query #2
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data privacy OR pedestrian* OR safet*) PUBYEAR < 2023

The Scopus queries have been filtered into two more periods for institutional and country/region analysis. The two periods examined were 2017-2019 and 2020-2022.

Search query for SciVal #1
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR "Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data AND privacy OR pedestrian* OR safet*) PUBYEAR < 2023 AND PUBYEAR > 2012 AND PUBYEAR < 2022 AND (LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "re"))

Search query for SciVal #2
TITLE-ABS-KEY ("Autonomous car*" OR "Autonomous Vehicle*" OR "Autonomous Driv*" OR "Unmanned Vehicle*" OR "Autonomous Navigation" OR "Self Driv*" OR

"Vehicle To Vehicle Commun*") AND TITLE-ABS-KEY (car OR cars OR automob*) AND TITLE-ABS-KEY (accident* OR security OR cybersecurity OR risk* OR data AND privacy OR pedestrian* OR safet*) PUBYEAR < 2023 AND PUBYEAR > 2011 AND PUBYEAR < 2023 AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ch"))

OBJECTIVES

The following objectives have been identified when examining the data collected:

- to explore the growing literature on autonomous cars,
- to examine the volume of literature on self-driving cars related to safety and security,
- to examine the national and regional distribution of authors involved in research on autonomous cars,
- to analyse changes in the publication output over the last six years in representations of country/region.

RESULTS

The first defined search query (#1) from the Scopus database returned 16 854 results. The earliest record dates back to 1967, but only the last 15 years have seen a significant annual publication volume. Subsequently, the second search query (#2) was run in Scopus, which resulted in 3041 records. These data were used to analyse the distribution of published papers by year, country and affiliation.

Analysing the data on a yearly basis, it can be seen that the number of publications on the subject has been steadily increasing over the past 20 years. This is also true when looking at the results of the query on self-driving cars and the results of the query on the safety of self-driving cars. Figure 3 also shows the annual distribution of the two sets of results. The number of publications in 2012 has increased significantly by 2022.

The figure shows the percentage of publications on self-driving cars (#1) and the percentage of publications on the safety of self-driving cars each year. It can be clearly seen that the percentage of publications related to safety, protection, accidents, and risks of self-driving vehicles has risen to over 20 % in the last 10 years. To summarise, one in five publications on self-driving cars also deals with related safety issues.

An analysis of the results of the first query by country showed the nationality of researchers on self-driving cars in the period under review. This gives an insight into the countries where intensive research and development work on self-driving vehicles is ongoing. Figure 4 shows that American, Chinese and German researchers published most publications.

Figure 4 shows an interval of several decades. It is well known that a large amount of research has focused on self-driving cars in the last ten years, so it is worth looking at the country-specific approach in recent years. The changes have been analysed over two 3-year periods: 2017-2019 and 2020-2022. Figure 5 shows the distribution of publications on self-driving cars by country over the two periods. It can be clearly seen that there has been a significant change in the publication output in the Asian region over the last three years compared to the 2017-2019 period. While US researchers registered the highest share of publications between 2017 and 2019, 2020-2022 was dominated by publications from Chinese researchers.

The figure shows that the number of publications by Chinese researchers (*from 816 to 1831*) has increased by more than 120 % in the last three years, with much lower publication numbers, but the figure for Indian researchers shows an increase of more than 150 % (*from 286 to 740*). For US and German researchers, there is no significant difference in publication numbers between the two periods.
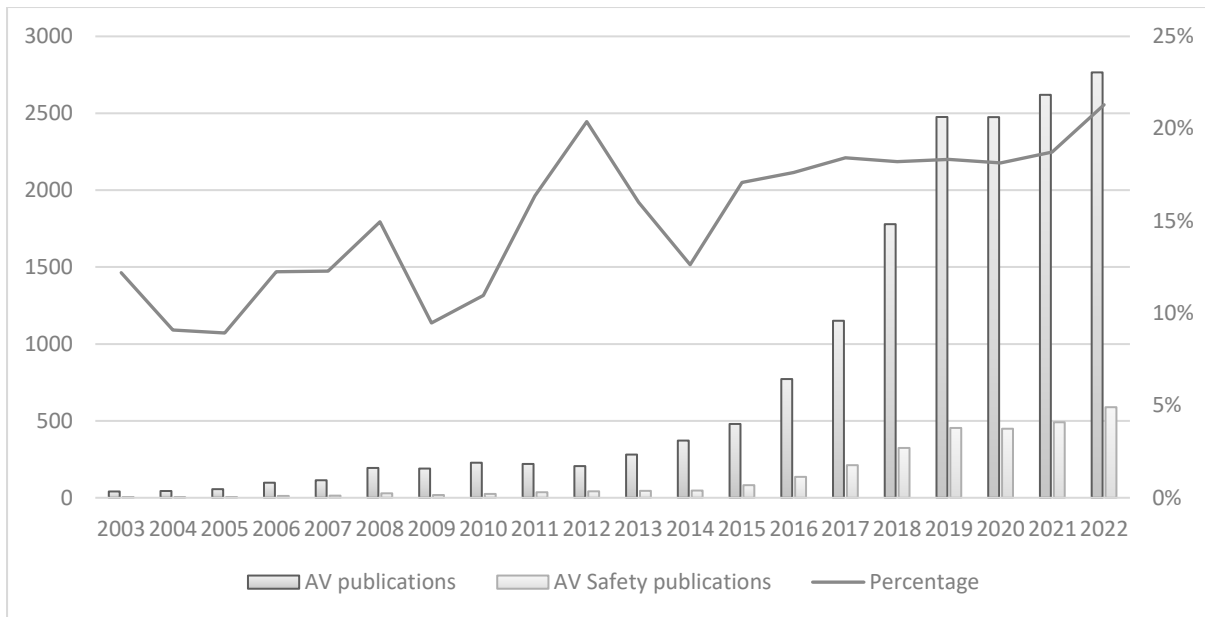
Figure 3. Number of publications / Comparison of the two search queries.
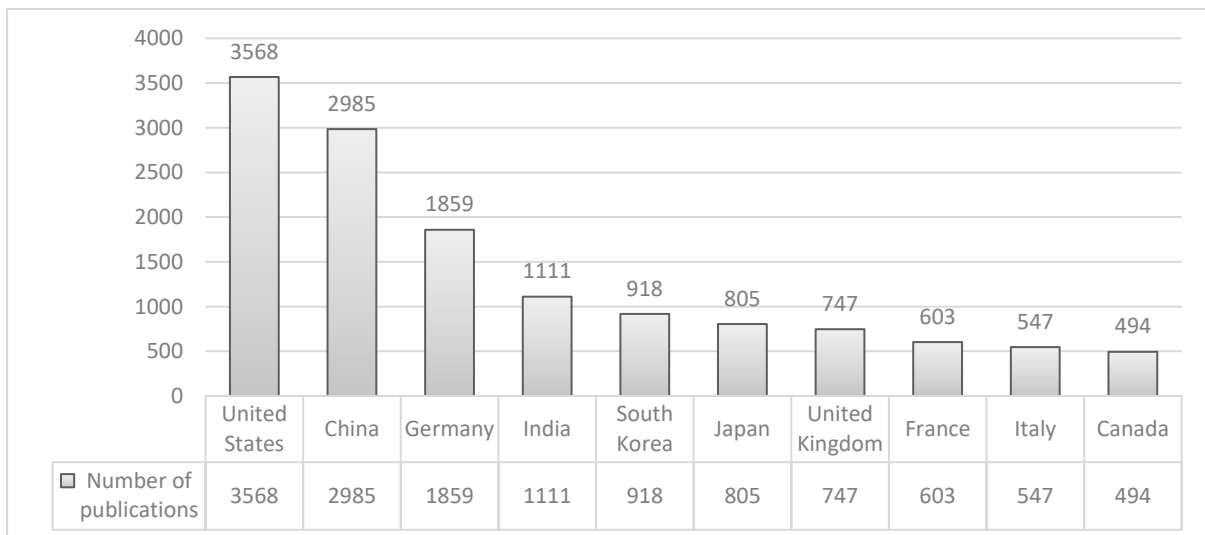

Figure 4. Number of publications by country (*search query #1*).

Figure 6 shows the second set of results (#2) from the same perspective. This figure shows even more clearly the trend already illustrated in Figure 5. The publication rates of Chinese and Indian researchers have increased significantly over the last three years compared to the 2017-2019 period. Similarly, to the results of the first search query (#1), no change in the publication numbers of US and German researchers is visible.

This study did not attempt to analyse the quality of publications, the only quality criterion being that the publication was indexed by Scopus.
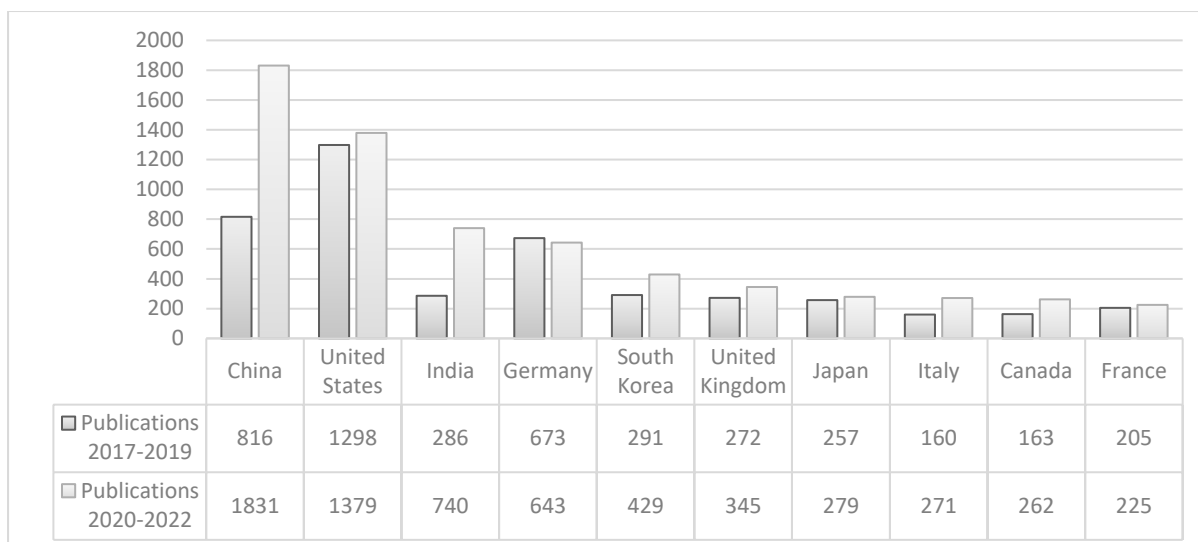
	China	United States	India	Germany	South Korea	United Kingdom	Japan	Italy	Canada	France
□ Publications 2017-2019	816	1298	286	673	291	272	257	160	163	205
□ Publications 2020-2022	1831	1379	740	643	429	345	279	271	262	225

Figure 5. Number of publications by country / 2017-2019 and 2020-2022 (*search query #1*).

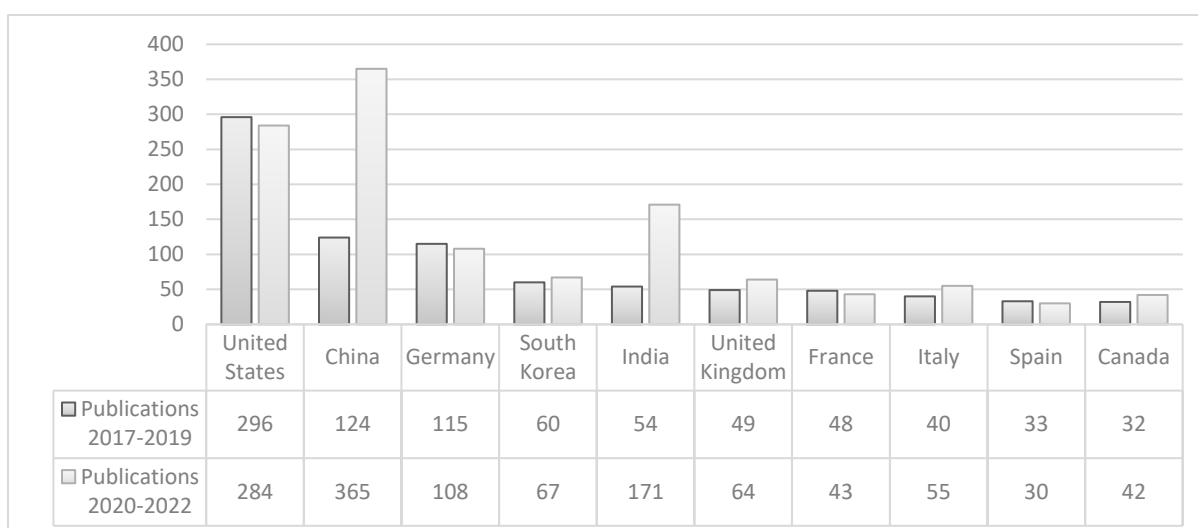|	United States	China	Germany	South Korea	India	United Kingdom	France	Italy	Spain	Canada
□ Publications 2017-2019	296	124	115	60	54	49	48	40	33	32
□ Publications 2020-2022	284	365	108	67	171	64	43	55	30	42

Figure 6. Number of publications by country / 2017-2019 and 2020-2022 (*search query #2*).

CONCLUSIONS

In this article, some research trends on self-driving cars are presented. The bibliometric analysis included an overview of publications on self-driving cars by year and by country. By analysing the publication data of the last six years, Asia is making significant efforts in the field of self-driving cars. China and India's research – in terms of numbers – has increased significantly in the last three years. Further analysis of the data from these two surveys is needed. The following research direction is to examine the publications by topic and to analyse and compare the published papers qualitatively. Since the Scopus database is the primary data source, the further scientometric analysis will be performed on the SciVal platform.

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