Why are Autonomous Vehicles Important? : With Focus on the Economic Impact and Rising New Industries*

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요 약

이 논문의 목적은 자율주행차의 중요성을 검토하고, 자율주행차의 보급으로 인해 어떤 산업이 확산되는지 그 경제적 효과를 분석하고자 한 것이다. 중요한 결론은 다음과 같이 요약할 수 있다. 자율주행차는 사물인터넷, 인공지능과 같은 4차 산업혁명을 이끄는 핵심적인 요인들과 밀접한 관련을 가지기 때문에 중요하다. 자율주행차는 여러 단계로 구분될 수 있지만 늘어드는 2035년까지는 대중화될 것이다. 자율주행차의 경제적 효과는 간접적 효과와 직접적 효과로 구분할 수 있다. 직접적 효과는 주로 비용의 절감과 관련되지만, 간접적 효과는 자율주행차의 보급으로 인한 산업의 변화와 밀접한 관련을 가진다. 이 두 효과를 모두 합한 경제적 혜택은 2050년까지 7조 달러에 달할 것으로 추정된다. 자율주행차의 확산은 자동차의 특성을 ‘자위의 상징’에서 ‘서비스의 일종인 이동성’으로 변화시킬 것이다. 이에 대한 가장 대표적인 사례는 이동하는 식당, 이동하는 편의점이 될 것이다. 자동차의 특성이 변화에 따라 정보와 오락이 결합한 인포테인먼트 산업, 이동성에 기반을 둔 산업, 데이터를 기반으로 한 산업들이 더 중요해질 것이다.

핵심 단어: 자율주행차, 경제적 효과, 이동성, 연결된 차, 더 오르는 산업

Abstract

The purpose of this paper is to identify the importance of AV and to analyze the economic impact of AV, identifying the rising new industries due to the AV’s proliferation. The main conclusion of this paper is summarized as follows. AV are important because they are intimately related with core factors of 4th industrial revolution such as Internet of Things and Artificial Intelligence. The development of AV is classified into several stages, depending upon technological advances. AV will be popular by 2035. Their economic impact will be classified into direct and indirect ones. The direct impact is intimately related with general cost reduction but, the indirect one with the change of industrial structure. Their total benefit will amount to $7 trillion by 2050. The proliferation of AV will change the characteristics of vehicles, from ‘Property as status symbol’ to ‘Mobility as a service’. The best examples are a moving restaurant and a moving convenient store. Therefore, infortainment industry, mobility-based industry and data industry will be more important than ever.

key words: autonomous vehicles, economic impact, mobility, connected cars, rising industries

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1. Introduction

Autonomous Vehicles (Hereinafter VA) are usually defined as follows: vehicles that can drive, accelerate, steer, brake and park on its own, without requiring the drivers’ assistance[1][2].

AV are intimately related with connected cars, which means cars are interconnected by the wireless Internet for the mutual exchange of information. For this reason, AV are sometimes called as CAV (Connected and Autonomous Vehicles). AV are also related with IoT (Internet of Things) since all the sensors embedded in or attached on cars are essential in AV, which will be explained in detail in the next chapter. As is well known, there are five or six levels of AV depending on the level of auto driving (See Table 1). Although the current level of AV is not level 5, it is predicted that fifth level AV will be available to the public by around 2020[1][2], and the potential economic impact will begin to occur (means that AV will be popular) in 2035 and proliferate globally by 2050[3].

The purpose of this paper, based on the above understanding, is to identify the importance of AV and to analyze the economic impact of AV, not by quantitative but by qualitative method, and finally to identify the rising new industries due to the AV’s proliferation. The research on these topics is not made extensively since AV are not popular yet. As a result, it is very difficult to find papers based on detailed quantitative method. For this reason, this paper will employ a qualitative method, which is based on review of various documents and related discussion.

[Table. 1] The levels of AV  Source: prepared by author using various sources

<table>
<thead>
<tr>
<th>The status of driving</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 0</td>
<td>non-automation NO autonomous driving system</td>
</tr>
<tr>
<td>Level 1</td>
<td>assist the driving Drivers always control the speed and direction of cars</td>
</tr>
<tr>
<td>Level 2</td>
<td>partly automation Drivers must give careful surveillance on driving conditions</td>
</tr>
<tr>
<td>Level 3</td>
<td>conditional automation Autonomous driving is possible on pre-determined conditions</td>
</tr>
<tr>
<td>Level 4</td>
<td>high automation Almost complete autonomous driving is possible on almost all road conditions</td>
</tr>
<tr>
<td>Level 5</td>
<td>complete automation Complete autonomous driving is possible</td>
</tr>
</tbody>
</table>
2. The Importance of AV from the perspective of 4th Industrial Revolution

When considering the current international discussion about 4th industrial revolution (hereafter IR), VA seem to be very important from the following perspectives.

First of all, AV will be a leading representative IT gadget in the coming decade, replacing the place of smart phone nowadays. VA are sometimes called a smart device (phone or pad) with four wheels. And, the difference between IT industry and car-manufacturing industry will be indistinct. As a result, we say that the age of 4th IR is that of convergence, meaning all kinds of industries are practically converged based on Information Technology.

Second, VA are very intimately related with Internet of Things. For their smooth driving, VA must collect lots of information surrounding cars with the help of sensors attached on the numerous parts of cars. VA are, so, a practical example for Internet of Things to be applied for driverless driving.

Third, VA are also a practical example for artificial intelligence (hereafter AI) to be applied for driverless driving. AI embedded on cars will control AV's driving by taking advantage of all data and information gathered by sensors attached on cars. AI will give directions on how to drive cars, i.e. accelerate, brake, park, and change lanes.

Fourth, it is natural to say that AV are best example to take advantage of big data since the smooth driving of AV requires all kinds of data, mentioned above. It is certain that these data have the form of big data. Without the help of big data, no smooth driving of AV.

Fifth, AV are one of the best example to show the importance of platform, where all kinds of data (big data) are gathered and new services based on big data will be provided by using relevant softwares. A company which occupies relevant platforms and softwares will have a dominant position in this industry. It is estimated that the portion of software in AV will be around 40%, while that is currently about 10%[4]. Moreover, it is predicted that operating system, similar to the case of the smart phone industries, will be installed in AV.

Sixth, AV are also an example to confirm the importance of contents. The proliferation of AV will provide lots of free time with commuters since they do not need to drive. Commuters will use their free time in consuming various contents including music, game, movies and entertainment. Thus, contents industry will be more important than car manufacturing industry in the coming decade. One study predicts that the value of contents in the automotive industry could shift from minimal to almost 20% of the value of the car (over $6,000 for the average cost of a car, 2014)[4].
3. The general Economic Impact of AV

It is well known fact that the proliferation of AV will directly reduce the possibility of car accidents since the fifth level AV, thanks to the development of IT, will guarantee the smooth driving of automobiles with enough driving-distance among cars. Thus, AV will remove or reduce the errors of drivers, which account for 90 percent of all fatal accidents[2]. It is estimated that AV could drop accident frequency as much as 80% with fifth level AV since over 90% of car accidents are caused by drivers' errors[4]. The reduction of car accidents will influence on several industries such as insurance industry, car maintenance industry and law industry. KPMG estimates that AV could shrink the auto insurance industry by 60%, and this decrease could amount to $108 billion when considering the current revenue of auto insurance industry at approximately $180 billion[4]. The impact of law industry is resulted from the decrease of law suit related with car accidents.

The second direct impact of AV is the possibility of making use of commuting time in other activities. It means that commuters will be free of car driving so that they are able to utilize the former commuting time in other behaviors such as email, search, contents consumption etc. As is mentioned before, this possibility would increase the importance of contents industry. This impact will generally lead to the decrease of the necessity of parking lots and/or garages, so that the former parking lots can be used for another purposes such as building apartments and offices. Thus, land-using industry will be more important compared to non-AV area.

Third, the most important impact would be that of replacing drivers, particularly in the areas of truck, taxi, and bus drivers [7]. For example, there are 3.5 million truck drivers in the US (in 2017) [12] and it seems not to be an exaggeration to say that these jobs will be completely displaced when fifth level AV are popular.

There will be a couple of indirect impacts, which will be more important as the market for AV will be matured, approximately, after 2035[3]. There will be a change of travel pattern, particularly in long-distance travel, from staying at hotels to sleeping at cars. At that time, the design of cars will be modified to provide security and comfort with commuters so that travellers would like to stay at cars rather than stay at hotels.

Moreover, the proliferation of AV will deprive people of the incentive of owing cars. Co-riding and/or owing only one car will be more convenient and less expensive since owing more cars will be expensive and onerous. Finally, the concept of services will be converted from 'customers go to services' to 'service go to customers'. Hotels would like to provide their
customers with commuting services to preserve their status in the market. Fixed restaurants and/or cafes will move to the place where customers reside, automatically, thanks to AV technology.

[Table. 2] The general Economic Impact of AV Source: prepared by author, using [3][5][6][7][8]

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Positive impacts and Negative Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impacts</td>
<td>Reduction in vehicle accidents</td>
<td>-Decrease in insurance cost</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Decrease in repair cost of cars</td>
</tr>
<tr>
<td></td>
<td>Alternate use of commuting time</td>
<td>-Decrease the necessity of parking lots and garages</td>
</tr>
<tr>
<td></td>
<td>Replacing drivers</td>
<td>-Increase in maintenance cost of cars</td>
</tr>
<tr>
<td></td>
<td>Travel behavior</td>
<td>-Decrease in repair cost of cars</td>
</tr>
<tr>
<td></td>
<td>Change of car ownership</td>
<td>-Decrease the necessity of parking lots and garages</td>
</tr>
<tr>
<td></td>
<td>Change in the concept of service</td>
<td>-Increase in possibility of using contents more than ever</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Drivers will lose their jobs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Increase the efficiency of transportation by driving 24 hours seven days a week</td>
</tr>
<tr>
<td>Indirect Impacts</td>
<td>Travel behavior</td>
<td>-Travelers will sleep in the car instead of hotel while travelling</td>
</tr>
<tr>
<td></td>
<td>Change of car ownership</td>
<td>-Decrease of incentive to own cars</td>
</tr>
<tr>
<td></td>
<td>Change in the concept of service</td>
<td>-From 'consumer go to service place' to 'service go to consumer'</td>
</tr>
</tbody>
</table>

When considering all these impacts, the total benefit caused by AV is predicted to amount to $800 billion in 2035[6], $7 trillion by 2050[3][6][8]. And, it is estimated that conservatively, 585,000 lives can be saved due to AV, and AV will free more than 250 million hours of consumers' commuting time, and reduction in public safety costs to traffic accidents will amount to more than $234 billion[3][6].

4. Economic Impacts among sectors

4.1 Positive and Negative Impacts among sectors

The following table is summarization of AV's economic impacts by sectors, which have been discussed in detail in the previous section. As is shown in this table, the distinction between negatively-impacted and positively-impacted industries is somewhat clear although the exact amount is not certain at this moment.

[Table. 3] The summary of Economic Impact of AV by Sectors Source: prepared by author, using [3][5][6][7][8] and [Table. 2]
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<table>
<thead>
<tr>
<th>Industries</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negatively Impacted Industries</td>
<td>Insurance Industry</td>
</tr>
<tr>
<td></td>
<td>Law Industry</td>
</tr>
<tr>
<td></td>
<td>Vehicle Driver (taxi, Bus, Truck)</td>
</tr>
<tr>
<td>Positively Impacted Industries</td>
<td>Car Sharing Industry</td>
</tr>
<tr>
<td></td>
<td>Contents Industry</td>
</tr>
<tr>
<td></td>
<td>Info-entertainment Industry</td>
</tr>
<tr>
<td></td>
<td>Land-using Industry</td>
</tr>
<tr>
<td>Mixed Impacted Industries</td>
<td>Car Maintenance Industry</td>
</tr>
<tr>
<td></td>
<td>Transportation Industry</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Industry where structural adjustment is required</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car manufacturing Industry</td>
<td>Car industry: mobility-service provider or transportation network operator</td>
</tr>
<tr>
<td></td>
<td>Entrance to car-sharing industry</td>
</tr>
</tbody>
</table>

However, we have to pay more attention to mixed-impacted industries. Car maintenance industry would have a positive impact because AV usually drive longer distance compared to non-AV, so that the necessity of maintenance will increase. And, in the case of transportation industry, Mckinsey estimates that the economic gains of AV in the trucking industry could be range from $100-500 billion per year by 2025. The bulk of these savings would come from the elimination of the wages of the truck drivers[4]. In other words, the negative impact of losing jobs will lead to the positive impact of economic gain of the trucking industry.

Finally, the most important sector which needs our attention seems to be car manufacturing industry, where structural adjustment should be made. For its complete explanation, it would be better to describe the change of characteristics of vehicles which is the main topic of the following subsection.

4.2 The change of characteristics of Vehicles

The proliferation of AV will naturally result in the change of the characteristics of vehicles,
from 'Property as status symbol' to 'Mobility as a service'. AV will carry passengers without stopping at parking lots or garages, so that vehicles will drive more distance compared to that of non-AV. It will naturally lead to the increase of their number of driving and, thus, their driving mileages. Because of this reason, people will not find any reason to buy additional cars. As a result, drivers’ incentive to buy and own cars will be diminished[11]. This will not happen in a day or a week, but will happen in a slow mode. According to the research of Barclays, AV will decrease the sale of general vehicles by 40% until 2040[12]. At that time, cars will not regarded as a status symbol, but regarded as a means of service. Car sharing services such as Uber and Lyft will accelerate the speed of this change.

According to the study conducted by Columbia university, Uber can replace every cabs in the New York city with a mere 9000 AV. In other words, ‘on-demand-mobility’, the characteristics of Uber, will replace private car ownership[1]. According to the research of AlixPartners made in 2014, the one shared-car will replace 32 individually-owned cars[12]. Moreover, Cars will be registered in the name of dealership[2] or manufactures instead of individuals. Thus, several firms have paid greater attention to begin and develop car-sharing services than ever. Best examples are MAVEN (GM, 2016), GO DRIVE (Ford, 2015), Quicar (Volkswagen, 2011), and CAR2GO(Daimler, 2008).

The implications of this change can be summarized as follows. First of all, the main function of cars is not property based on status, but service based on mobility. The role of cars must be accordingly changed. Second, car manufacturing companies must adapt themselves to this changing environment. Some of them would like to transform their company into platform company which provide mobility services to consumers. Third, the words of services and mobility should be keep in mind in order to preserve their competitiveness. Car manufactures must transform themselves into mobility-service providers, or transportation network operators[3].

4.3 What kind of industries will be more important in the age of AV?

The two key words of AV era are ‘services’ and ‘mobility’. Thus, industries based on them may have greater opportunities to lead relevant market and industry. Candidates for these industries are as follows.

First of all, the most prominent industry would be infortainment industry, which combines information and entertainment industry. The earned time due to AV, for example the freedom form driving, can be used on other activities except driving. Although the initial infortainment
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System provides customers with simple driving-related information and several kinds of music, it will provide soon various internet services such as search and email as well as all kinds of contents such as picture, music and movie. Its market size is currently not big because the market of AV is in the initial stage. However, the potential of growth is enormous, when considering the case of the development of smart phones. As is well known, the portion of contents and software (apps) increased gradually, compared to that of hardware. Thus, many firms such as apple, google, microsoft and baidu, as is shown in [Table. 4], are currently paying lots of time and money in developing infortainment platforms, through which all kinds of driving-related information and contents will be provided[10]. There are lots of possibilities for them to be a central part of AV in the near future.

[Table. 4] The current status of developing infortainment systems of several IT firms source: prepared by author, using [10]

<table>
<thead>
<tr>
<th>IT firms</th>
<th>Infortainment platform</th>
<th>Main Features</th>
<th>Firms with collaboration</th>
</tr>
</thead>
</table>
| Apple      | Carplay               | -Siri  
- Navigation service based on map  
- Internet search  
- Multi-media | GM. Fiat-Chrysler, Audi, Nissan, Honda, Hyundai |
| Google     | Android Auto          | -Google Now  
- Navigation service based on map  
- Internet search  
- Multi-media | Benz, BMW, GM, Toyota, Hyundai |
| Microsoft  | Windows embedded automotive | -Window OS embedded infortainment system  
- Internet search  
- Multi-media  
- MirrorLink | Ford, Toyota, Hyundai, BMW |
| Baidu      | Carlife               | - Connection with iOS, android OS and infortainment system  
- Navigation service based on Baidu maps  
- Internet search  
- Multi-media | Benz, Volkswagen, Hyundai |

Second, there would be a possibility of emerging new service industry, where two concepts of mobility and services are melted into new one. In other words, usage based services will shift to location based services[3]. The best examples are a moving restaurant and a moving convenient store. Other areas where such concepts can be utilized would include health and wellness, leisure travel and tourism, hotel and hospitality, retailing, dining and restaurant,
location-based advertising[3].

Finally, the importance of data industry must be emphasized once more. The infrastructure of infortainment and new service industries is data, i.e., big data including all kinds of information surrounding AV and behavior pattern of commuters. Since AV are intimately related with IoT (internet of Things), the possibility of providing good services is generally dependent upon the possibility of getting suitable data. Strategy Analytics emphasized the importance of data as follows: “In the passenger economy (the age of AV), data will be fundamental to the delivery and use of services. Data analytics, predictive analytics, and system optimization become important competitive factors in this new industry[3].” Mckinsey predicted that the car data industry could be worth as $ 750 million by 2030[8].

5. Conclusion

The main conclusion of this paper is summarized as follows. AV will be available around 2020 and be popular by 2035. Their economic impact will be classified into direct and indirect ones, AV’s total benefit amounting to $7 trillion by 2050. It is estimated that conservatively, 585,000 lives can be saved due to fifth level AV. Two concepts that should be considered in analyzing the newly rising industries would be mobility and services. The characteristics of vehicle are changed from 'Property as status symbol' to 'Mobility as a service'. And, the newly-rising industries would include infortainment industry, mobility-based industry and data industry.

When analyzing AV’s economic impact, couple of factors would not be sufficiently discussed. The most important one is Artificial Intelligence. The development of AI will give greater impact on AV, since AI will accelerate the speed of proliferation of AV. Combined with AI, there will be more reduction in car accidents, more saved time, and more speedy replacement of truck and taxi drivers. And, the incorporation of AI would increase the role of mobility and services in identifying newly rising industries. The energy problem is not considered sufficiently, either. As is well known, AV will have the form of electric cars instead of internal-combustion engine cars. This transition will give a positive impact on saving the energy.

When considering AV's economic impact, institutional problems surrounding AV would not discussed sufficiently, either. The appropriate government policies, which are very important for the proliferation of AV to proliferate, should be discussed more. For example, the government of U.K. has released the report of 'The Pathway to Driverless Cars' to deal with
this problem, concentrating on her future efforts to maximize the potential economic gain from AV[9]. Insurance policy would be another example of that kind of problem. Who or which will be responsible in the car accident of AV? And, how to define and decide who is responsible?

Moreover, some technical problems surrounding AV should be considered more. Among them, the best example is the possibility of hacking, which would decrease the safety of the driving in AV. Another example is a problem surrounding big data. When considering the popularity of big data, the harmonization between the free use of big data and the protection of individual information must be considered simultaneously.

References


