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King Abdullah Petroleum Studies and Research Center

Drivers of Transportation Fuel Demand: Shared Automated Mobility-On-Demand

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About KAPSARC

The King Abdullah Petroleum Studies and Research Center (KAPSARC) is a non-profit global institution dedicated to independent research into energy economics, policy, technology and the environment, across all types of energy. KAPSARC's mandate is to advance the understanding of energy challenges and opportunities facing the world today and tomorrow, through unbiased, independent, and high-caliber research for the benefit of society. KAPSARC is located in Riyadh, Saudi Arabia.

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Key Points

Mobility-on-demand services provide a glimpse into the potential impact of an automated mobility future. Current signs suggest an important role for public policy in reaching a desired low-congestion, energy-efficient mobility future.

- The potential for faster, more reliable and cheaper travel offered by automated taxis is likely to be offset by a concomitant increase in travel demand.
- There is a risk that shifts away from high passenger-load transit, induced demand from children and the elderly and reduced downsides of suburban sprawl would result in more congestion.
- Greater energy efficiency offered by automation and consumer acceptance of higher levels of ride-sharing would contribute to keeping congestion and energy demand growth in check.
- Cost- and time-savings-based incentives for inducing preferred behaviors are potential policy levers to help shape the pathway to desired outcomes.
- A resilient policy framework will be required during this mobility ecosystem evolution.

Summary for Policymakers

Smart Mobility, the term we use to describe the integration of matured technologies that permit driverless vehicles to provide on-demand ride-sharing services, has the promise of providing safer, cheaper and more convenient travel while increasing the efficiency of energy and road use. Cheap, reliable and accessible mobility could in turn lead to economic growth, given the relationship between the two. However, there is also a substantial risk that Smart Mobility could result in increased congestion, energy use and urban sprawl. Understanding the potential societal impacts of Smart Mobility and likelihood of various outcomes is important for developing a resilient policy framework that leads to a desired mobility future.

Recent studies suggest that Smart Mobility could have a wide-ranging impact on energy use through both energy efficiency and travel demand. Energy efficiency could be higher in a Smart Mobility future. Right-sizing, reduced frequency of start-stop driving, platooning, higher adoption of alternative powertrains and vehicle light-weighting as accident risk decreases could all contribute to increased energy efficiency. However, despite higher energy efficiency, energy use may still increase because of increased travel demand.

Travel demand in a Smart Mobility future is likely to increase because it would be cheaper, easier and more convenient. Empty miles, migration from transit and travel demand from populations previously unable to drive would all add to vehicle miles traveled (VMT). Rising congestion because of increased VMT may set an upper bound on travel. However, automated vehicles could lower the societal and personal impact of congestion. From the society's perspective, automated vehicles would use road space more efficiently. From the passenger's perspective, the hassle of congestion may be reduced if they can focus on activities other than driving.

Ride-sharing has the biggest potential to limit the increase in VMT and congestion. However, people are reluctant to ride-share, as seen by the dominance of personal vehicle ownership in the majority of countries. On the other hand, people in countries with high transit use are more open to the idea of ride-sharing. In such countries, growth of Smart Mobility could instead be a potential problem if it occurs at the expense of mass transit.

Lower travel time, higher accessibility, reliable availability and lower cost remain important factors that will shape consumer attitudes toward Smart Mobility adoption. For the seasoned generation, private ownership may remain attractive even in an automated future from both a cost perspective as well as the desire to retain independence. However, the multitasking-inclined, smartphone-savvy younger generation appears more open to the idea of ride-sharing. Thus, with generation turnovers, Smart Mobility might become more common.

Smart Mobility could result in the simultaneous densification of urban cores as well as growth in medium-to-low population density regions. For suburbanites, automation would decrease the inconvenience of driving. The reduction in commute burden could unlock cheaper and bigger housing options further out, encouraging sprawl. At the same time, Smart Mobility would make city travel easier and could lead to more densification, especially in the cores of big cities.

Adaptive and nimble public policy response holds the key to shaping the path to the desired future. Potential policy levers to incentivize preferred behaviors include congestion pricing and time-savings-related inducements for increased vehicle occupancy and efficient road space use. Explicit public-private partnership provides another approach for testing innovative policies by assessing market response through deliberate experiments. By contrast, the current regulatory environment has seen the public sector playing catch-up with the mobility-on-demand service providers, given the latter's relatively unregulated expansion. This has resulted in some friction between the two. However, with traditional automakers and technology companies entering the market, one can expect a higher degree of collaboration between the public and private sectors. Consumers are likely to be the biggest beneficiaries of such partnerships as they would ensure affordable, equitable and uninterrupted service.

A Smart Mobility future provides an opportunity to address the challenge of rising demand for mobility where there are limits to supply expansion. From a policy perspective, this would require a shift from the current extremes of the spectrum, i.e., personal vehicle ownership-and transit-oriented planning, to shared-trip-oriented planning.

Background to the Workshop

On April 27, 2017, KAPSARC hosted a one-day workshop in Washington, D.C., focused on research aimed at understanding the potential personal and societal impacts of Smart Mobility. Topics discussed included energy impact of Smart Mobility, drivers and barriers to adoption, impact on congestion and land use, and public policy response for achieving desired future mobility outcomes. The sessions centered on four main themes, covered in the following sections of this paper:

- Potential impacts of connected and automated mobility on travel demand and vehicle efficiency and implications for energy use.
- Factors affecting consumer attitudes and demand for Smart Mobility.
- Societal impacts of Smart Mobility.
- Public policy for achieving an energy-efficient, low congestion, Smart Mobility future.

Impacts on Personal Mobility and Energy Use

Smart Mobility has the potential to cause a paradigm shift in the transportation field, but with highly uncertain impacts on energy use. It could decrease energy use by as much as 60 percent from current levels through the combined effects of connectivity, automation and ride-sharing. However, there is also a risk of raising energy consumption by as much as 200 percent if vehicle miles traveled (VMT) increase and ride-sharing does not become widespread.

Energy use depends on vehicle efficiency and travel demand. Energy efficiency could be substantially higher in a Smart Mobility future. Factors that could increase efficiency include:

- Right-sizing – flexible selection of a vehicle suitable for the particular trip.
- Drive-cycle smoothing or reduced frequency of start-stop driving.
- Platooning, resulting in reduced aerodynamic drag.
- Crash avoidance, resulting in fewer traffic interruptions and less congestion.
- Higher fuel efficiency from light-weighting because of lower accident risk.
- Greater adoption of hybrid and alternative powertrains.
- Smooth driving at intersections from vehicle to infrastructure integration.

On the other hand, faster travel on highways as offered by automation and connectivity could result in increased energy use, partially offsetting energy efficiency gains.

More importantly, travel demand will increase as it will be easier, cheaper and more convenient. Smart Mobility would lead to lower costs on both a per mile and travel time basis, encouraging greater passenger and goods movement. Thus, it is likely to result in higher vehicle miles traveled. Since people can focus on other activities instead of driving, and are not required to search for parking, they would be willing to make both more and longer trips. Additional demand may arise from subpopulations that previously were unable to drive, such as children and the elderly. Empty miles would also increase because of automation. Shifts away from transit and walking to using vehicles might also occur, adding extra VMT.

All of this additional travel demand could result in increased congestion, reducing the efficiency advantages from automation. It could impose limits on travel, unless automated vehicles use space more efficiently through more ride-sharing. However, recent studies suggest that people are reluctant to share rides and thus vehicle occupancy may not increase significantly. Currently, U.S. consumers would rather pay thousands of dollars extra for vehicles that are eligible for single-occupancy carpool lanes than carpool in a non-eligible vehicles. This trend may not be representative of the rest of the world. In many developing countries, for example, shared vehicle use is a common practice.

The net effects of automation on travel demand and efficiency would depend on adoption levels, which in turn will vary across consumer segments. The effects of connectivity would scale non-linearly with adoption, as enough vehicles need to be on the road to connect with one another. Despite the rate of technological development and adoption, it is easy to imagine two to three decades of mixed – automated and non-automated – use even in developed countries. This is because it would take at least a decade for the current non-automated fleet to turn over.

Managing this transition presents challenges to both the industry and policymakers. Activity based models represent one option to simulate future travel demand. However, this requires assumptions about changes in consumer behavior in a Smart Mobility scenario. Rather than speculating about consumer behavior, stated preference data could be gathered from survey experiments. Alternatively, consumer behavior in simulated environments could be studied. Revealed preference data on the use of taxis and private chauffeured vehicles, especially in countries with low-cost drivers, could also provide interesting insights into what to expect in an automated future.

The Consumer's Perspective

Consumer acceptance of current mobility-on-demand (MoD) options including Uber, Lyft, etc., provides a peek into the future. They find current MoD options to be a quick, reliable, comfortable and affordable way to get around. The majority of consumers using MoD are switching from taxis and vehicle sharing with friends and relatives, as well as public transit. Some of the reasons contributing to the shift from taxis to MoD include:

- Lower MoD fares, indirectly subsidized through investors' funding.
- Doubts over finding a taxi.
- Inability to know how long it will take for a called taxi to arrive.
- Service time gaps such as the afternoon taxi-shift change.

The indirect, slow and infrequent nature of public transit has led to the defection of transit users to MoD. Yet, the majority of people still prefer to drive their own vehicle instead of using MoD, as they feel an emotional connection with their vehicle. Remaining independent in terms of mobility is also high on people's priority list.

Consumer attitudes toward automation are also evolving. Although currently the majority of consumers do not like the idea of giving up control of their vehicle, there are differences in preferences across generations. The elderly, who realize their eyesight and response times are diminishing and who may no longer have a driving license, see automated vehicles as a way to regain their mobility. Younger generations such as Gen Z and Gen Y (born after 1980) view automated vehicles as freedom. They like multitasking, which they can easily do in a self-driving car. Other consumer segments open to the idea of automation include innovators, technology savvy consumers and those who have had some experience with technologies such as advanced driver-assistance systems.

The younger, smartphone-savvy generation is more open to the idea of ride-sharing. Thus, with generation turnover, ride-sharing might eventually become more common. To ease the transition, partitions could initially be installed in vehicles until social norms around ride-sharing develop and people become more comfortable with it.

Factors that can shape consumer attitudes and affect demand for Smart Mobility include travel time, accessibility, reliability and cost. Flexibility for point-to-point travel (unlike public transit), better road space use and quicker response times due to vehicle connectivity could all lead to shorter travel time. Higher accessibility may arise from automated vehicles' ability to offer better and on-demand options for moving among workplace, residential and shopping locations. Reliability could be high depending on fleet size and frequency of operation. Consumers can also plan their schedule better by knowing the exact time it will take for the vehicle to arrive. Costs can be low as there are no drivers involved. Increased levels of ride-sharing can reduce costs even further.

From a cost perspective, the incentive for ride-sharing might be low, at least in developed countries in the absence of significant policy intervention. This is because the cost difference between automated and shared automated use is rather low. Moreover, automated taxis involve a significant cleaning cost, around 30 percent of total per mile cost. Thus, automated taxi use would only be slightly cheaper compared with personallyowned automated vehicles. As a result, personal vehicle ownership might still remain attractive.

In developing countries, low cost would be a major incentive for shared use of automated vehicles, where consumers are more open to ride-sharing. Cheap, reliable and accessible mobility could further spur economic growth in developing countries, given the relationship between mobility and economic growth.

Societal Impacts

The Smart Mobility future has the promise of saving lives, increasing accessibility and reducing space required for parking, but potentially at the expense of increased congestion in the absence of policy intervention. Early adoption of automated vehicles is likely in major urban areas because their high capital cost can be offset through large-scale use. However, such regions often have good public transit networks, meaning that a shift from high capacity transit to Smart Mobility would lead to increased congestion. In contrast, for cities lacking decent transit networks, Smart Mobility represents a great solution compared with the current personal vehicle ownership model. This is especially true for a country such as the U.S., where transit accounts for less than 7 percent of national VMT.

The impact of current MoD growth on transit can provide a glimpse of the future. Subway ridership declined over the last two years in the majority of U.S. cities including New York, despite continued economic growth. At the same time, MoD use, including taxis, resulted in a 3.5 percent increase in VMT over the last three years in New York. The core section of the city saw a 7 percent increase in VMT. In addition, the biggest growth in VMT occurred between 4 to 7 p.m. when traffic flows are already high, highlighting MoD's contribution to congestion. Thus, a significant portion of the travel demand resulting from economic growth is turning to MoD, at least in current times of low oil prices and subsidized MoD rides.

One way to view the trend of increased MoD is as a shift to smaller sized vehicles with lower passenger loads, expressed as passenger miles per vehicle mile. Specifically, subway and rail have the highest passenger loads: around 25 passenger miles per vehicle mile. In contrast, taxis and MoD have the lowest passenger loads, around 1 passenger mile per vehicle mile after accounting for empty VMT. With more ride-sharing and less empty driving, this load could increase to 2-3 passenger miles per vehicle mile. This would be a significant gain from the current 1.2-1.5 level for private vehicles, which continues to be the dominant travel mode at least in the U.S. However, in cities with a high transit share, continued growth of smaller sized vehicle use, even if pooled, would lead to increased congestion if MoD replaces transit rides.

The future impact of automated technology on land-use change remains an open question. Because private ownership might still be attractive in an automated mobility future, the decreased disutility of driving could result in sprawl, especially into medium- to low-population density regions. This is because the reduction in the hassle of commuting could increase the demand for cheaper and bigger housing options further out from the urban core. The money saved in housing could easily offset the higher upfront capital cost of personal automated vehicles. At the same time, Smart Mobility would make city travel easier and could lead to more densification. Similar to taxis and MoD, it would be more profitable to run an automated vehicle fleet in high population density regions with high travel demand, i.e., the urban core. Historically, both the suburbanite populations as well as the population in the cores of big cities have been growing in countries such as the U.S. Both growth patterns might continue to coexist even in an automated MoD future.

Policy Planning

Public policy can play a key role in shaping the path and outcomes for a Smart Mobility future. One of the major concerns identified is a potential increase in congestion, which is related to travel time. This can be addressed by creating incentives for preferred behaviors. For example, road pricing could be used to induce different travel times to address congestion. To encourage ride-sharing, policymakers could create incentives through reduced travel times via dedicated carpool lanes within the city core. Implementing such policies is particularly feasible in a world of connected automated vehicles. To discourage empty VMT, policymakers could impose charges on non-occupant vehicle use.

A joint effort between the public and private sectors would also be important in achieving an energy-efficient, low congestion mobility future. Public entities and MoD service providers have not had a close association thus far. The relationship will only get more complicated with the arrival of automated vehicles.

The current approach of trial and error based regulation, when too strong, can put the private sector out of business. When too weak, it leads to unfairness in the marketplace, such as what happened to the incumbent taxi industry when MoD service providers arrived on the scene. Thus, an alternative policy approach for testing market response to innovative strategies might be more suitable for ensuring a smooth transition to the Smart Mobility future.

Public-private partnership provides another way for collaboration going forward. These are essentially contracts and are common practice in infrastructure development. Transportation sector examples of public-private partnership include private companies running transit agencies' assets. Another example is the development of dedicated public parking spaces for car sharing companies to encourage provision of service in traditionally underserved regions. The Smart Mobility future could involve expansion of such arrangements to include automated ridesourcing.

In a Smart Mobility future, public-private partnership could provide significant benefit to both the entities and the consumers. They can lower the risk for the public sector. Private sector investment would ensure their commitment to the project's success. It also gives the public sector the flexibility to set the contract conditions as desired. For example, the public sector can request a bid for a fleet of automated electric vehicles. This can help the public sector test innovative policies by assessing the market response before setting regulations, especially if the market is not yet ready for the desired changes.

Data sharing, especially origin-destination data, could form an integral part of a public-private partnership contract. Data sharing can help the public sector identify and eliminate bottlenecks in their infrastructure, resulting in faster travel and thereby larger travel demand for the private sector. It can also provide greater opportunity for wholescale integration of automated MoD services with transit and promotion of multi-modal travel.

Benefits for the private sector include getting bank financing against government contracts. Such contracts create predictable investments for the private sector. Partnering with the public sector will also allow the private sector to expand their current MoD services to include all forms of transportation, including buses. This would act as an incentive for the private sector to support multi-modal travel. Public-private partnerships can also provide containment of liability for automated MoD service providers, thus lowering their insurance costs. Keeping costs low is important for MoD service providers to grow or even retain their current market share. The current subsidized MoD services, compared with taxi services, may not be sustainable in the long run, especially once the investment funding dries up. Greater cooperation and partnerships with public entities would also help cut costs that deal with lawsuits and regulations. As more and more traditional players, such as automakers and technology companies, enter the automated MoD market, one can expect a higher degree of partnership with the public sector.

In terms of consumer benefits, the presence of the public sector would ensure that consumers receive affordable and equitable service. For example, to ensure affordability, the public sector could do away with surge pricing or set a more reasonable ceiling on prices. Encouragement for ride-sharing through cost and travel time incentives would result in cheaper and faster travel for consumers. These partnerships can also help protect consumers against service disruption from private sector decisions to abruptly eliminate services, such as recently happened in Austin, Texas.

From an urban planning perspective, Smart Mobility provides an opportunity to address the challenge of increasing demand for mobility when there are physical limits to expansion of supply (particularly road space). The key would be to change the planning paradigm from the ‘either/or’ represented by personal vehicle ownership- or mass transit-oriented planning, to focus on a shared-trip oriented planning that can embrace the whole of the spectrum of opportunities. Identifying how mobility services can be developed and offered within a multi-modal integrated system is the key to unlocking the potential offered by Smart Mobility.

About the Workshop

KAPSARC convened a workshop in April 2017 in Washington D.C. with 40 international experts to understand the potential personal and societal impacts of Smart Mobility. Specific attention was given to the energy impact of Smart Mobility, drivers and barriers to adoption, impact on congestion and land use, and public policy response for achieving desired future mobility outcomes. The workshop was held under a modified version of the Chatham House Rule in which participants consented to be listed below. However, none of the content in this briefing can be attributed to any individual attendee.

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