A GLIMPSE INTO THE FUTURE: ROAD PRICING & DRIVERLESS CARS

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Futurology is a field of study more often characterised by its failures than its successes. Jake Russell-Carroll's contribution to this volatile area is a compelling look at the future of road travel. This thoughtful and well-informed essay examines one possible direction from which a solution to our traffic problems may come.

Introduction

According to the transport economist George Smerk *'It is obvious and inevitable, with larger numbers of people on the move, that the paths leading to the focal point of their movement will be crowded'* (1965).

With growing populations, agglomeration towards cities, and rapid growth of car ownership worldwide it is hard not to agree with Smerk's assertion that we will always be plagued by traffic congestion and its associated externalities. This assertion is further strengthened by the relatively limited success of road pricing to date, the widely believed best available solution. But what if Smerk was wrong?

With advancing driverless or autonomous vehicle (AV) technologies we are now at the dawn of a transport revolution that could provide a far superior solution to the externalities of driving. Consequently, this paper will compare the current effectiveness of road pricing in solving congestion to the potential impact of the AV. However, this by no means is an attempt to show that road pricing will ultimately become redundant. Quite contrary, the latter half of this essay argues that road pricing will likely become more important and effective in our driverless future, with the practices of the new Taxi Company 'Uber' indicating what this might be like. Firstly though, In order to provide context I will delve through what exactly is an AV, and also briefly explore the theory behind road pricing.

What Exactly Is An AV?

In 2013, the USA National Highway Transportation Safety Administration (NHTSA) defined five levels of automation, ranging from level 0 with no automation to level 4 with full self-driving automation, designed to operate completely independent of driver intervention. Much of the excitement on this topic has derived from the developments of

Google's prototype AV that has already driven autonomously for over 500,000 miles. This car handles all safety critical functions, monitoring the environment around it and only ceding control to the driver in certain difficult situations. This classes at a level 3, so in terms of technological advancement the horizon for AV introduction is not overly distant. For comparison purposes, the rest of this paper will deal with the potential benefits that could arise from the widespread adoption of level 4 AVs.[1] If still skeptical that this technology will ever emerge, when reading the remainder of this piece, consider the words once uttered by Lord Kelvin in 1899, 'Radio has no future. Heavier-than-air flying machines are impossible (and) X-rays will prove to be a hoax.'

The Theory Behind Road Pricing

Without road pricing there lays a gap between an individual's costs of driving (fuel, insurance, wear-and-tear etc.), and the externalities or social costs of driving; congestion, accident, environment, and road damage costs. As more cars enter a road, although average cost decreases, the marginal social cost rises and road is allocated by queuing (congestion), which is allocatively inefficient (Button, 1993). The theoretical basis for road pricing is thus to close the gap between individual and social costs. In the same way to users of any other scarce resource, this can be achieved by making people pay for their use. Only then would the correct decisions on whether, when, and how one should travel can be made, or in other words the road system can move towards allocative efficiency.

Road Pricing vs. The AV: Solving Congestion Externalities

Congestion Costs

A 2012 Texas Transportation Institute report based on data from 498 urban areas in the USA estimated that traffic congestion in 2011 resulted in almost 5.5 billion hours (628,000 years) of excess travel delay in the USA, and nearly 2.9 billion gallons of excess fuel consumption, equating to a total cost of about $121 billion (Schrank et al., 2012).

Singapore was one of the first places to tackle congestion with road pricing. Traffic entering the central-business-district after implementation dropped 44 per cent, and speeds rose from 11mph to 21mph, and despite an increase in vehicle ownership of 77 per cent a decade later, traffic levels remained 31 per cent below original volumes (Keong, 2002).

In London, traffic entering the charging zone decreased by 17 per cent, with chargeable vehicles down 31 per cent. 50-60 per cent of travelers switched to public transport, 20-30 per cent diverted around the zone, and the remainder made different adaptations. However, while these examples have proven to be somewhat effective, the

1. It is assumed that prices of AVs have declined to the extent to which they are widely affordable, like cars today.

reach and implementation of road pricing on a wide or nationwide scale has been limited (largely due to political and technological factors), and thus it hits far below its optimal potential for solving congestion externalities. Consider London, although it is noted for having a successful congestion charging zone, this is only in the city centre and the average commuting Londoner still spends 66.1 hours stuck in traffic annually.

AVs offer a far more potent and widespread solution. While road pricing can create greater throughput on some roads (less cars=less stop/start conditions), AVs can potentially provide this for all roads. Through finely controlled and coordinated breaking and acceleration, AVs could facilitate significantly higher throughput at peak travel hours. Research suggests that platooning[2] of vehicles could raise motorway capacity by as much as 500 per cent (Fernandez and Nunes, 2012, as cited in KPMG and CAR, 2012). Driverless technology uses a combination of LIDAR (Imaging/sensor) technology with vehicle-to-vehicle and vehicle-to-infrastructure wireless technology. This 'smart infrastructure'[3] could eventually eliminate the need for road markings, signals, and traffic lights. The 2012 KPMG report claims that simulations of intelligently controlled intersections indicate a superior performance of some 200-300 times that of our current system.

As discussed below, AVs will likely be used as part of a shared mobility system rather than being privately owned (especially in cities), meaning that vehicles may be in use over 70 per cent of the time. This reduces the need to search for parking, which according to Donald Shoup of UCLA causes a lot of unnecessary miles; 'In one 15-block business district in LA, cruising for curb parking creates about 950,000 vehicle miles of unnecessary travel per year, equivalent to 38 trips around the Earth or four trips to the moon.'

A significant point to make is that regardless of whether AVs create time savings for travelers, since a person is now free to engage in productive activities while in transit, the opportunity cost of driving is largely alleviated. Thus, AVs would decrease the time costs of congestion even if congestion were not majorly improved. Driverless cars may be customized to become mobile offices, sleep pods, or entertainment centers, and those billions of hours wasted in traffic become opportunities for productivity increases.

Accident Costs

Globally, 1.2million deaths occur each year resulting from car related accidents and another 50 million are seriously injured. Road accident costs, which encapsulate injuries, property damage, and lost productivity, are estimated at $518 billion globally, costing in-

2. Platooning is where vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) wireless communication allows cars to pack tightly together, moving in train-like formation.

3. 'Smart' infrastructure consists of V2V and V2I technology, where vehicle information will be organized on a cloud system and structured to make optimal traffic decisions.

dividual countries from 1-2 per cent of their annual GDP. Significantly, human error is the critical reason for 93 per cent of accidents (Johnson, 2013).

In its current form road pricing is limited in terms of reducing accidents. Since accident numbers increase as congestion increases, road pricing's ability to reduce crashes relies on decreasing the number of cars on the road. The London congestion charge has resulted in a decline in fatalities and accidents, but as mentioned road pricing is only utilised in the city centre, and in 2011 a total of 24,443 road traffic accidents occurred in London. Of these, 159 were fatally injured, 2646 seriously injured, and 26,452 slightly injured (TFL Report, 2012).

Again however, AVs offer a much more effective solution. AVs don't get tired, drink drive, or break the speed limit. Frank Sgambati, a director at Robert Bosch LLC, explains that, 'Bosch is developing next-generation driver assistance systems as it pursues a vision of collision-free driving.' According to the USA Department of Transport, the aforementioned 'smart infrastructure' could mitigate up to 80 per cent of all crashes (KPMG, 2012).

A 2013 report by Eno Transportation Foundation estimated that 21,700 of the 32,367 fatalities in the USA every year could be prevented with a 90 per cent adoption rate of AVs. Hayes suggests that road accident fatalities could eventually approach those seen in aviation and rail, about 1 per cent of current rates; and KPMG and CAR predict an end goal of 'crash-less cars' (Hayes, 2011, as cited in Eno Report, 2013). In addition, according to the NHTSA traffic accidents account for about 25 per cent of all congestion delays. In this regard, an even greater amount of traffic delays could be eliminated (Anderson et al, 2012).

Environmental Costs

Although cars are becoming more fuel efficient, 2.9 billion gallons of fuel are still being expended in the USA alone due to congestion delays. While road pricing is an option regarding internalizing this externality, it is widely accepted that a more cost effective and efficient method is to increase fuel taxes (Fahey, 2004).

In contrast, the adoption of an AV smart infrastructure would see far superior fuel efficiency than even the most fuel conscious driver could achieve today. Platooning would decrease the effective drag coefficient of following vehicles, reducing fuel use by up to 20 per cent. Furthermore, in a virtually crash-free environment, the need for safety features such as reinforced steel bodies, crumple zones, and airbags means that vehicles can become much lighter. A 20 per cent reduction in weight corresponds to a 20 per cent rise in efficiency (Eno, 2013). These lighter vehicles also correspond to less road damage costs, as trucks, which cause nearly all road damage can become significantly less heavy.

The Future Of Road Travel And Road Pricing

After exploring how AVs potentially offer a superior solution to the externalities of driving, one could be forgiven for questioning whether road pricing could become redundant. However, the widespread adoption of AVs will not be without its own problems, and this section actually aims to display how the future will likely see road pricing become more important, effective, and most significantly, viewed in a different way. But before addressing these problems, we must first explore how people will use and view road travel in the future, as only then can we fully build a picture of the future of road pricing.

Mobility-On-Demand

Of all the changes AVs will cause, one of the most significant ones is with regards car ownership. In the future, we may not need to own cars but simply hail one to fulfill all our transport needs. Brad Templeton, adviser to the Google Self-drive car project "call(s) it mobility-on-demand. You pop out your mobile phone, say where you want to go and how many people and in a short amount of time a vehicle rolls up."

Sound familiar? Although the vehicles are not driverless, this mobility-on-demand idea is actually already in practice today. Taxi companies such as 'Hailo' and 'Uber' use 'Smartphone' applications to coordinate a fleet of cars to cater for peoples travel needs on-demand (but significantly, Uber also uses it to coordinate prices). As these companies still require human labour, using their services for all your travel needs is not currently financially feasible. However, remove drivers from the equation and the costs of this mobility-on-demand drop significantly.

Columbia University conducted a case study comparing the impact of having a driverless shared-mobility system over privately owned vehicles in Ann Arbour, Michigan (population-285,000: area-130miles). In 2009, there were a total of 200,000 passenger vehicles, an average of 740,000 trips daily, and vehicles were in use about 5 per cent per day. The study showed that with a fleet of 18,000 AVs, consumers could expect to wait under one minute for a vehicle to arrive, and the vehicle would be used 70 per cent of the time on average between 7am-7pm. AAA estimated that ownership and use of a medium sized car driven 15,000 miles per-year-per-mile costs $0.59 (car, insurance, fuel, repair etc.) compared to $0.41 with a shared fleet of 18,000 in Ann Arbour, a 31 per cent decrease. Furthermore, parking costs would significantly decline as the fleet is in use 70 per cent + of the time.

The Problems:

Induced Demand

As seen in the Ann-Arbour case, with mobility-on-demand one would anticipate a decline in vehicle numbers. However, as having an AV infrastructure increases the capacity of roads significantly we are likely to encounter the problem of induced demand. In the past governments have increased the supply of infrastructure with the logic that this will result in more space for the current level of cars. But this approach leads to market failure, as the supply and demand for road space do not equate (Fahey, 2004). In essence, increasing the supply of road makes it more attractive to start driving as congestion costs have decreased, and thus it acts only as a short-term solution. This problem is even worse with an AV system. Firstly, those currently under the legal driving age or those unable to drive (disabled, elderly etc.) can now be added to the demand for road space. Secondly, now that it is cheaper, more convenient, and productive to use an AV, those currently taking public transport will have incentive to switch to AVs. As people switch from public transport, a scenario of increased fares and declining service will likely occur, which further exacerbates AV demand. Thirdly, due to a reduced need for parking (which takes up to 1/3 of space in urban areas), cities are likely to become even denser in population, thus further increasing the demand for travel.

Reduced Revenues

Another problem is shrinking government revenues. According to the European Commission (2012), declining government revenues has already become a problem; 'As vehicles become more energy efficient and use alternative fuels' less fuel tax is paid and thus 'the capacity of governments to finance transport infrastructure.. is seriously hampered.' Furthermore, the significantly lower demand for parking with AVs means less pay-and-display and parking fine revenue. When you consider that local authorities in England made £594 million in profits from parking in 2012 this marks a substantial loss in revenue (BBC, 2013). Considering these two problems road pricing takes on a new level of importance, especially regarding raising revenues. To put it into perspective, only £1.2 billion has been raised from the London congestion charge since its introduction in 2003.

How Road Travel & Pricing Could Resemble The Uber Service

By combining the benefits of driverless technology, mobility-on-demand, and these problems, the future of road pricing begins to take shape, and it looks a lot like a large driverless Uber service. The key here is Uber's pricing method. They use 'surge'/dynamic pricing for their mobility-on-demand taxi fleet, which in essence just applies the laws of supply and demand. Prices increase when supply of taxis is low and prices decrease when supply is high. A person can view the price of their intended journey on the Uber app, which also displays how many taxis are available and where they are located. Apply this 'pay-as-you-drive' dynamic pricing system to a shared mobility-on-demand network (essentially the aforementioned 'smart' infrastructure) and the effectiveness of road pricing dramatically increases. Prices change constantly as supply and demand changes, meaning that the externalities of road travel can be accurately internalized.

When roads start moving towards congestion conditions, prices rise significantly, deterring those less in need of the road space to undertake the AV journey.

The obvious obstacle facing this scheme is the same one that has prevented nationwide pay-as-you-drive road pricing schemes to be implemented over the last decade; lack of political will. Simply, paying money for something that used to be free is naturally unpopular, and many also consider road pricing as regressive.

However, a key thing to consider is that people are unlikely to view these road pricing costs in the same way as they do for current road pricing; as an additional cost to the individual cost of driving. As displayed by the Ann Arbour case, the costs per mile of driving with a shared fleet is much lower than the overall cost of buying and having ownership of a car. Thus, people may come to view road pricing as paying for the service of road travel. If one considers that cars are only utilised on average 5 per cent of the time, paying to have it 100 per cent of the time seems clearly allocatively inefficient. Furthermore, with declining government revenues, the obvious efficiency savings of AVs, and potentially lower costs of road travel for individuals, perhaps the incentives will be adequate to facilitate the necessary political will and social acceptance for this road pricing system to become feasible.

Conclusion

This paper attempts to offer a glimpse into the future, firstly highlighting how AVs could offer a far superior solution to the externalities of driving then the current forms of road pricing. But it is also identified that in order to preserve benefits and prevent declining government revenues, road pricing may take on a new level of importance. The second conclusion is that road travel will likely become to be viewed and used in a manner much different of that today, and with this, road pricing has the potential to be implemented far more effectively.

It is important to point out that both these conclusions entail major societal transitions, and will no doubt provoke major resistance. The enormity of the transition to AVs in particular means that nothing can be said with absolute certainty, and the full scale of the economic, political, and social implications cannot be captured within the scope of this essay.

For instance, how will economies deal with the displacement of all those currently employed in unskilled driving (3 per cent of the USA workforce)? How will public transport be affected? And how will AVs be regulated?

Some optimism towards overcoming these obstacles can be found if we look back to the emergence of the first automobiles, where the transition wasn't entirely smooth either.

According to the New York Times in 1902, admiration for the automobile was quickly "succeeded by open hostility." "The cars were scaring the horses and the farmers were shooting the cars" (Silberg, 2013). If the necessary political will and social acceptance can be achieved, the AV provides hope that we one day may prove Smerk's assertion of perpetual congestion to be untrue.

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