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Self-driving cars

A case study in making new markets

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This essay considers the prospects for the future of the self-driving car, and looks in particular at the issues around creating a functioning market for such vehicles. The aim is to shed light on the principles and practicalities of 'market making', a discipline in which the authors are experts. This essay is released alongside, and intended as an accompaniment to, a longer paper by the Big Innovation Centre entitled: 'Market Making: A modern approach to industrial policy'. This report can be accessed at http://www.biginnovationcentre.com/Publications.

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Self-driving cars: coming to a road near you?

The recent and much-publicised bills to authorise driverless cars in the US states of Nevada and California has raised a number of interesting questions about the nature of this innovation and the potential market for these vehicles[1]. Would self-driving cars make a big difference to our daily lives? Is it realistic to expect a market for them to emerge?

The two questions are interrelated. We can glean from our knowledge of innovation that the less disruptive innovations are, the more they can make use of or insert themselves seamlessly into the existing socio-technical infrastructures, the greater their chances of success[2]. To go against the grain and cause serious disruption often requires major acts of faith and the development of large technical systems, to borrow Thomas P. Hughes' term[3]. In short, the less disruptive a technology is deemed to be, the quicker and wider the market for it can grow, *ceteris paribus*.

How disruptive are driverless cars? To adopt a purely technological angle, the short answer is not much. At one level, these events can be seen in the context of the inexorable march of machines to acquire skills we have hitherto regarded as inherently human[4]. The notion of driverless vehicles in other modes of transport has been around for a while. An early example is the Parisian *Aramis* project. *Aramis* was an advanced form of personal transport developed for RATP (Régie Autonome des Transports Parisiens) in Paris, between 1969 and 1987, by the French defence company Matra. *Aramis* was designed to combine the most attractive aspects of personal and public transport, with small, driverless carriages combining to form a flexible train whilst in transit. The vision behind *Aramis* was that users could summon carriages from passing trains which would then rejoin the train via contactless linkages. The flexible nature of the *Aramis* train would remove unnecessary stops and transfers, combining the best aspects of conventional cars with the more ecologically-sound benefits of public transport[5].

Whereas *Aramis* required a dedicated infrastructure (eg stations, rails) and proved to be a somewhat expensive failure, driverless cars can more appropriately be seen as an evolution of an existing artefact – the conventional passenger car – even if they partly share *Aramis'* ideal. In the last few decades, cars have literally been swamped with all forms of electronic systems. From engine management systems, to trip computers, and

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[1] http://www.nytimes.com/2012/01/24/technology/googles-autonomous-vehicles-draw-skepticism-at-legal-symposium.html; http://www.bbc.co.uk/news/technology-19726951; http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201120120SB1298&search_keywords=

[2] See Urry, J. (2004). *The 'System' of Automobility*. Theory, Culture & Society 21(4-5): 25-39.

[3] Hughes, T. P. (1983). *Networks of Power: Electrification in Western Society*. Baltimore, MD., John Hopkins University Press.

[4] http://www.guardian.co.uk/technology/2012/sep/30/google-self-driving-car-unemployment?INTCMP=SRCH

[5] Latour, B. (1996). *Aramis, or the Love of Technology*. Cambridge, MA., Harvard University Press.

self-diagnostic tools, passenger cars have evolved to the point where they can be seen as a hybrid, a complex assemblage of mechanical and electronic systems. In the more recent past, we have seen automakers embedding technologies such as Bluetooth connections, GPS navigation systems, in-vehicle infotainment and wi-fi systems and so on[6].

The leap to the next stage – driverless cars – may not be as revolutionary or as potentially disruptive when seen from this long-term, evolutionary perspective. The European Commission project known as SARTRE – Safe Road Trains for the Environment – has already demonstrated that driverless vehicle trains in motorways seem to work safely. Cars in these trains are fitted with features such as cameras, radar and laser sensors – allowing a 'carriage' vehicle to monitor the 'locomotive' and other vehicles in their immediate vicinity. The most interesting aspect of this project is to show that there is little or no change required in either the vehicles or the infrastructure for the train to work. All that is required is a wireless network between cars in the train and the appropriate software to ensure that, for example, gaps between vehicles travelling at speed (~52 mph) remain at around 20 feet[7].

Google has recently taken these ideas to yet another level. The Google driverless system combines information gathered from Google Street View with artificial intelligence software, combining inputs from video cameras inside the car, a LIDAR (light detection and ranging) sensor positioned (prominently) on top of the vehicle, radar sensors on the front, and a position sensor attached to one of the rear wheels to help locate the car's position. It has been in gestation for a while – benefiting from Google's close links with Stanford University – and is effectively designed to replicate the capabilities of human drivers – eg in terms of seeing and sensing road conditions and other road users – while mitigating or eliminating altogether the problems associated with human error and miscalculation.

In summary, although the Google driverless car can be regarded as a disruptive technology in the sense that it ultimately does away with one of the linchpins of the automobility system (ie the licensed, legally responsible driver linking the car to the road and traffic management infrastructure), it is very much the product of an incremental evolution and convergence of a number of different technologies. The more interesting questions are:

- How does this change impact upon the broader automobility system, of which the car-driver combination is a key component?
- What is the potential market for driverless cars?

[6] http://www.independent.co.uk/life-style/motoring/wifi-cars-hitting-the-information-superhighway-2260187.html
[7] http://news.bbc.co.uk/1/hi/8349923.stm

- Will driverless cars become as common as driven cars are now, with driverless progressively displacing driven? Will driverless cars meet the same fate as *Aramis*? Could they instead be confined to a niche (e.g. catering for those with mobility problems or disabilities, taxi ranks in smart cities)? Or, will we have driverless / driven hybrids with driverless features switched on and off (eg during long motorway journeys or traffic jams) as circumstances dictate?

The potential benefits of self-driving cars

Before we tackle these questions, let us consider the arguments for driverless over driven cars. There are three main selling points for driverless cars:

1) **Fewer accidents**. A significant proportion of accidents and loss of life on the roads are due to driver error. Driverless cars could drastically reduce the accident toll. Lives saved is the measure that will conclusively show the advantages of driverless over driven cars.
2) **More productive commutes**. A significant percentage of the population in developed, car-rich economies spend considerable time commuting to work. Driverless cars would enable these unproductive hours and minutes to be converted into productive work and/or leisure time. GDP and wellbeing indices should go up accordingly.
3) **Fewer traffic jams**. Driverless cars would be better adapted to higher volumes of traffic, as they would be able to travel at higher speeds while keeping shorter distances between vehicles. Decreased congestion and better overall fuel economies will be achieved as a result[8].

Moreover, driverless cars could extend ownership to new groups of people (eg the visually impaired) and protect road users from well-documented hazards (eg drink drivers)[9]. Eventually, insurance premiums could drop to negligible amounts even for neophyte drivers, assuming we will retain the practice of training people with skills that they may rarely need to call upon.

Barriers to the growth of a market for self-driving cars

But there are plenty of uncertainties about this transition to a driverless future. The current socio-technical infrastructure around cars is closely associated with a complex system of practices that may change in unpredictable ways. Will driverless cars reduce congestion on the roads? Possibly yes, but maybe not. Driverless cars could lead to an

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[8] http://www.bbc.co.uk/news/magazine-18012812.
[9] As Sergey Brin, one of Google's founders, put it: ""This has the power to change lives. Too many people are underserved by the current transport system. They are blind, or too young to drive, or too old, or intoxicated." Quoted in: http://www.theregister.co.uk/2012/09/25/google_automatic_cars_legal/

increase in short journeys into crowded city areas bypassing parking charges (eg send the driverless car round the block while you wait for your take-away meal or pick up the dry cleaning). City centres could be filled with driverless, empty cars negotiating traffic jams without a passenger in sight.

Maintenance networks

The existing socio-technical infrastructure around the car was built slowly, the range of distances people were prepared to travel expanding as more and better roads were built, and as filling stations and maintenance networks were gradually put in place. We easily forget how much our everyday use of the car is wholly dependent on this infrastructure. Kevin Borg starts his book *Auto Mechanics* with a suggestive scene setting paragraph: "Cars break down. They always have. On a warm spring day in 1901, a man named Robin Damon expected to enjoy the new freedom of automobility – swift individual travel without rails, without schedule, and free of wilful horses. Instead, he and his friends spent six hours in the hot sun replacing spark plug gaskets, putting in new ignition points, and replacing a broken battery wire in the friend's stranded 'gasoline carriage'. The promises of the new technology, it turned out, were conditional"[10].

This vignette reminds us that cars – driven or driverless – still need be maintained and repaired. If anything, driverless cars with their intricate electronic systems and complex interaction between electronic and mechanical systems might be prone to difficult-to-diagnose and difficult-to-cure problems. The ability of rescue patrols to repair cars on the spot will probably be quite limited and the skills and equipment of service dealerships will need to be significantly upgraded. Driverless could become a synonym for undriveable.

Cyber-security risks

Even if the electronics in driverless cars prove to be reliable – or at least, as reliable as contemporary mechanical systems – there are other dangers lurking. A joint report by Internet security firm McAfee and Wind River calls attention to the security risks involved in embedded car devices[11]. More specifically, the report argues that experiments such as the Google driverless car and smart roads (eg equipped with traffic or speed sensors) demonstrate the potential of coordinated, connected communication from all sorts of electronic systems within the car. However, little has been done to ensure the security of these systems. It is worth reminding ourselves that the first remote keyless entry systems did not implement any security and were easily compromised: a regular learning universal remote control for consumer electronics was able to record the key signal and replay it at a later time. This was only corrected after some painful lessons

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[10] Borg, K. L. (2007). *Auto Mechanics. Technology and Expertise in Twentieth Century America.* Baltimore, MD., John Hopkins University Press, p. 1.
[11] http://www.mcafee.com/us/resources/reports/rp-caution-malware-ahead.pdf

and examples of high-tech security loopholes persist to this day[12]. The increasing use of embedded and connected devices in cars could lead to serious problems from remote attacks via Bluetooth to the hacking of private data stored in the car's infotainment system.

Legal liability

Lastly, there is the issue of liability in the case of accidents. The law is notoriously slow in catching up with new technologies and the novel practices they enable (eg defining and enforcing copyright in a digital age). There are a number of potentially hazy areas such as how the hardware and software involved interact with the car's mechanical systems; product liability issues with different manufacturers who take crucial roles in putting the system together (eg is it a Google car or a Toyota Prius driverless-enabled by Google?); the role of other cars and road users such as pedestrians or cyclists; and the responsibility of the owner to perform proper maintenance on the vehicle and its automated systems.

What would happen in the case of a collision say between a driven and a driverless car, or even between two driverless cars? What would insurers be prepared to cover and what types of arguments would the law be prepared to hear in cases of damages and personal injuries? And what exactly would insurers insure? Drivers will still matter, at least as owners of vehicles with ultimate responsibility for their maintenance, with the possibility that manual overriding will take precedence over driverless features as far as the law is concerned[13].

From self-driving cars to other disruptive technologies: lessons for market makers

The market for driverless cars does not just depend on manufacturers persuading legislatures to pass bills and a reluctant public to give up driving. For driverless cars to realise their commercial potential, they have to fit with the current automobility system or the system needs to be reconfigured to accommodate a novel entity. Some of those adaptations will require minor changes in the practices that make use of cars in our everyday lives, whilst others will need major investments in changing or upgrading existing networks (eg service and maintenance).

This example illustrates how markets are enmeshed in a complex matrix of socio-material infrastructures and gradually shaped by a multiplicity of actors with different

[12] http://www.channel4.com/news/bmw-security-loophole-leads-to-rise-in-car-thefts

[13] California's Senate Bill 1298 (Vehicles: autonomous vehicles: safety and performance requirements) states: "The driver shall be seated in the driver's seat, monitoring the safe operation of the autonomous vehicle, and capable of taking over immediate manual control of the autonomous vehicle in the event of an autonomous technology failure or other emergency".

agendas and priorities. Markets provide efficient solutions for problems that can be framed and disentangled from all sorts of externalities and controversies (eg protests by pressure groups, spokespersons for future generations). But their strength is often their limit. Markets can easily marginalise, forget or ill-treat those whose concerns have been excluded for one reason or another and produce all forms of externalities[14]. The example of driverless cars provides another instance of how innovations affect a variety of constituencies whose interests and concerns may be challenged by the innovation[15].

Ultimately, driverless cars may yet turn out to be the right answer to the wrong question if the contemporary challenge is how to get us out of energy-intensive modes of personal transport to more efficient and ecologically-sound modes of public transport. The story of *Aramis*, with its visionary compromise between private and public modes of transport, may yet have a happy ending. The British company Ultra has designed a personal rapid transit (PRT) system, based on driverless pods capable of carrying 4 passengers and their luggage, linking Heathrow's T5 with the business car park. The pods are battery-powered, driverless vehicles offering a novel way to travel to and from the terminal[16]. Could this yet be the future of driverless vehicles?

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[14] Callon, M., P. Lascoumes, and Y. Barthe (2009). *Acting in an Uncertain World*. Cambridge MA, The MIT Press.
[15] Somewhat prematurely perhaps, driverless cars have already featured in political campaigning: http://www.youtube.com/watch?feature=player_embedded&v=NUuBXCEWOhc
[16] http://www.ultraglobalprt.com/

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