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Disruption on the road ahead!

How auto technology will change much more than just our commute to work

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Authorship

Each year NZIER devotes resources to undertake and make freely available economic research and thinking aimed at promoting a better understanding of New Zealand's important economic challenges. This paper was funded as part of this public good research programme.

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Key points

New auto technology will bring disruption with massive opportunities

- Near autonomous cars followed by driverless vehicles (smart cars) will transform our commute to work and much more over the next two decades.
- Electric and hybrid cars are set to become a large part of our fleet, changing the demand for motoring and disrupting our pay-as-you-go revenue base.
- These twin technologies – smart cars powered by electric power – are up amongst the most disruptive technologies of the 21st century. Expect big changes in the way we get around and much more.

Expect a much safer and easier commute

- Electronic Stability Control – an 'old' new technology – has led to massive reductions in fatalities.
- Technology now entering in the mid-stream car market – autonomous braking and lane keeping – promise dramatic accident reductions.
- Cruise control and car-to-car communications will put more cars on the same space of road, reducing congestion. This could enable road capacity to increase by between 43 and 250% without additional investment in tarmac.
- Smart phone software now takes on local congestion caused by people looking for parks and enables peak pricing of parking.

The benefits and impacts extend outside the car interior

- Car-based technologies hold the promise of reducing the billions of dollars we spend on roads by improving how we use them and by saving lives.
- A host of new smart phone apps are starting to enable drivers to compete for public transport passengers, or simply share a ride home.
- Public transport use will also be challenged as car journeys become cheaper, safer and easier to make, and without the environmental emissions.
- Lower congestion and an easier commute make suburbia more appealing. Expect more and more people to live further away from the city centre.

Policymakers and transport providers need to rethink approaches

- We need to:
  - rethink our reliance on infrastructure solutions to transport problems and look at how to effectively embrace the new technologies.
  - assess whether accelerating the adoption of the technologies (e.g. nudge-type policies that encourage upgrade of car purchases) may have a bigger payback than spending on roads and rail investments
  - have a sharp eye out for the many transitional risks the technology transformation will bring.

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1. New technology brings new opportunities and risks

And not too far into the future...

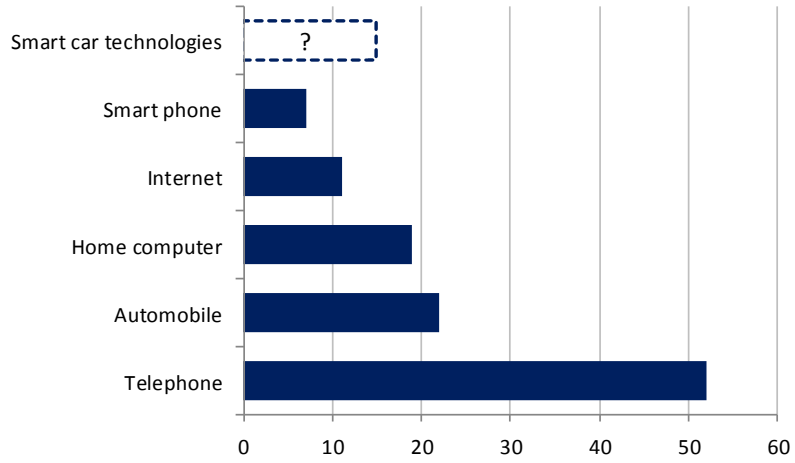
Near-autonomous, and then driverless vehicles, will transform our commute to work and much more over the next two decades.

The rate of technological change is increasing as evidenced by the time it took for US households to adopt various innovations (see Figure 1). Near-autonomous vehicle technology, such as assisted braking, is now available in many new cars.

Over time, we expect the New Zealand car fleet to be much different to the fleet today. In a recent survey, 54% of transport professionals believe cars that do not require the attention of the driver will be commonplace by 2030 or 2040 (Begg, 2014).

Figure 1 The rapid uptake of disruptive technologies

Years taken to achieve 50% penetration in US households



Source: Dediu, 2011

The new 'smart car' technologies are some of the most disruptive technologies of the 21st century, shaping both expenditure plans and policy choices alike.[1] Policymakers need to be aware of the opportunities, the risks and the new policy challenges these technologies bring.

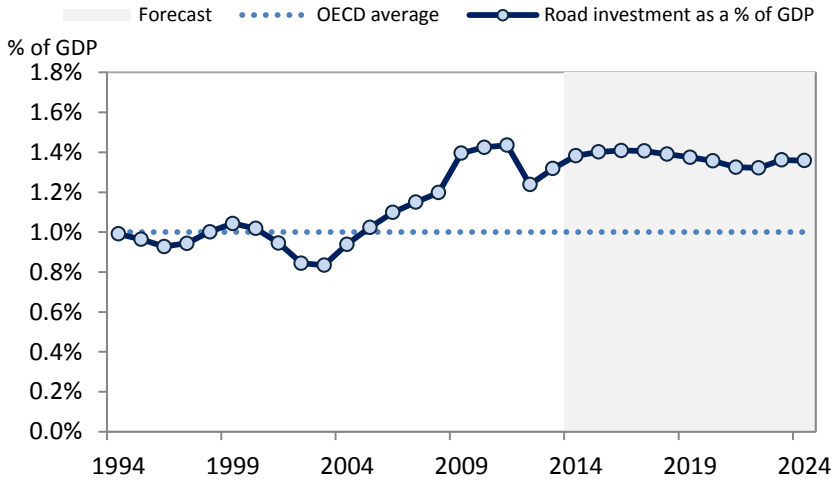
Hey big spender, not so fast!

Land transport is big money. The Government will invest $3.4 billion next year and plans to grow spending on land transport to $4.4 billion a year by 2024/25. Our expenditure on roads is above the OECD average as a proportion of GDP and has been so since 2007 (see Figure 2).

[1] McKinsey estimates a global economic impact of around $1 trillion by 2025.

Figure 2 We continue to spend more on roads than our OECD peers

Roading investment as a % of GDP long run average



Source: OECD, NZIER, draft GPS on land transport 2015/16-2024/25, Treasury long-term fiscal model 2013.

Some of the expenditure compensates for past underinvestment in Auckland. Government expenditure plans show no sign of slowing anytime soon. Passenger transport expenditure of $547 million (2013) is also at record levels.

The new technologies can reduce land transport expenditure needs

The disruptive technology shifts now arriving in the automobile market will deliver:

- large safety improvements that reduce fatalities
- environmental benefits that reduce pollution like carbon emissions
- added capacity to our existing road network, and in many cases avoiding the need to invest in so much tarmac to solve problems such as congestion.

The benefits from the new technologies will arrive well inside the 40-year planning horizon of road and rail investments we make today. The technologies have the potential to significantly affect the expected returns from these investments. We need to quantify the impacts and start taking them into account when we make transport infrastructure investment plans.

We discuss below how the technologies can reduce the need for infrastructure investment by government. The question for government is how it might best reconfigure its transport expenditure patterns to take account of the new technologies. Another question is whether it should facilitate the more rapid adoption of the technologies by consumers and thereby enable reductions in road and other infrastructure investment.

2. Expect a safer and easier commute

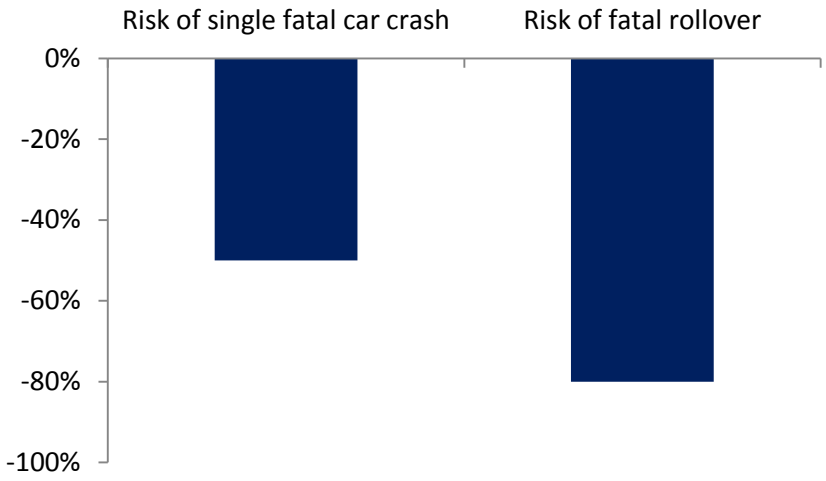
Life-saving technology now on board

New crash avoidance technologies are transforming safety on the road. Let's first look at a somewhat 'old' innovation, standard in most new cars sold today – electronic stability control (ESC).

Thanks to big data analytics, we can now look at the safety of the same cars with and without that technology on board by using insurance claim data, adjusted for traffic density, age of driver and so forth. The Highway Loss Data Institute (HLDI) in the United States estimates that ESC lowers the risk of a fatal single-vehicle crash by about half and the risk of a fatal rollover by as much as 80 percent.[2]

Figure 3 Even the 'old' new technology is saving lives

Impact of electronic stability control on fatalities



Source: The Highway Loss Data Institute

Given these safety improvements, as well as better policing and lowering alcohol consumption, it's no wonder the road toll is coming down. Unfortunately New Zealand's average light vehicle fleet age is around 13 years and maybe 30-40% of the vehicles on the road don't have ESC on board.

Forward collision avoidance systems now available offer even larger safety gains. Features include autonomous braking when drivers fail to do so and adaptive headlights, which shift direction as the car steers around bends.

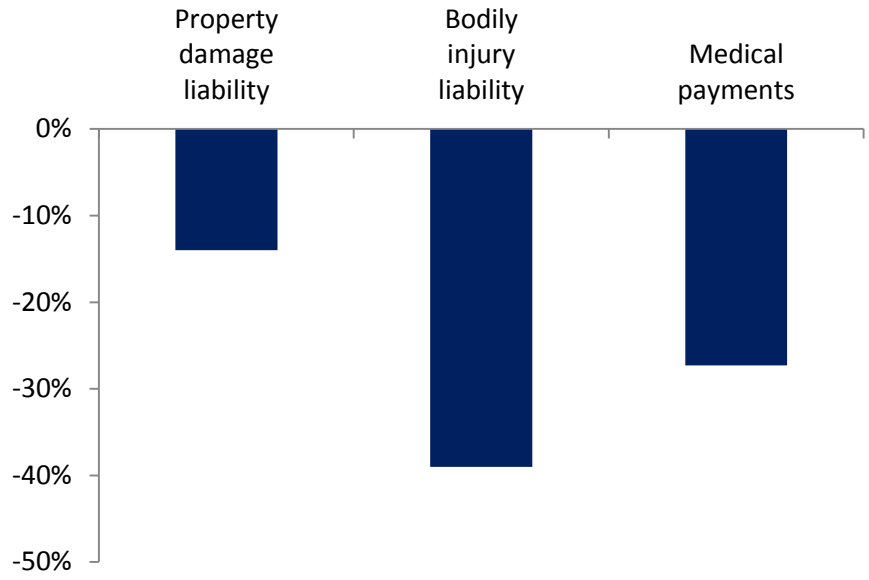
HLDI's first assessment of a high-volume, non-luxury vehicle (Honda's 2013 sedan) fitted with a collision and lane departure warning system indicates the benefits we

[2] Insurance Institute for Highway Safety, Highway Loss Data Institute http://www.iihs.org/iihs/topics/t/crash-avoidance-technologies/topicoverview

should expect from this new technology. These include reduced insurance claims for property damage and injuries (Figure 4).

Figure 4 Expect even larger gains from the 'new' new technology

Honda collision and lane departure warning system



Source: The Highway Loss Data Institute

The Honda HLDI assessed is less advanced than that available in New Zealand, where Honda has introduced a more sophisticated crash avoidance system. We expect even larger safety gains as these improved technologies are rolled out.

Road controlling authorities spend around $300 million per annum on safety works, and a further $350 million is spent on road policing and safety promotion.[3] Safety works include, for example, wide shoulders, safety barriers and skid resistant surfaces on roads. This raises an important question for transport agencies to consider: dollar-for-dollar could investment in cars with lane keeping technology and ESC offer higher social returns than traditional road safety investments?

Faster adoption of these technologies could be facilitated by nudge-type policies[4] that encourage people to scrap old cars and buy cars with collision mitigation technologies on board.

Out on the open road once again – expect less congestion

The Government's road investment programme is addressing congestion bottlenecks in Auckland and Wellington. Smart adaptive cruise control (ACC) now comes not only with a package of safety features, such as autonomous braking, but also 'driverless' features that may open up even more road capacity to further reduce congestion.

3 Government Policy Statement on Transport 2012/13.

4 The KiwiSaver rule that enables people to opt out of saving is an example of nudge-type policy.

Take a drive on YouTube...

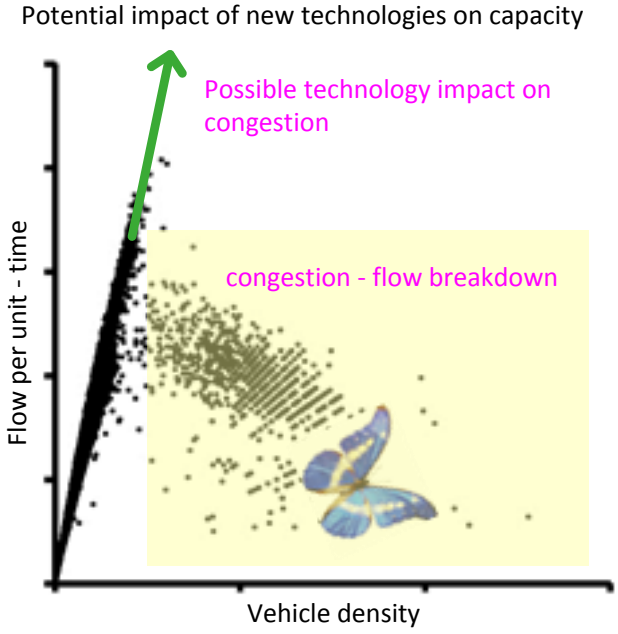
Short of driving a showroom car, the best introduction to this technology revolution is to watch the new Hyundai advertisement on their driver assist technologies.[5]

A convoy of sedans is driven by stunt men who climb through their cars' sunroofs and leap onto a flat deck truck, accompanied by classical music. The front driver of the convoy remains in his car, and blindfolds himself as the convoy follows a sweeping bend (lane keeper) and then automatic emergency breaking is applied to avoid hitting a truck (brake assist). The blindfolded stunt man then muses that the system works. We are advised not to try this at home.

...and see the difference computers can make to driving

ACC keeps the following distance between vehicles constant, manages braking deceleration rates and can shorten vehicle following distances. Unlike humans, computers are not prone to the 'butterfly' effect. As drivers brake and slow unevenly, they send a 'backward shockwave' causing congestion way upstream. ACC has the potential to increase the capacity of the existing road network by forestalling the tipping point at which throughput on the network collapses (see Figure 5).[6]

Figure 5 New technology has no butterfly effect, lifting capacity



Source: NZIER

Estimates suggest ACC could effectively add between 43% (sensors alone) to 250% (car-to-car communication) to road capacity, depending on the technology and driver behaviour. The capacity gains from sensors alone are linear – they grow as the number of cars in the fleet with this technology grows (Yunpeng et al., 2013). This is a powerful example of how the weightless software economy can increase the productivity of our physical economy.

5 You can watch the clip here: http://www.youtube.com/watch?v=Xbjdmw8D9-Y

6 For example, at 6:30 am SH1 at Mount Wellington is carrying 4,000 vehicles per hour, but by 8:15 am when it is needed most, the flow has fallen to just over 2,000 vehicles/hour.

This all means we have a new baseline for future transport investments. New technology will extract more and more value out of our existing tarmac and we need to learn how to take advantage of this. We need to start incorporating this technology change into our transport investment planning and modelling.

3. The electric car raid on the till – so much for peak oil

While smart technologies are improving safety and opening up road space, other technology innovations and market forces are reducing the cost of motoring. In combination, these technologies may maintain or even increase demand for road use by private vehicles.

The petrol engine is becoming more efficient...

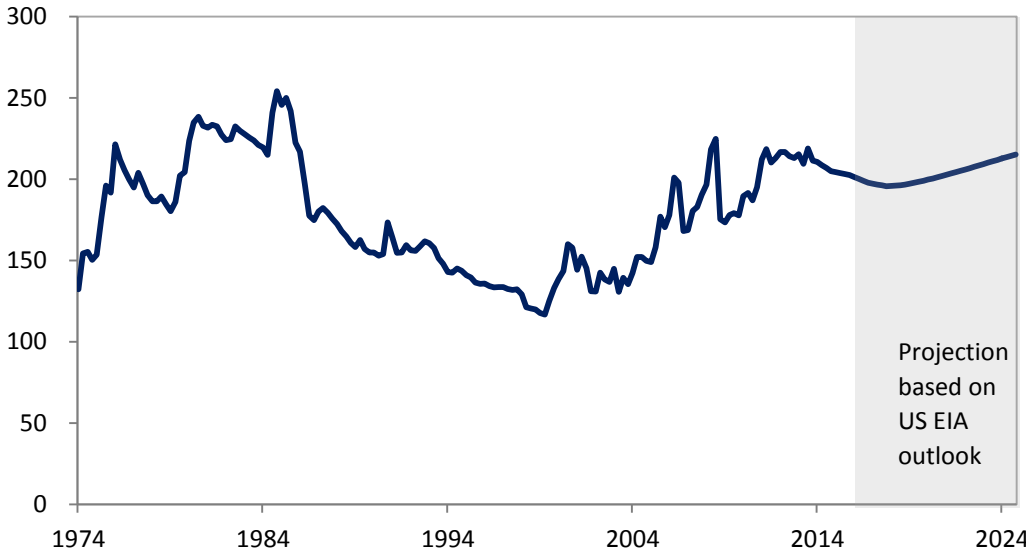
The petrol engine is becoming more efficient. The US Energy Information Association's (EIA) projection is for fuel economy gains to more than offset increases in travel from 2012 to 2040, reducing fuel consumption.[7]

...and falling energy costs support the continued use of combustion engines

The EIA sees crude oil prices bottoming at around USD$91 per barrel; however, others are more bullish seeing a trading range of USD$70-USD$90 by 2020 (Morse, 2014). The United States is now producing as much oil as Saudi Arabia – the world's largest oil producer – due to the use of new oil fracking technology.

Figure 6 Technology increases supply and puts downward pressure pump prices

Real average petrol pump price – cents per litre



Source: MBIE fuel price data and US EIA oil outlook

Large exchange rate fluctuations and unpredictable geopolitical disruptions in the markets aside, that scenario suggests we are unlikely to see real pump prices approach the record set in 1984 anytime soon.

[7] EIA 2014 Annual Energy Outlook 2014 Early Release Overview, http://www.eia.gov/forecasts/aeo/er/early_consumption.cfm

...but there is intense competition from electric and hybrid engines

Electric and hybrid engines now provide a genuine alternative to the combustion engine. This year the New Zealand cost of the fully electric Nissan Leaf halved and its range extended to 175km. General Motors has signalled that it will release an electric vehicle (EV) with a 360km range in 2016.[8] Meanwhile the market leader Tesla has just released a new model S sedan which has a battery range of over 400km (basic model price USD$70,000).

The cost of batteries has been a key hurdle for electric vehicles. This has offered some temporary comfort for internal combustion engine producers. But investment in research and production technology is increasing storage and driving down battery costs. The energy density of rechargeable batteries has increased over eight fold in the last 60 years (Levinson, 2014). Tesla is investing USD$5 billion in a new battery factory that will single-handedly double the global production of batteries. Tesla expects this factory will cut the cost of an EV battery by more than 30%.[9]

UBS Global Research (2014) forecasts a rapid decline in battery costs of 50% or more by 2020.[10] EVs may become more competitive even in the context of falling oil prices.

...that will erode our pay-as-you-go land transport funding base

Recently we saw the entry into the New Zealand market of plug-in hybrid electric vehicles (PHEVs). The Mitsubishi Outlander's daily operating cost is around NZ$1 per day for the average driver commute and a petrol motor is there for those longer trips. Less than 1% of the light fleet are hybrids, but their numbers are growing at a compound annual rate of 26%.[11] Electricity providers see a new market for power and are beginning to offer deals specifically for overnight charging of PHEVs.[12]

Hybrid and electric cars have the potential to erode our pay-as-you-go road funding base. These vehicles may pay minimal if any petrol excise duty and avoid paying road user charges if the engine is petrol. If 3% of the light passenger vehicle fleet become PHEVs, capable of travelling the average daily commute in full electric mode, the loss in fuel excise revenue will be around $30 million annually. A recent forecast estimates that hybrid-type vehicles will comprise between 75-84% of the New Zealand vehicle fleet by 2050.[13]

Government will need to act soon to protect its revenue base

As hybrids become commonplace, governments will need to reassess what is the most fair and efficient means of collecting revenue from road users. Extension of the current road user charging system to hybrids to avoid excise revenue losses would have high compliance costs and more evasion. The most intuitive solution is a distance-based charging regime that uses global positioning technology. Work on developing an alternative charging system needs to be progressed soon given the pace of technological change and the lead time required for implementation.

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8 http://www.businessweek.com/articles/2013-12-12/exclusive-the-inside-story-of-gms-comeback-and-mary-barras-rise#p4

9 http://www.teslamotors.com/sites/default/files/blog_attachments/gigafactory.pdf

10 UBS Global Research, Global Utilities, Autos & Chemicals. 'Will solar, batteries and electric cars reshape the electricity system?' http://knowledge.neri.org.nz/assets/uploads/files/270ac-d1V0tO4LmKMZuB3.pdf

11 Ministry of Transport light fleet statistics for the period 2006 to 2013.

12 http://www.mmnz.co.nz/assets/MercuryEnergyOffer.pdf

13 New Zealand's energy economy in 2050 http://www.unitec.ac.nz/advance/index.php/new-zealands-energy-economy-in-2050/.

4. Crowd-source your parking and public transport

While public transport will see more competition as technologies make private car use more attractive, it will also have to contend with a new weightless competitor on the block. Software apps available on smart phones are now offering passengers alternatives to the bus. Public transport is financially exposed to this competition.

Public patronage growth successes...

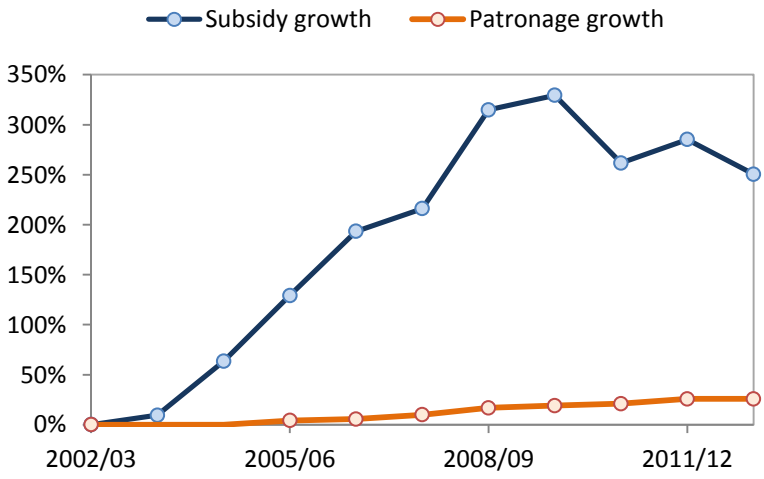
While Auckland has been successful in growing public transport patronage, doing so has required large subsidy increases. The patronage gains have come from a fall in trips made by car passengers, rather than by drivers (Richard Paling Consulting, 2014). Actual car trips have increased by around 23% since 2001.

...have come with a big price tag for the public purse

There is a noticeable wedge between public transport patronage growth and funding growth at the national level (see Figure 7), which is also true of Auckland. Auckland's 50% increase in the use of use public transport required a 250% increase in expenditure over the last 10 years. The taxpayer subsidy for a return trip on rail, for example, is from $15-$50 per head depending on the destination.[14] There is a risk that any significant loss in passenger commuter numbers will lead to even greater public funding demand in the future.

Figure 7 Public transport expenditure is at risk

Public transport patronage and subsidy expenditure growth since 2002/03



Source: Ministry of Transport, Transport Indicators, indicator II015[15]

[14] Hon Brownlee quoted on Stuff, http://www.stuff.co.nz/national/politics/10289369/Poll-Public-transport-beats-better-roads

[15] Ministry of Transport, Transport indicators, indicator II015, http://www.transport.govt.nz/ourwork/tmif/infrastructureandinvestment/

...and new forms of competition for passengers are arriving

New software innovations are now beginning to compete for these hard won commuter public transport passengers. There are over 100 rideshare apps competing for vehicle passenger markets available for downloading to smart phones. Only a few will survive. As in the early days of creating online markets such as Trademe, the various rideshare contenders are fighting it out to be a dominant 'network' provider in different geographic areas around the world.

The Uber ride app has hit headlines with taxi drivers in London protesting against the new 'hire a driver' competition. It has cut this author's typical journey cost from Auckland airport to the city by around 10%, and has cut the price of shorter trips within Auckland by 30%-40%. This is achieved by the Uber app lowering overhead costs and improving coordination between passengers and drivers and thereby reducing driver downtime.

More relevant to the commuter market are apps such as Carma carpooling. This app connects neighbourhood passengers and drivers through smart phones. It uses a default fixed rate per km, tracking trip distance and then automating payment at trip end. Its Auckland market presence can be viewed online.[16]

...and even take on solving parking problems

Apps such as MonkeyParking[17] even take on reducing city congestion. People aimlessly driving around looking for a park cause around 30% of city centre congestion (Begg, 2014). Using MonkeyParking, you can identify a person leaving a park on your smart phone, choose to accept their price for vacating the park and then be guided to the parking spot.

The interesting effect of such apps is that they can be used to arbitrage regulated travel and parking prices. As such, the market has provided a technology-based solution to a challenge that most governments have consistently failed to address: the use of peak pricing to curb travel demand.

Some governments are responding by enforcing their monopolies on parking prices. San Francisco's city attorney issued a cease-and-desist order to MonkeyParking citing a police code that prohibits the buying, selling or leasing of public street parking spaces. Beverly Hills and Santa Monica city councils have voted to ban exchanging a public parking space for any form of compensation.[18]

Should MonkeyParking take hold here, we are optimistic New Zealand politicians will be more open-minded to the public benefits these kinds of app bring.

A tough ride ahead for public passenger transport?

If these apps are successful in avoiding the hassle-cost of connecting people, they will benefit drivers and passengers alike. A trip home in a car takes around half the time of a bus, the driver's cost of a car can be shared and some passengers will see safety benefits from a door-to-door service. If these changes lead to a drop in public transport patronage, there is a risk of per-person public transport subsidy levels growing further.

16 https://carmacarpool.com/

17 http://monkeyparking.strikingly.com/

18 http://www.latimes.com/local/california/la-me-parking-disruption-20141028-story.html#page=1

Growth in public transport patronage over the last decade has been supported by increased expenditure, large increases in pump prices and the largest economic recession in decades. This tail wind support may no longer continue over the next decade and passenger transport will need to adapt to new technology challenges.

5. Impacts outside the car window

A rerun of the 1950s style urban growth?

An extensive report on the impact of the new vehicle technologies on London argues that "it will not be good for the economy or environment if autonomous cars lead to lower density cities or higher car use" which the author views as "most extreme in US cities" (Begg, 2014). The author is concerned that we are in for a re-run of the 1950s where growth in car ownership shaped city form.

His concern that sprawling cities are not good for the economy is highly contentious. After all many sprawling US cities are economic powerhouses. It is nevertheless important to consider how cheaper, safer and more convenient private transport will affect urban form and the environment.

Figure 8 Will suburbia be the winner from better auto technology?

Source: Dreamstime.com

Travel costs are an important determinant of where households locate…

Glaeser and Kahn (2004) contend that cities can be thought of as the absence of physical space between people and firms. Cities then exist to eliminate transportation costs for goods, people and ideas. As such transportation technologies then dictate urban form and lowering the cost of travel will contribute to urban sprawl. This outcome may be truer of cities with high land prices like Auckland as people seek to travel further afield to gain affordable housing.[19]

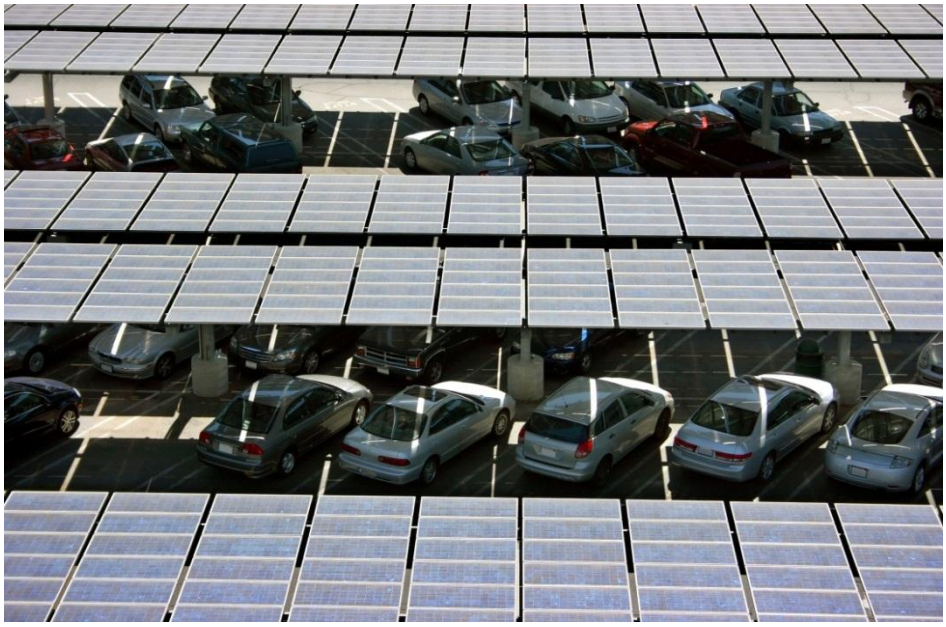
19 People's demand for household space is increasing: New Zealand's average new home build is now 200 square metres. This is well below that in Australia and the United States, which is 280 square metres. We can expect New Zealand to follow as incomes increase.

…and other new technologies may complement urban living

The net cost of providing electric lines infrastructure to suburban households may fall significantly making urban living more attractive, if households can generate their own power. Roof top solar panels have fallen in price dramatically and can be used to charge electric cars and other household appliances. An advantage of electric vehicles is that their batteries can be used to store energy for household power usage.

The economics of this aspect of the technology story is just beginning to unfold and we anticipate it will be several years before its effects will be known. If, however, this new energy technology *does* take hold, it is another factor that will make urban living more attractive for some.

Figure 9 Future Auckland park and ride?



Source: © Roza | Dreamstime.com

As driverless and near-autonomous vehicles make car use more attractive we may then see further pressure put on metropolitan urban limits. As the new technologies have significant environmental benefits from reduced emissions, urban planners will need to find other rationales for limiting urban sprawl.

The demand for household space is unlikely to be fully met by high-rise apartments (often favoured in city planning) because these typically cost 28% more per square metre to build than a typical suburban home (Rawlinsons NZ 2013 and Rider Levett Bucknall 2014 Q1 average of medium and high quality residential and multi-unit build cost). Thus on a dollar for dollar basis urban living can provide a family with more space than a multi-unit apartment.

And there will be much wider economic impacts

There will be further extensive social and economic impacts of the new car technologies that are beyond the scope this article to explore in depth, such as:

- more efficient combustion engines and electric vehicles will likely reduce New Zealand's reliance on oil imports, improving its long-term current account balance
- scarce hospital system resources can be redirected away from expensive emergency response and intensive care services often associated with car accidents
- the expected large reduction in serious accidents and fatalities will reduce required insurance premiums and Accident Compensation Corporation levies. It will also significantly reduce the amount of assets they need to hold in provision for serious injuries and fatalities
- investors in transport infrastructure such as toll roads, tunnels and bridges, freight logistics and passenger rail need to start factoring in the implications of driverless vehicle technologies for demand and productivity gains
- a wealth of investment opportunities will also be created on the IT side. The emergence of companies such as Trademe and Xero offers some hope that New Zealand will be able to capitalise on these global technology shifts
- smart cars and electric vehicles have disruptive implications for a range of more traditional New Zealand businesses such as taxi and rental car companies, motor vehicle servicers, and tourism operators
- the potential transition towards a significant electric vehicle fleet in New Zealand and abroad presents downside risk for the upstream fossil fuel sector, refining, and petroleum retailers.

A partial analysis of the benefits of the new technologies – focused only on the widespread market uptake of electric vehicles – estimates a net benefit to New Zealand of $10.5 billion (Hyder, 2009).

Research from Morgan Stanley provides a rough estimate of the widespread adoption of driverless technology in the United States being worth around USD$1.3 trillion annually. This is equivalent to around 7% of United States GDP in 2013.

The big savings come from fuel savings (USD$158 billion), reductions in accident costs (USD$488 billion), increased productivity (USD$507 billion) and from congestion savings (USD$149 billion).[20]

If we accept Morgan Stanley's estimates as being in the ballpark, this suggests the arrival of driverless technology into New Zealand could have significant economic benefits.

[20] http://robohub.org/morgan-stanley-reports-on-the-economic-benefits-of-driverless-cars-2/

6. Rethinking policies

It is important not to passively wait until the full extent of the impacts of these technologies is revealed. Policymakers should think about how we can harness new technologies to improve social outcomes.

The Ministry of Transport is beginning to implement a significant work programme exploring the implications of the new technologies (Ministry of Transport, 2014a). This is great but it is important that awareness of the rapid changes about to occur in the next 15 years are also understood by the wider public and public sector including city councils, the Treasury, Ministry for the Environment, and the Accident Compensation Corporation.

We have identified several areas where government should be proactive including:

- ensuring urban and transport planning reflects the likely risks, opportunities and transition issues these new technologies bring to the reshaping of cities and transport networks
- revising the road sector's approach to cost benefit analysis to take on board the potential impact of the new technology on required road capacity and on road design
- recognising the emerging competition for public transport passengers and considering how public transport can be made more attractive to customers
- ensuring the Accident Compensation Corporation component of vehicle registration fees is continuously updated to reflect the riskiness of different vehicles so new car buyers receive appropriate price signals
- assessing whether nudge-type policies, which encourage people to scrap old cars and buy cars with crash avoidance technologies on board, have better life-saving returns than current infrastructure safety investments.

The history of New Zealand's transport policy making has not been proactive. A period of underinvestment in land transport has led to the congestion problems in Auckland. Today we continue to build roads assuming a business-as-usual future. Rather than considering schemes that encourage an accelerated take-up of technology, we usually regulate for its use late in the day to try and minimise the regressive impacts on low income households.[21]

Governments have an important role in facilitating the introduction of these new technologies and helping to manage the many transition risks. Diverse mixes of car technologies in a fleet will pose risks. Imagine borrowing your friend's manual car and forgetting for a moment you no longer have autonomous braking operating. There will also be legal and regulatory issues to work through. For example, who is at fault when the software fails?

In sum, given the opportunities, risks and challenges associated with the new vehicle technologies, it is important to widen the public policy discussion away from its narrow focus on road and public transport investment priorities.

[21] For example, the New Zealand government has regulated that ESC is to become mandatory in new cars from 2015 onwards. However by this time it will already be provided in most new cars – the regulation will have very little impact in changing behaviour.

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