

The influence of internet use on transport demand

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C Bowie, M Trotter, L Baker, L Early and C Robertson
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NZ Transport Agency
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
research@nzta.govt.nz
www.nzta.govt.nz

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Abbreviations and acronyms

HTS	New Zealand Household Travel Survey
IoT	internet of things
ICT	information and communication technology
IT	information technology
UFB	ultra-fast broadband

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Executive summary

This study sought to understand how people's use of the internet could be expected to influence transport demand in New Zealand.

The question of how internet technology will impact on travel patterns, demand and behaviours is not new, but is complex. It entails interaction between a rapidly evolving technology (the internet) and a historically fundamental component of society (transport) which also continues to evolve. While the speed and scope of technological change have been great, the extent to which the internet has modified, increased or reduced travel demand is not clear.

This research first took a broad view of how the internet might influence transport demand. A literature review complemented by in-depth interviews was undertaken that sought to identify the mechanisms by which these influences might operate, and how the effect might be measured in New Zealand. Following this review specific focus was given to the influence of the internet on work-related transport demand.

The nature of how internet use will influence transport demand for work-related travel is generally well understood, or at least thought to be, but the magnitude of effect and timeline for change is much less so. In isolation it may be possible to quantify the influence of internet use on transport demand for staff at a single organisation, though the applicability of this measurement to other organisations – even those operating in the same sector – may be low.

This is due to transport being just one driver of investment in new technologies within organisations, and among the case study organisations was often a relatively low priority. Internet technology and services are shaping where, when and how staff work, and in turn potentially lowering business costs and increasing staff productivity. These processes influence transport demand, but it is highly unlikely that this influence can be attributed solely to investment in a specific technology.

Precise measurement of the influence of the internet on transport demand is therefore inherently difficult. There are many confounding influences within an individual organisation that act on the relationship between the two; measuring and predicting this across an industry sector or urban area only adds to the challenge. However, this should not stop the business and the transport sector for continuing to invest and plan ahead for expected eventualities.

Ultimately this research demonstrated that the internet itself does not act directly upon transport demand. Rather, the internet provides opportunities for people to change existing behaviours and adopt new ways of living and working that in turn influence their day-to-day demand for transport services.

Abstract

This report presents a discussion of the influence that internet-enabled communication technologies are having, and might have, on patterns of transport demand in New Zealand. First, a range of mechanisms by which the internet could reasonably be expected to influence transport demand are described. In-depth interviews with decision makers at public and private organisations in New Zealand highlighted two main areas where change is being driven by internet communication technologies: direct effects on transport demand; and the changing nature of the physical workplace, which has outcomes for transport demand as people change where, when and how they work.

There is a dearth of literature that quantifies a causal association between use of the internet and transport demand. Additionally, suitable datasets to measure the influence at city, regional or national levels do not currently exist in New Zealand. Much investment and change in use of internet communications technologies is taking place at an organisational scale. Though, the relationship between investment in technology and transport outcomes is confounded by factors of behavioural preferences, societal and organisational norms, and internal policies. The experience of these organisations identifies changes we can expect for both transport demand and working behaviours in an increasingly digital society.

1 Introduction

This study explores how people's use of internet technologies influences patterns of transport demand in New Zealand. The research was undertaken across two stages.

The first stage was an exploratory study of the mechanisms by which the internet is expected to influence transport demand in New Zealand. This drew on international literature and key informant interviews to identify current and future internet trends expected to affect transportation, and sought available data that could be used to quantify the direction and scale of influence in New Zealand. The focus of this stage was to understand the feasibility of developing indicators of the internet's influence on transport demand that could be used in next generation city or regional transport models. If feasible, a subsequent stage of work would develop a methodology to do so and provide a proof of concept using Auckland as a case study location.

The first research stage identified a range of potential indicators of the internet's influence on transport demand in New Zealand. However, it did not find an adequate method or source of data that could be used to robustly model any causal relationship at a city or regional scale. This stage of the research also pointed toward the dearth of studies that have comprehensively quantified internet influences on transportation at the substantial geographic scale that would be needed to inform city and regional transport models.

In New Zealand, there is some data for the changing use of internet technologies; however, surveys are conducted infrequently and with small sample sizes. While appropriate for monitoring trends in internet use over time, they are not well suited for use in regional transportation models. Temporal and geographic scale is important to monitor and predict changing patterns of demand, and confounding factors need to be controlled to understand the scale of influence.

Given the expected difficulty of undertaking a quantitative study to model the influence of the internet on transport demand, it was decided to focus on internet technologies only in the context of business activities in New Zealand.

Thus, the second research stage made use of in-depth interviews with a range of large public and private organisations in New Zealand. The focus of these discussions was:

- 1 The type of transport-related behaviour change that organisations want to enable for their staff
- 2 The role of internet technologies in relation to these behaviours and policies
- 3 Transport-related and other outcomes organisations expect to see because of investment in, and use of, internet technologies
- 4 Real and expected barriers to achieving the desired behaviour change within each organisation.

In this report, we discuss key themes from these interviews and present a 'think piece' that proposes the mechanisms by which internet communication technologies are likely to influence work-related transport demand in New Zealand.

Chapter 2 of this report describes the research approach for stages one and two in further detail, and outlines the decision making that took place at the hold point between the two research stages. Chapter 3 broadly describes the mechanisms by which the internet could reasonably be expected to influence transport demand. Building on this, chapter 4 presents a review of relevant literature, with a focus on the types of internet-related activities most likely to influence transport demand in New Zealand. Chapter 5 concludes the first stage of this research with a discussion of interviews held with a group of key

informants with knowledge of New Zealand's internet and/or transport modelling sectors. Chapter 6 introduces stage two of the research, and presents an in-depth discussion of the case study interviews undertaken for this work. These case studies engaged senior staff working within large public and private organisations to explore how modern internet technologies are enabling them to drive changes in staff's travel behaviour. Chapters 7 and 8 present the conclusions and recommendations of this study.

2 Research approach

2.1 Research stage one: literature review and key informant interviews

The first stage of this research was an exploratory investigation into the nature and direction of the effect of internet communication and commerce on transport demand in New Zealand, namely the impact of internet-enabled video communication and related technologies, and internet shopping.

A review of the mechanisms by which use of the internet for these activities is likely to influence transport demand was undertaken (chapter 3), followed by a literature review (chapter 4). This literature review was accompanied by structured interviews with key informants in New Zealand (chapter 5).

Stage one of this research gave specific focus to:

- recent New Zealand and overseas trends in the use of different internet communication and commerce tools and services
- studies that quantify associations between internet use and changes in transport demand
- emerging and future internet-enabled technologies and services, the time frame in which they will appear, expected uptake, and their likelihood to shift or disrupt existing transport demand
- methodologies for measuring and inferring the influence of internet communication and commerce on transport demand, particularly those that could be relevant to regional transport modelling and could be applied in New Zealand.

2.2 Hold point

Stage one of the research was followed by a hold point so that findings from the literature review and key informant interviews could be discussed with the project Steering Group at a workshop. This workshop focused on the current and future trends identified by the research, the nature and size of the effect of internet communication and commerce on transport demand, and a proposed approach for further research in stage two.

Ultimately, the literature review and key informant interviews pointed to a range of generally agreed hypotheses for how the use of the internet for video communication and internet shopping would affect transport demand. However, there was a dearth of studies where these hypotheses had been tested and quantified at a city or regional scale using secondary data (section 4.6).

At this point it was agreed with the Steering Group that seeking a quantitative approach to determining the influence of internet communication and commerce on travel demand was unlikely to produce robust outputs. It was agreed that the focus of research in stage two would be an in-depth study of the nature of internet use at a range of New Zealand organisations, and the influence this is having on travel-related working behaviours.

2.3 Research stage two: case studies

A case study approach was undertaken for stage two of this research, with in-depth interviews held across six New Zealand organisations to discuss the influence of internet technologies on work-related travel behaviours. These case studies focused on:

- the type of transport-related behaviour change organisations want to encourage among their staff
- policies that organisations hope to implement to drive behaviour change, and what type of investment in technology is being made to support these
- the role of internet technologies in modern travel plans and policies, and where these sit in relation to increasing the efficiency of an organisation
- transport-related and other outcomes that organisations expect to see because of investment in internet technology and changed working behaviours, and how these outcomes could be tracked or measured
- barriers, real or expected, to achieving the desired behaviour change, and the role of internet technologies in contributing to or mitigating these.

3 Mechanisms by which internet use may influence transport demand

3.1 Introduction

Predicting the influence of internet communications and internet commerce for transport demand and economic modelling is necessarily a speculative task. Some evidence exists for historical internet and transport trends to be examined independently. Sourcing data that can infer causal or associative links between the use of internet technologies at a relevant spatial or temporal scale for city or regional level transport modelling is more challenging.

The task is speculative also because any attempt to use historical information to predict future internet and transportation trends will be subject to bias given our limited understanding of future behaviour. The rate of development and potential for step changes in internet-related communication, commerce and transportation technologies further confound this problem.

Despite this, the question of how internet technology will impact on travel demand, patterns and behaviours is not new, and seeks to understand an interaction between two rapidly developing sectors that increasingly overlap. Transportation development has historically been a major influence in shaping our settlements, and in turn how people live, work and socialise. A relatively younger, but rapidly growing and advancing technology, the internet too has had a significant impact on how people, communities and cities function. With transport activities increasingly being managed, planned, operated and accessed via the internet, the potential influence of emerging and future technologies on transport demand, patterns and behaviours is large.

This research calls on the framework summarised by Mokhtarian (2003), which builds on the work of Claisse (1983), Mokhtarian and Salomon (2002), Niles (1994) and Salomon (1986; 1985), to describe the possible relationships between the internet and travel demand. These early pieces of research adequately describe today's potential influences, even if the underlying technologies and activities are now different. This framework is presented in the following section.

3.2 The nature of potential influences

Internet technologies have the potential to influence transportation through the following mechanisms:

- **Substitution** – the replacement of physical travel with activities carried out via the internet instead. Video conferencing, working from home and online learning have all been hypothesised to replace the need for people to travel for work and education. Many government and business functions that previously required travel for face-to-face interactions, such as banking, renewing passports and driver licences, and even voting in some overseas regions, now have the option to be carried out online.
- **Complementarity** – (also referred to as stimulation or generation) the potential of internet use to increase demand for and use of transport modes. This relationship is effected by two processes:
 - **Enhancement** – use of the internet creates demand for and use of transport, or facilitates the use of transportation. There are many examples of the internet enhancing transport demand today: internet shopping generates freight movements; and web-enabled mobility services (for example, Uber and Lyft) facilitate transport demand by a particular mode. Use of the internet can generate

trips, for instance WSP Opus' project team for this research is based in multiple offices around New Zealand and travelled to meet in person occasionally, though the project itself would not have been possible for this team without emails and video conferencing for day-to-day activities. As access and payment for mobility services are increasingly provided to people and businesses online the enhancement of transportation via the internet will likely increase at a rapid rate

- *Efficiency* – the internet and wider telecommunications have long been used to improve transport efficiency through processes such as organising meeting times, calendars and making multi-modal transport bookings (for example, taxi > airport > rental car) for end-to-end journeys. Increasingly, the internet is improving the efficiency of transportation with real-time automation. Taxis and ride hailing services connect drivers with travellers based on current location, so a driver finishing one trip will begin another nearby without needing to return to a central location or make a long journey to start a new trip. Automated internet-enabled systems are fundamental to emerging and future generation mobility services, vehicle technologies, network management operations and end-user (people and business) information, planning and payment platforms.
- *Modification* – the ability of internet use to modify the nature of a trip. 'People focused' internet-enabled transportation tools, such as mapping and navigation products and public transport journey planners, are frequently used to modify individual trips. The trip still takes place, but depending on online information, it may take place at a different time (for example, planning a return trip based on real-time public transport information). Alternatively, the mode used to make the journey may be altered (the next available bus is inconvenient so a person decides to drive, taxi, walk or cycle instead), or the route taken may be changed (navigation software suggests a faster route factoring in distance and current traffic conditions).
- *Neutrality* – the overall effect is neutral. Communicating via the internet or carrying out an activity online is not always a substitution for transport demand; as people's lives are increasingly conducted online, the transport alternative for engaging in many activities does not exist. For example, a person who buys music online may not have had the desire to visit a store and purchase the same album. A distance learning student might otherwise not have studied at all and instead sought another vocation. Geographically dispersed staff within a company might not be a part of a project team if not for the ability to communicate via the internet. The convenience and usability of modern internet technologies can increase activity to higher levels than what was previously feasible, so travel demand is unaffected in some instances.

4 How might the internet influence transport demand?

4.1 Introduction

People travel for many reasons, including travelling to and from work and education, and for everyday activities such as shopping, moving goods around and socialising. Golob and Regan (2001) suggested that the internet and information technology (IT) affected personal travel in a variety of ways. They described eight factors that had the most significant impact. These included online shopping (e-commerce), other online services and in particular telemedicine, flexible working arrangements such as telecommuting, self-employment, contingent and part-time working arrangements, mobile working and education.

Golob and Regan (2001) further stated that individual travel was becoming more effective with advances in the internet (telecommuting and scheduling tools) as IT gave people virtual accessibility to a rapidly growing range of activities. More recently, Delbosc and Currie (2015) found that increased person-to-person contact through information and communication technology (for example, social media platforms) was strongly associated with more frequent in-person contact for young adults. The question remains — what is the quantified effect of the internet on transport demand? Is improved virtual accessibility causing people to physically travel more to either access a wider range of activities or to move goods and services around? Or is it reducing travel demand as activities which once relied on physical travel to a location are replaced by activities that can be completed virtually?

4.2 Internet communication technologies

In New Zealand, Crothers et al (2016) found an increase in the number of phone calls made over the internet between 2007 and 2013, with two-thirds of people using the internet to make phone calls in 2016 and 40% doing it on a weekly basis. Data from Australia also showed a decrease in fixed line communications, with a 34% reduction over the five-year period from 2008 to 2013 in wired telecommunication network revenue, and a 25% increase in wireless telecoms carriers' revenue. Total Australian home voice over internet protocol users more than doubled between 2009 and 2013, making up just under half the number of fixed-line home phone services in Australia. The volume of 'over-the-top' messages, such as WhatsApp and voice over internet, was more than SMS traffic globally in 2014 (Commonwealth of Australia (Australian Communications and Media Authority) 2014).

Internet communication technologies play an important role socially in allowing individuals to keep in touch with a wide range of family and friends with ease. There is evidence that these technologies have not replaced the need for travel in many cases. In-person meetings between people are still the most widely used form of communication; they just take place less frequently compared with technology-enabled methods. Further, video calling on platforms such as Skype allows people to continue 'face-to-face' communication even when they live in different countries, and it is unlikely that a sizeable substitution of physical travel has taken place. The quality of relationships people can maintain over large distances using internet communication technologies may increase the likelihood of travelling to visit family and friends they might otherwise have lost touch with, thus generating transport demand. Services such as instant messaging might have replaced the need for a phone call, but not necessarily a trip, and may be used to arrange physical meetings that require travel.

For business, the relationship is similarly complex. Video conferencing has certainly reduced the need for some trips to be made, particularly where groups of people are involved and a phone call might not be

sufficient. One-to-one, however, a video call functions much like a phone call. Technologies that provide the opportunity to share more than just voice and video content (for example, sharing documents and presenting remotely) potentially substitute the need for physical travel.

4.3 Activities complemented or modified by internet communication technologies

4.3.1 Employment and business

Internet-enabled communications have widespread use in the business environment, facilitating one-to-one, one-to-many and many-to-many interactions between people in different locations locally, nationally and internationally.

WSP Opus has encouraged the use of such technologies, with the video-conference tool Skype being implemented. The intended outcome of using such technology was a reduction in travel (both vehicle and air) between offices for collaborative project work. Initial results point to a reduction in physical travel leading to a demonstrable cost saving. Though, the change can also be attributed to complementary company travel policies and strategies for reducing the need to make physical trips, and savings as a percentage of pre-Skype baseline costs have not been calculated.

The internet has also influenced physical travel by replacing the need for some travel to generate business. One example is a New Zealand recruitment firm where staff no longer travel overseas on an annual basis to attract workers, as the internet allows them to connect with the right people from New Zealand, saving them \$60,000 each year (Glass et al 2014). Another example is an architect who does not need to travel to sites as often, as planning and design is done digitally.

Telecommuting is an example often given as a suppressor of travel demand. Early forecasts were very optimistic of the ability of people to work remotely from their places of work to reduce travel demand and congestion (Golob and Regan 2001). However, one element that needs to be considered is the difference in travel behaviour between full-time, part-time and self-employed people. Giuliano and Gillespie (1997) even went as far as to say that the greatest effect IT and the internet will have on travel will be through the indirect societal changes of temporary and short-term employment and self-employment, which will outweigh the influences of telecommuting on travel demand.

Many companies around the world, such as Dell, Aetna and Xerox, advertise their use of telecommuting, which gives employees greater flexibility and allows companies to gain and retain talent. Tools that enable telecommuting are essential (such as remote access networks and security systems); however, data shows that employee travel is significantly reduced. Aetna reduced employee commuting distances by 204 million kilometres and Xerox employees travelled 148 million fewer kilometres. These companies also saved millions of dollars on real estate costs as they needed less space for people to work (Morgan 2015). Hospice Waikato recently trialled video conferencing, with a view to implementing the service in 2017 as a way of remotely connecting doctors and health care professionals with patients. In an article (Leaman 2016), Hospice Waikato was quoted as saying:

With an ageing population, there's going to be more and more demand on hospice and palliative care services. We can't simply employ more and more healthcare professionals, putting them in cars, and have them travel around patients' homes and rest care facilities... Allowing doctors to connect virtually with patients is much more productive and a better use of our resources because the doctor isn't having to spend three hours travelling in a car to see a patient.

4.3.2 Internet commerce

'Internet commerce' covers all commercial activities carried out on the internet, including buying and selling goods and arranging for professional services to be conducted. These goods and services might be provided physically or via the web.

Internet commerce is one of the fastest growing sectors in most western countries (Golob and Regan 2001). Thomas and Jose (2015) credited the creation of eBay and Amazon in the early 1990s for leading the way in internet commerce and the rapid development in technology (such as hand-held mobile devices and 3G and 4G accessibility) for driving consumer demand for online transactions. Even though internet commerce only accounts for approximately 6% of total retail sales in New Zealand (Glass et al 2014), with 84% of people surveyed by the World Internet Project in New Zealand in 2016 (Crothers et al 2016) wanting to do more shopping online and 40% wanting to use it more for entertainment, it is inevitable that it will both generate and suppress travel demand in the future.

In 2016 Crothers et al (2016) found 84% of people bought things online, an increase from 2007. The number of people selling things online was also increasing, with 59% of people saying they did this in 2013. These insights are important as some of these transactions are likely to suppress the need to travel, with people purchasing goods online rather than travelling to shopping areas. However, some of these transactions also generate travel demand as goods purchased online are delivered. Therefore, it can be assumed that internet commerce in terms of online consumer shopping creates substitution, complementarity, modification and neutrality outcomes for transport demand. The specific effect is dependent on the business processes that are in place to make products available for sale and put them in the hands of buyers.

Internet commerce has given rise to new businesses, and therefore travel demand via freight and people movements (employees and consumers who might still visit a physical store) that would otherwise not have existed. Statistics New Zealand (2013a) noted that businesses taking online orders grow faster and export more products, while Glass et al (2014) highlighted that the internet allows new businesses to launch that are based 100% online. The results are not causal, it is also possible that exporters and fast-growing firms are inherently more likely to take online orders compared with other businesses. These businesses can establish themselves with lower costs and risks, due to savings on rent and minimising space required for physical shops, and allow owners greater flexibility. Online businesses also generate travel demand by widening their customer base beyond their immediate area, and therefore sending products further afield, generating courier and freight trips (Glass et al 2014).

Crothers et al (2016) found the most common e-commerce activities in New Zealand are getting information about products, comparing prices, doing online banking, paying bills and booking travel. An increase in consumer administrative online transactions (paying bills and booking travel) is likely to reduce trips as people do not need to travel to make these bookings/payments in person.

It is, however, disputed as to how online shopping affects travel demand. Mokhtarian (2004) stated that online shopping could substitute, complement or modify (change the mode, timing or other characteristics) shopping trips. Farag et al (2007) initially supported this theory, suggesting that online searching of products with the purpose of comparing products prior to purchase could replace shopping trips. However, their results, based on survey data collected from 826 respondents, showed that people (who self-identified as internet users) who frequently searched online tended to make more shopping trips than people who searched infrequently, regardless of whether these people lived in urban or suburban areas. They also found that people who shopped often in-store also bought often online, and that online shoppers made more shopping trips than non-online shoppers but of shorter duration. The results point to online shopping being a generator of travel rather than a substitution or suppressor of

travel, though they might also simply reflect that people who do more shopping trips are likely to do more online searches.

Other studies that support online shopping as a generator of travel demand include a European study (Boston Consulting Group 2001) that found 75% of people who browsed for product information online purchased the product in a physical store. Ward and Morganosky (2002) found many individuals in Europe started their shopping process by searching for information online before travelling to a physical shop. Casas et al (2001) found that people who shopped online tended to make more shopping trips than people who did not purchase online. Golob and Regan (2001) and Farag et al (2007) also found that often people made 'chain' trips, travelling for multiple purposes, for instance completing one trip chaining shopping and recreation legs of the journey.

Further, prior to widespread use of the internet consumers may have been more likely to visit multiple stores in-person to compare prices before purchasing a high-value product. It is possible that internet commerce has substituted the need to make these scouting trips, even if the actual purchase itself is made in person and generates a trip.

One difficulty in comparing these studies is the variation in the definition of what constitutes online shopping and the methods for analysing generators and suppressors. It is also possible that consumer behaviour has evolved since these studies were completed. Yet given these difficulties, it is generally agreed that online shopping has the potential to alter time and location constraints associated with in-store shopping and bring more flexibility to shopping activity (Couclelis 2004). Online transactions related to shopping for household goods such as groceries are more significant for altering travel patterns and demand, given their repetitive nature, than more infrequent leisure shopping trips (Golob and Regan 2001).

The 'on-demand', 'peer-to-peer' and 'sharing' economies have all grown to become influential market segments due to internet technologies. On-demand movies and television have not only disrupted traditional sources of media, but also provided this entertainment in people's homes. Approximately 70% of New Zealand users downloaded and watched videos online in 2015 (Crothers et al 2016). In 2014, 26% of Australians were most likely to watch films via online digital sources in the following 12 months (Commonwealth of Australia (Australian Communications and Media Authority) 2014). Companies such as Netflix and Lightbox have provided flexible in-home entertainment options. These platforms have potentially substituted the need to travel to see a movie or pick up a video/DVD from the neighbourhood rental store. The latter is most likely, and the demise of movie rental stores is evidence of this, while there remain many people willing to travel to see a new movie, given the time delay between movies being screened at the cinema and made available online. Increasing levels of television and movie consumption via the internet also has a neutral effect on transport, where it represents increased consumption of media, and not substitution of travel to hire or watch a movie.

Peer-to-peer platforms, such as TradeMe, and the sharing economy, such as AirBnB, allow people to access goods and services directly from one another via the internet. TradeMe and similar platforms are likely to have enhanced demand for transport via freight movements and people travelling to pick up and drop off products sold online. In contrast, AirBnB provides accommodation, a service that has long been available, and so the influence on transport demand is not always a direct enhancement effect. Many people who use AirBnB already want or need to travel to a location, so their transport demand already exists. What has potentially changed, however, is the nature of that movement: instead of travelling to stay in established centres, accommodation is provided in residential areas, so transport patterns are modified locally.

The 'death of distance' hypothesis is often considered a factor influencing travel demand. It assumes that technological advancements in transportation and communications have reduced the cost of moving products and information over long distances, and therefore geographical factors of distance play a less constraining role in business. Improvements in internet and IT (satellite assisted shipping, inventory management and universal cargo containers for transferring between different modes) have benefitted long-distance travel of goods and people. However, reducing the role geography plays in transportation has not necessarily reduced costs for companies and thus not greatly influenced freight patterns (OECD Observer 2008).

Given that the internet has enabled numerous new and existing New Zealand and overseas businesses to sell products and services to New Zealanders, and for people to directly buy and sell goods, services and even property amongst themselves, it is to be expected that, from an overall system perspective, internet commerce has generated transport demand.

Enhancement of travel demand via economic activity does not provide a complete picture, with daily transport demand and transport patterns potentially changing markedly. Online shopping generates freight movements, which are not a direct substitution for what might previously have been a return journey for an individual. The freight movement itself may start and end in different locations, ranging from a distribution warehouse (where multiple deliveries are chained into a single trip thereby increasing efficiency) to someone's house (in the case of a peer-to-peer transaction). Transport demand and patterns are likely to be considerably modified by internet commerce activities, with associated trips potentially taking place by different modes, and at different places and time of day.

Many internet commerce transactions will have a neutral effect for transport demand. Some products and services are delivered directly via the internet, for example downloaded music or tickets to an event. While this may have substituted for a person buying these products in person or a freight delivery, many transactions will be the result of the internet providing access to a wider audience than was previously available. It should be noted though that while the purchase of a ticket may not influence transport demand, attending the event itself is likely to, so there are follow-on mechanisms by which internet commerce can influence transport demand.

4.3.3 Social activities

The advent of online social media platforms has, like other internet technologies, provided people with the opportunity to easily engage with individuals and groups who are geographically disconnected. These interactions have a complex effect on transport demand, and it is not a simple case of engagement via social media representing a substitution for travel. There are, however, many elements of typical social media platforms that likely influence travel demand and patterns. Functions such as 'checking in' at a specific location, reviewing local hospitality services, marketing to an individual's network of friends and followers, and wanting to be seen to be keeping up with current trends or having a particular lifestyle (in fashion, travel, dining and entertainment) all have the potential to encourage people to make a trip that they might otherwise not have taken.

Social media connections and online gaming have influenced people's need and desire to travel. Games like Pokémon Go have been strong drivers in influencing people's physical activity. Although the game needs to be played as a pedestrian (walking around to find and 'catch' characters) (Althoff et al 2016), some players travel to specific areas by other modes of transport to play the game (Murison 2016). The duration of this phenomenon is unclear, though the success of Pokémon Go points to the likely emergence of similar products. The 'niche' aspect of these products and influence on transport demand

for a relatively small group of people make it unlikely transport planners will need to account for them, at least in the short-term.

Memarovic (2014) also discussed the way internet technology has, to a certain degree, influenced people's need or desire to travel to a physical location, such as a bar or café, to gather, unwind and socialise freely. Social media can provide some of the benefits that these physical spaces provide, such as the ability to connect with people through conversation, space in which to feel comfortable and be on a level playing field with other people present, and a home-away-from-home. These are also accessible to everyone.

4.3.4 Internet mobility services

Mobility itself is being transformed by internet-enabled hardware and applications. Access to public and private transport services is increasingly available via mobile and web apps, while online tools allow people to plan and navigate their way through the transport network in real time via multiple different modes.

Emerging technology in this space, combined with changes to policy and regulations, are likely to contribute to a population-level change in transport behaviour over time. Shifts such as on-demand mobility, and reduced vehicle ownership and increased use of shared vehicles, signal the potential for major changes in daily transport demand and the pattern of transport use in New Zealand's towns and cities. Some of the supporting internet technology is already available; however, predictions on the rate of uptake vary, and most discussions about significant changes to the entire fleet are based decades in the future. As such, predicting the influence of these future trends is a speculative task at present and is based on many assumptions.

The internet of things (IoT) is already creating a global network of context-aware devices, allowing everyday objects (such as vehicles, home appliances and personal activity trackers) to understand their environment, interact with people and make decisions, improving business processes and people's lives (Whitmore et al 2015). Smart objects are being integrated into physical infrastructure, including new highway developments (for example, Bluetooth gateways on roads to provide travel times for drivers) (Siemens AG 2014). IoT also has the potential to increase the efficiency of logistics and supply chains by improving data quality and detail, likely resulting in improved product traceability, more efficient freight planning and greater demand for these improved services (Whitmore et al 2015).

The IoT increases efficiency in freight through route optimisation, tracking and tracing, web-based load matching systems and web-based information clearing houses for modal transfers (Golob and Regan 2001). Golob and Regan (2001) predicted that utilisation of this technology may result over time in smaller, more frequent freight trips in smaller vehicles, or in more efficient consolidation of freight resulting in larger freight movements over long distances.

In addition to changes to the number or frequency of trips, new internet-enabled 'blended' transportation services are coming to market overseas. Uber and Lyft have introduced blended services, for instance UberRUSH. Moving things and people in the same vehicles allows parcels and people to cross-subsidise each other. By co-existing, the two services are cheaper than either could be alone, but the impact of this has not yet been quantified (Petersen 2015). Services such as these could collectively impact on transport demand in terms of trip reduction. Perhaps greater efficiency gains will be felt if fewer vehicles are required to move people and things, so reducing demand for vehicle parking and vehicles.

Herring (2004) stated that, although there is an ever increasing number of technology and computer-mediated communication options as technology is constantly redesigned and developed, the difference between successive technologies is not the most significant factor. Rather the greatest impact is from more people engaging with them year-on-year.

Future generations of vehicles may be reliant on the internet to operate. Connected and autonomous vehicles will communicate amongst themselves and with infrastructure, while data generated by vehicles and people will be used by machine-led systems for automated decision making throughout the transport system. People will be at the centre of this system as developments increasingly seek to improve their experience and become predictive in the delivery of services. While we are still decades away from a fully automated transport system, the vision and drive to achieve this exists now.

4.4 Factors influencing uptake

There are differing rates of technology adoption and use by different users, including age, location and income (Statistics New Zealand 2013b). A time delay exists for any emergent internet technology to move beyond early adopters, to achieve mainstream saturation with a population segment, to build experience and competence with the technology, and lead to transformative behaviour that alters transport demand. Based on existing data, it is expected that the rate at which this occurs will differ for various sections of society.

Crothers et al (2014) showed the pattern of uptake of new technology as an innovation S-curve. The S-curve describes three groups of people who adopt innovation at different times: primary adopters are quick to use new technology and are influenced by advertising; secondary adopters are socially influenced and delay adoption until the primary adopters have used the technology for a period; while tertiary adopters may only adopt a technology once it becomes commonplace amongst secondary users. Primary adopters often have greater economic means, so can adopt any new technology early. As technologies become more commonplace, the price of adoption generally decreases. As Herring (2004) pointed out, the more mainstream and popular something becomes, the more mundane and ordinary it is perceived to become. For example, chatrooms and web-boards on the internet were popular in the early 2000s, but as they become more popular, early users moved on to newer platforms on social media.

Another key factor influencing the uptake of internet communications and commerce is internet speed. A number of studies (Buente and Robbin 2008; Davison and Cotton 2003; Horrigan and Rainie 2002; Rainie and Bell nd) found that internet speed influences internet uptake and use, with slower connections resulting in limited content experiences and less time spent online compared with higher-speed connections. In New Zealand, internet use is higher in cities than towns and rural areas, regardless of the age of users, which could be expected given the differences in internet infrastructure, with less infrastructure in rural areas. This is changing due to the government's Ultra-Fast Broadband programme and Rural Broadband Initiative, with internet use increasing faster in rural areas than towns (Crothers et al 2016).

There are many factors that might affect people's uptake of online shopping and therefore alter their shopping trips. These include personal shopping attitudes and behaviour, internet behaviour, lifestyle characteristics, land use and accessibility, and sociodemographic characteristics (Frag et al 2007). Crothers et al (2016) found that New Zealanders had concerns about the security of online purchasing, with 4% of online purchases in 2015 having problems with theft of credit card details. These concerns could influence the secondary and tertiary adopters of e-commerce technology, hindering or slowing their participation in e-commerce or online transactions. Ease of use for customers is also likely to influence people's uptake of online shopping. Thomas and Jose (2015) highlighted that the increase in mobile-friendly or responsive design websites made it easier for consumers to purchase and consume goods online. More businesses are transforming their websites to be responsive to consumers. Some companies are also using big data to personalise the online shopping experience for customers, encouraging consumers to return and continue shopping.

Golob and Regan (2001) adapted three constraints first described by Hagerstrand (1970) that influence people's ability or willingness to change travel behaviours due to technology and the internet. These are coupling constraint, capability constraint and authority constraint. Coupling constraint describes people's desire to be physically present at certain places at certain times, which Golob and Regan suggested can be altered if people believe the internet and technology can reduce the need to be physically present. Capability constraint describes the ability of a person to overcome spatial separation given the resources available at any time, which the internet provides a means of overcoming. Authority constraint describes factors such as physical shop opening hours. The internet removes this constraint, enabling shops to be open virtually 24 hours a day.

4.5 Future trends

Social media will likely play an increasingly influential role in e-commerce. Social commerce allows people to share what they are purchasing on social platforms, buy products, get reviews and other people's recommendations, and ask questions. Examples of recent social commerce trends include: the hashtag #AmazonCart, which allows people to add items to their online shopping carts by including the hashtag in social media posts; Facebook's 'Buy' button, which allows people to purchase items directly from a company's Facebook page rather than going to their website; and Shoppable Instagram, which creates a 'shoppable' version of a company's Instagram page for people to purchase directly from (Price 2016). Social commerce assists people to make purchase choices and allows customers to interact with companies 24/7, encouraging people to interact to discuss or rate a particular product may influence what and how people buy. Thomas and Jose (2015) suggested that social commerce will have a significant influence on e-commerce and that new technologies such as facial recognition and virtual changing rooms will make the internet and the services that can be provided through it even more accessible. Technology applied to increase trust between users (purchasers) and providers (sellers), leading to improved security and faster service, will further increase the number of online transactions, and potentially decrease on-road trips.

There is increasing demand from consumers for faster delivery of goods, with consumers often shopping online based on available shipping methods (Chao 2016). This demand is seeing companies respond by introducing fast delivery services. Amazon's Prime Now delivers purchases within two hours and restaurant orders within one hour in certain parts of the United States and Britain (Amazon.com Inc 2016a). Want It Now in Australia partners with retailers to deliver online purchases within three to four hours (Want It Now 2016). Amazon has also trialled an innovative delivery system using unmanned aerial vehicles, or drones, to deliver packages to customers within 30 minutes (Amazon.com Inc 2016b). Domino's Pizza has trialled a similar technology to deliver pizza in New Zealand using both a robotic ground-based unit and a drone (Clayton 2016; Domino's Pizza Enterprises Ltd 2016). The demand from customers could lead to further innovations in the delivery and courier sector, reducing or changing on-road travel demand. In the case of pizza deliveries, these might replace meals that would have otherwise been cooked at home and so increasing travel demand, another example of the direction of effect being uncertain.

According to the World Economic Forum (2015), the IoT¹ presents key business opportunities in the future. These include a shift for businesses from product to outcome-based services, with businesses competing on delivering measurable results to customers, rather than simply providing a product. This

¹ The World Economic Forum refers to the internet of things as the 'industrial internet'.

shift will require a focus on collaboration between different groups. The ability of the IoT to help workplaces become more flexible and operate remotely while still having access to real-time data from assets will significantly affect some workplaces. For example, the ability to work remotely will be significant to worksites in isolated areas with few amenities, such as agriculture and mining. Rio Tinto has begun evolving the way it works, with skilled equipment operators sitting alongside data analysts and engineers in remote command centres to operate heavy equipment such as drills and excavators (World Economic Forum 2015). Whitmore et al (2015) noted that further developments aim to enable web content to be understood by machines, allowing search engines to behave more intelligently and removing the need for humans in data processing and sharing. Challenges exist around security and data privacy, and interoperability among existing systems. However, these changes to the way people work will influence the need for travel to particular work locations.

4.6 Summary

The potential influence of internet communication and internet commerce on transport demand is complex. Both communication and commerce technologies provided online have the capacity to substitute, complement and modify transport demand – with even a single transaction or interaction potentially creating all three outcomes. In addition, without understanding people’s past behaviour or the alternative action an individual would take if the internet communication or commerce opportunity were not available, it is difficult to know how much of a neutral effect the use of the internet has on transport demand.

We found little evidence of quantified causal or associative relationships between online activities and transport demand, and international examples may not be relevant to New Zealand where underlying behaviours, social norms and transport systems are specific to their local setting. What the review of literature and current trends presented here has provided is a starting point for understanding the type of influence different internet activities might have on transport demand in New Zealand.

5 Key informant interviews: Internet trends and transport in New Zealand

5.1 Introduction

To develop a New Zealand specific setting for this study, we conducted semi-structured interviews with key informants, identified based on their knowledge of the internet and/or transport modelling sectors. The purpose was to draw on insights not readily available in existing published documents, and identify examples where the impact of internet technologies on transport demand has been, or could be, quantified and explored using available data in New Zealand.

Participants represented these organisations: Auckland Transport/Joint Modelling Application Centre, InternetNZ, KotahiNet and Sapere Research Group. They were asked questions on what:

- internet trends are influencing or will influence transport demand in New Zealand
- internet-related transport demand factors might be measured at a city or regional level
- attempts have been made to quantify the influence of internet commerce and communication tools on transport demand
- is the scale and direction of the impact on transport demand
- is their opinion on the importance and feasibility of studying the influence of the internet on transport demand.

The interview questions are listed in appendix A.

5.2 Internet trends that will influence transport demand

5.2.1 Remote working

A first set of trends discussed in the interviews related to remote working capabilities. The rollout of ultra-fast broadband (UFB), and its high take-up in New Zealand (relative to global trends) is well underway. This will enable improved home internet services, allowing people to work from home or from diverse locations. This in turn will impact transport demand.

There has not been much impact to date in terms of actual numbers working remotely. Telecommuting has been possible for 10–15 years. It was initially held back by technology, but the quality of internet connectivity and features such as video-conferencing have leap-frogged ahead. Now the barriers are to do with human behaviour. Many workplaces are still figuring out how to do it, for example how to run a meeting when half the people are not in the room.

Those interviewed thought that these challenges could be overcome and remote working become natural. As one asked: Why do people need to come into work? Why do organisations need large office buildings? Why does there need to be mass movement of people in and out of cities all at the same times? One current trend is office teams split between locations, such as Auckland and Wellington. All of them commute each day, but they have a remote team dynamic. This might be a stepping-stone to transition to all working from home in the future.

5.2.2 Internet commerce

Online shopping for physical goods was considered by all to have increased significantly. However, our participants considered it unclear how this was influencing or would influence transport demand. One assumption is that it reduces trips by individuals travelling to retail stores, substituted by freight or delivery trips to homes. Participants were unaware of evidence of this in terms of trips on an individual basis. Freight and delivery trips are forecast to increase, but they were not sure if this was due only to internet activity. Trip substitution itself is one of the unknowns, for example, there is not much change in travel if people try the item on in the shop first, then go home and buy it on the internet (motivated by price rather than convenience).

TradeMe has four million users, ie nearly the population of New Zealand. Users buy and sell to each other and the goods are delivered. This type of online activity affects delivery transport patterns. NZ Post is turning itself into a last mile parcel provider, reinvented from carrying letters and bills (which now are sent online) to parcels. NZ Post has also focused on how to send parcels more easily. Parcel postage can be printed out online, so customers do not have to go to a post shop.

There was no expectation that 3D printing would affect transport trends in at least the next five years. It cannot produce something from nothing, so it switches from people delivering finished items to people delivering reels of plastic materials that can be used to print finished items. There is still a delivery trip.

5.2.3 Mobility as a service and shared mobility

The move to mobile devices, in particular smart phones with increased capabilities, and apps and services, was considered to be affecting transport planning and transport in general. For example, individuals could easily make temporary use of someone else's driving expertise at low cost via Uber. Companies offering mobility as a service are predicted to increase. In the short term, interviewees expect that private sector operators are most likely to drive emerging technology and innovations focused around the use of the internet to plan, book and pay for services. One interviewee noted that it is essential public transport providers follow this approach, and leverage modern technologies while driving their own innovations, to avoid being left behind. Longer term trends will potentially see changes in transport behaviour from the public as they become more used to using a range of transport modes and become more open to the concept of services such as shared and autonomous vehicles.

Participants suspected these would influence transport demand, but it was unclear how. While shared mobility would decrease trips, cheap mobility services would lead to some increase in trip making. Whether trips took place in peak or off-peak times would also make a difference. One camp said traffic would increase; another said decrease.

A related trend is people's desire to use their mobile device while travelling, notably applying to younger people and to commuter trips where staff want to remain productive. In this respect, car travel will probably decrease in favour of passenger transport modes where one can more easily use mobile devices. Again, it is unclear how far this trend will affect transport demand. Participants talked about evidence that people were more prepared to not drive, for example getting their driver licence later. The effect of the internet might be one factor combined with other influences on travel, such as traffic congestion and increasing urban density, which make public transport or active transport modes (cycling, walking) more appealing.

5.2.4 Autonomous vehicles and commerce

In the future, autonomous vehicles will provide new transport options. This category includes driverless cars, self-driving trucks and drones. How fast this change happens depends not only on the availability of

the technology, which is advancing very rapidly, but on favourable laws, commercial viability, and demand and supply in New Zealand.

Related to trends in e-commerce, parcel drones are in the last phase of trials and are in the sights of large online retailers such as Amazon, here and overseas. These could replace existing ways of transporting packages. The Civil Aviation Authority is considering how to deal with drones, which will utilise the middle space below planes but above the road. An extension of this might be the use of drones for other purposes, for example next generation emergency services. Examples of use might include police surveillance, scouting of a fire scene, search and rescue, flying a defibrillator to a heart attack patient or traffic management. Human passenger drones are being trialled overseas.

Self-driving passenger car trials are taking place internationally. Autonomous truck fleets are much closer, largely due to freight trips on pre-determined routes allowing for a more controlled environment, and information from the USA suggests that if your competitor starts using self-driving trucks and you do not, you will be out of business in three months. They are safer, drive 24/7, and only need fuel and vehicle maintenance. Interview participants said the projected increase in freight transportation in the next 20–30 years would not involve drivers. Leaving aside employment, this has implications for road maintenance as autonomous trucks do more hours on the road.

Internet connectivity along the road network will either be an enabler or a throttle on this trend. Participants talked about the requirement for autonomous vehicles to access internet as they drove. New Zealand will need internet access on all roads these vehicles need to travel on, including heavy vehicle bypasses. Currently, there are parts of the national road network, particularly outside urban areas, that do not have internet coverage.

5.2.5 Real-time data

Having very detailed data about transport available online in turn affects transport patterns. One example is data from mobile phones:

- Uber drivers pick up a passenger and follow the route as directed from their phone. It can be possible to adjust the route taken in response to traffic congestion.
- Google Maps can optimise travel directions by learning from previous users, such as giving pedestrians the option to take a shortcut, eg through a department store.
- Google Maps provides online traffic information, derived from the data that comes to them from everyone using their phone to look at Google Maps.

Our participants also proposed future applications of real-time data. If data came from a New Zealand road sensor network, and if individual users could consume that data in a meaningful way, apps could provide travel advice to users' mobile devices. Data could be used to smooth out traffic flows. It might eventually be possible to receive optimised and individual travel recommendations on a mobile phone, which would affect the times individuals chose to travel and the routes taken. What is still lacking is the granular traffic data.

One potential of the IoT lies in the availability of transport data. It is becoming quicker, cheaper and easier to measure the physical world in real time, for example actual transportation flows. This is significant for cities improving their management of public and other transport flows, and for the logistics of transporting goods to customers being informed by data flowing from customer back to supplier in real time.

The current status of IoT in New Zealand is the equivalent of the early days of cloud computing, where there is discussion, interest and growing understanding, but it is still quite early in terms of actual

projects happening. Sensors are becoming cheaper, networks are cheaper and more extensive, it is possible to store and analyse the data, and the value of real-time data is going up. One example of a project in development is an Australian company looking at monitoring culverts using New Zealand expertise. Travel to inspect culverts in remote areas would be replaced by sensors and networks monitoring water flows. This would detect problems earlier (before road subsidence occurs), avoid the need for travelling to inspect and contribute to road safety. Another application could be real-time data about ice on rural roads.

5.3 Internet-related transport demand factors that might be measured

There is data available on trends in internet take-up (for example, the UFB rollout) and internet use (for example, from the World Internet Project studies in New Zealand). For transport demand there is the New Zealand Household Travel Survey (HTS) (Ministry of Transport 2018). Our participants found the question of what internet-related transport demand factors could be measured at a city or regional level in New Zealand a challenging one.

5.3.1 Remote working

Participants believed that the proportion of people who work from home in New Zealand is still relatively small. There is research on where jobs are going to be in the future, and one participant cited research that reported higher levels of working from home in Auckland compared with Australia. Participants made some suggestions for potential sources of data coming from:

- increases in Skype calls and Skype meeting take-up
- activities that have declined, for example are businesses buying fewer company cars as less travel is undertaken?

One participant looked quickly at the 2013 Census question on how you got to work today, in preparation for the interview. He looked at people who commuted against people who had internet access. There did not seem to be a strong correlation, that is, having internet access did not correlate with being less likely to commute to work or vice versa. He suggested further study questions: When someone is making a decision about whether to commute or work from home, what are the main factors they consider? How high or low on that list of factors is good access to the internet?

5.3.2 Internet commerce

Participants suggested the following potential data sources to understand internet commerce trends:

- bank transactional data to see any shifts from transactions made in a physical bank to those made via the internet
- data on GST paid when goods are bought on Amazon and the like, and data from the New Zealand Customs Service
- NZ Post information about the changes e-commerce has meant for their delivery business, for example parcel volume by post code over time
- TradeMe data on the location of sellers and buyers who clicked on 'ship it to me'
- commercial data to answer questions such as: when a shopping complex closed due to earthquake damage, did people start traveling somewhere else to shop or did they switch to internet shopping?

One participant considered New Zealanders did not do enough shopping online for it to show up as a significant factor in a transport study.

5.3.3 Mobility as a service

Participants focused on obtaining data from Uber and similar companies on their transport trends. Another suggestion was to talk to the customer insight teams at organisations such as Auckland Transport for data from surveys and focus groups.

5.3.4 Other issues

Our participants were in favour of making useful data open and available. This would allow people to figure out interesting new ways to use the data and match it with other datasets in unexpected ways. An exemplar was the release by New York City of crash statistics for every city intersection, allowing third parties to use the data to plot out black spots, and produce insights and apps. Those we interviewed considered there would be increasing amounts of data and that data would increasingly be available both commercially and openly.

One participant suggested some frameworks for research:

- The internet is effectively transportation of digital data. It could be possible to use models already applied to physical transport to see how they apply to digital transport. This would treat the internet as a transport mode.
- Economic data and economic impact could be used to measure reductions in cost because of increased efficiency or some other tangible dollar saving, or new or increased economic activity.

5.4 Attempts to quantify the influence on transport demand

Our participants were generally unaware of any studies attempting to quantify the influence of internet commerce or communications tools on transport demand in New Zealand or overseas. One noted the frameworks were quite undeveloped, and was not aware of any effective frameworks that were actively in use. While there is good work on overall transport demand and the trends in New Zealand, e-commerce is difficult to quantify and the relationship between internet commerce and transport demand would be complex to model with any degree of confidence.

5.5 Scale of the impact on transport demand

As one interview participant pointed out, no one can say at the moment how important the topics described below are for influencing transport demand, but everyone suspects that they are.

5.5.1 Remote working

The internet enables working at home as an alternative to the 9–5 work pattern, but in the last census the statistics on numbers working at home did not change much. Participants stated that as the quality of internet technology and services improved, people would probably make more use of these tools.

The potential is there for an individual to hold multiple, location-independent jobs, or to move from the city to a small regional centre and continue their career. This would particularly apply to professional services, which comprise about 10% of the workforce. This could lead to decreased transport demand.

Alternatively, this capability might result in trip substitution, such as travel off-peak instead of peak. People might work in a remote rather than a central location, resulting in a different pattern rather than fewer trips.

With social media, one suggestion was that people are better connected, but mainly talking with those they already know from work or socially, not with strangers. People may continue to want to have social contact at work, so travel the same amount, while using social media and instant messaging to communicate more with the people they already have a connection with.

5.5.2 Internet commerce

Use of TradeMe and other auction sites has led to an increase in peer-to-peer exchange of parcels, replacing demand for delivery of letters and resulting in an increase in fragmentation in terms of decentralised people having items delivered to other people. With the rise of e-commerce, individuals are going less to physical stores for certain things, such as computers and cameras. However, this is still a small proportion of total spend. It is harder to sell vegetables or shoes online, and the online shopping experience remains uneven in quality. E-commerce is evolving, but for different types of shopping and for different demographics at different rates. Once people can do all their weekly shopping easily online, that will start to make a difference to transport demand in New Zealand.

5.5.3 Mobility as a service

Interview participants considered that mobility as a service, together with autonomous vehicles, will increase travel demand, as it will become easy and perhaps so cheap that people will travel more. Participants did not have a clear view of how quickly this change might happen. The degree of increase may depend on whether people travel in shared vehicles (for example, commuting by ride-share arranged online) or whether services such as Uber (operating as it presently does in New Zealand, ie without the sharing service) predominate.

5.5.4 Autonomous vehicles

With driverless cars there is a debate on whether they will have a net positive or net negative impact on total transport demand. The technology is available; however, autonomous vehicles are not currently making a difference. There are not enough of them, they are expensive, and the technology in terms of communicating with vehicles is not yet practical. Research shows the need for many autonomous vehicles on the network before they start to make a difference in terms of capacity, travel times and convenience. It takes a long time to replace a fleet unless there are incentives. Different countries and cities will have different take-up rates, and if individual cities decide to become leaders, that will speed up the change. Therefore, take-up rates and potential problems are unknown.

Participants suggested that road-based autonomous vehicles are probably going to be dominant. Drone initiatives are happening and some will work. It is unclear what the net effect will be. Drones will not take off unless they can be done cheaply or provide a special service or selective function. There is talk about having drone air corridors above motorways, but it will be years before everyone is confident that it will work and the legal issues are resolved. There will also be drone congestion to consider (how to manage what happens if everyone at a rugby match orders drone-delivered pizza). In the long term this might substitute a lot of drone trips for just a few car trips given the carrying capacity of current remote controlled drones operating in populated areas.

5.5.5 Real-time data

The impact of real-time data on transport demand is in its early days. Real-time data is currently used for various transport operations and for publishing travel information online. Apps that make real-time travel information available to mobile devices make it easier to use public transport. Knowing when the bus will really arrive, travellers do not have to stand around and wait, which makes the trip more valuable. In the short term people change their departure times and route based on real-time information. They are not deterred from making a trip, as other factors are more important when deciding to travel.

Apps that compare different modes of travel are not as successful at the moment. For example, Aucklanders do not have many options, and there is no evidence that they compare modes and change on a day-to-day basis between car and other modes. They may, however, change transport mode in the long run. As systems become more integrated, this may become more important.

5.5.6 Other factors

Clearly the internet has an influence on transport demand, but our participants had no sense of the scale. There are contradictory trends, and it is difficult to quantify this influence on what trips take place and when. One participant noted that people tend to over-estimate short-term change and under-estimate long-term change. So, in the long term there may be a reshaping of where people live, work and shop, with the potential to massively reduce demand for transport or change its shape completely, but the size of this change is an unknown. This participant felt that the influence of the internet caused a relatively small change in transport behaviour rather than a large one, a change dwarfed by other influences. What the technology makes possible and what people desire to do are different things.

5.6 Studying the influence of the internet on transport demand

Our participants had varying views on questions around the importance and feasibility of this as a topic for research. One considered that it would be possible to quantify some things, such as whether working from home is growing, and the influence of online shopping (drawing on data from NZ Post). Another participant felt it would be difficult to quantify this topic as information is not easily available, the topic has wide scope, and there is not a lot of information now on aspects that will change quickly in the future. They suggested the value in the research would be to try to understand the unknowns and uncertainties, and if the changes are likely to be significant in scale.

A third participant did not think it would be possible to break down internet influence to a few major factors that could be tracked and modelled to a sufficient degree of accuracy, when there are step changes such as driverless cars and drones coming. The internet is already having an impact on certain aspects of life and if we cannot measure what is already here, it is probably quite hard to predict step changes and whether and how they will happen. Therefore, this participant favoured a focus on real-time measurements rather than projections. The other participants had observations on research direction that are discussed below.

5.7 Access to the internet

InternetNZ is trying to measure the digital divide, the difference between the people that have and consume and are fully engaged in the internet and citizens that are partially or not engaged. As more of government and commercial business moves online, the divide between the internet haves and have-nots

may widen. There are multiple digital divides, such as poor versus wealthy, migrant versus well-established, elderly versus young and non-English versus English-speaking cultures. Social factors affect internet uptake. Factors to measure include where and when is the internet available around the country, do people purchase it (can they afford it) and do they have the skills to use it?

Disadvantaged groups may find it hard to sign up to internet plans and become customers, for example if they do not have a credit card or if they have migrated to New Zealand and do not have a credit history. If purchases are cheaper online, people who have the internet get that benefit and people without the internet have to pay more. In terms of transport patterns, people who cannot buy online must travel to shop, and may have to spend more on travel, and cannot use apps to plan travel. People who an employer will not trust or enable to work from home will have to travel to work. Another interview participant put emphasis on the generational aspect, suggesting that as internet-based activity increased more for younger generations, this might have a corresponding impact on transport demand.

Comments were also made about rural internet access, which is improving but not universal. The combination of UFB fibre deployment in urban areas and the Rural Broadband Initiative will reach perhaps 97–98% of the population, and there are projects to address blackspots with basic mobile communications. However, in terms of transport, there are significant geographical challenges. There are areas with no address points, with no people living there and no internet coverage, but tourists and workers travel there (for example, Fiordland). A participant said that one of the questions he heard inside the telecommunications industry was: why is network connectivity across the state highway network not emphasised? Road networks will need good internet access to encourage commerce and enable autonomous vehicles. This participant considered there was a need for research on the future requirements of an autonomous vehicle fleet in conjunction with a mapping of New Zealand's transport networks against its internet (broadband, satellite telemetry etc) networks.

5.8 Summary

In line with the general findings of the literature review, the mechanisms by which the internet could reasonably be expected to influence transport demand were well understood by the interview participants. Yet despite their combined knowledge, none were aware of examples where these relationships had been robustly measured.

Various information sources were discussed. However, much of these datasets are proprietary (such as bank data, online retail records, taxation information) and not publicly available. Further, if relevant datasets were available that made analysis of internet influences on transport demand possible at a city or regional level, it would be extremely difficult to control for the numerous behavioural, social and economic factors confounding the causal relationship. This reinforces the challenge for city and regional transport authorities who would like an in-depth understanding of external factors that are driving change on their networks.

The research to this point did not satisfy the initial objective of developing quantitative indicators of the internet's influence on transport demand that could be used to inform next generation transport models. It did, however, capture a range of findings that warranted further investigation. The second stage of this research subsequently explored the role of internet technologies for work-related transport demand.

6 Case studies: internet influences on work-related transportation

6.1 Introduction

Stage 1 revealed a paucity of data available to quantify the influence of internet technologies on transport demand in New Zealand. In response to this, the Steering Group agreed to take a case study approach for the second stage of the research. The focus of the case studies was the use by New Zealand organisations of internet technologies, and the resulting influence on patterns of transport demand within each organisation.

Each case study was undertaken via in-depth interviews with staff at offices of major New Zealand organisations. Those interviewed were:

- Paul Vester, IT Client Services Manager, WSP Opus.
- Annette Highnam, General Manager, Datacom.
- Mike Edginton, Chief Information Officer, Department of Conservation.
- Campbell Jensen, Senior Manager Property Master Plan, Air New Zealand.
- Cathryn Boyd, General Manager Future Workforce Strategy, IAG.
- Paul Swift, Wellington Regional Manager, BizDojo.

This chapter discusses the types of working behaviour these organisations are seeking to support or change, and the role of the internet in this process. An understanding of the types of transport-related working behaviours is presented alongside potential implications for transport demand in New Zealand. Given the commercial nature of the interviews undertaken for this research, this discussion is generalised across all organisations and no individuals or organisations are quoted directly in the text.

6.2 Work-related travel

Internet-enabled technologies have the potential to significantly modify transport demand generated by the movement of people for business purposes. Remote access to people and information from dispersed locations means staff may not have to physically travel to the office each day, while organisations with distributed national and international teams can collaborate without the need to travel long distances.

While technology might be able to replace most trips from a practical perspective, the quality of engagement is much less than can be achieved by in-person communication, so demand does not match the potential opportunity. Nevertheless, if all organisations substituted 10% of business-related trips they would enjoy a substantial overhead reduction, while the transport system would experience substantial changes to demand.

The organisations interviewed for this study generally broke business travel down into three areas:

- daily commute of staff to and from the office
- vehicle trips made directly for work purposes
- air travel for work.

The following sections explore how organisations are seeking to change each of these transport activities, and the role of internet technologies in driving and supporting this transformation.

6.2.1 Commuter trips

Work-related transport behaviour starts with people's commute to and from work each day. In Auckland, some organisations are actively seeking to reduce the frequency of single-occupancy vehicle trips made by staff for their commute, an approach commonly referred to as a 'travel plan', and one office interviewed has set a target of reducing these to just 30% of all staff commuter trips.

Motivations for changing these behaviours varied, from being a requirement within a lease agreement for locating in a building/area of the central city, to reducing the overall cost paid for parking spaces that are occupied by personal vehicles each day. One organisation, following a shift in premises, reviewed their investment in commercial car parking spaces across Auckland and implemented a strategy to substantially reduce the overall number of parks they lease. These changes are being introduced gradually over the next two to three years, with staff who insist on retaining a personal parking space incrementally paying more toward the true cost of that space until eventually covering it in full.

Such financial disincentives can motivate staff to change their transport behaviour, though organisations are also rewarding positive change and investing in solutions that make it easier to do so. Staff at the Auckland office of one organisation were offered a one-off monetary bonus for demonstrably changing their commuter behaviour in a sustained manner. Senior managers led this behavioural change, opting out of company-provided vehicles and commuting to work via public transport or active means.

Internet applications are utilised to connect staff to encourage shared travel to work. New Zealand car-pooling apps are promoted among the workforce of some organisations to allow staff to identify co-workers who share a similar trip. This organisation-specific approach appeals, as staff are more comfortable travelling with colleagues as opposed to the wider public, though future opportunities to partner with other organisations located in the same precinct also exist.

Most organisations spoken to in Auckland were in the Wynyard Quarter neighbourhood, described as an area where thousands of people come to work each day. The organisations located here employ tens of thousands of staff elsewhere in New Zealand and overseas, and account for a relatively large percentage of national GDP. If offices located in the Wynyard Quarter alone all reduce their single-occupancy commuter trips to 30% of daily trips, there is potential for a large effect on patterns of transport demand during peak periods in Auckland, including:

- increased public transport patronage, and demand for 'last mile' connections between major hubs such as Britomart and the Wynyard Quarter
- increased demand for distributed 'park and ride' facilities across wider Auckland
- a rise in walking and cycling to fill last mile gaps at both ends of the commuter journey
- decreased demand for all-day and commercial parking leases in central Auckland
- reduced vehicles on major arterials due to mode shift, and increased occupancy of individual vehicles.

Organisations are actively working with Auckland Transport to understand how they can encourage and support commuter behaviour change among staff, but also to advocate on behalf of staff for improved public transport services that make changes in behaviour feasible. Increased capacity and frequency of buses running between Britomart and Wynyard Quarter is an example of this. Wynyard Quarter is just one localised instance; learnings from changes in transport behaviour here are relevant to other commercial and industrial areas in Auckland and around New Zealand.

6.2.2 Vehicle trips

All organisations spoken to were seeking to reduce the number of trips made by company vehicles and taxi-type services. This is primarily driven by cost reduction. Reduced trips mean that organisations can invest in a smaller corporate fleet, so fewer vehicle and parking space leases are required. There is also an efficiency component. If staff are driving they are less productive, so a meeting that lasts an hour has downtime either side while staff travel.

Generally, most organisations did not foresee a large reduction in vehicle trips due to investment in internet communication technologies. Phones have long been available for conversations that do not require face-to-face interaction, and while video calling may improve this experience there often remains a need or preference for some work to be carried out in person. One organisation with two Auckland offices stated that investment in these technologies had made it easier for staff to base themselves at either office, depending on their meetings that day, while remaining in close contact with teams at the alternate office. There was a desire from this organisation to significantly reduce the amount of money spent on taxis transporting staff between the two offices. Internet communication technologies are essential to providing the flexibility and quality of environment that enables staff to work from either location day to day.

Two of the organisations spoken to have many staff across New Zealand travelling a long distance each day to carry out work at non-office based locations. These trips cannot be substituted by internet communication technologies because the work generally has elements to it that require the physical presence of staff. However, the nature of travel to and from site can be modified. The daily travel of a staff member who works at a remote site might look like this: home > office > site > office > home. The office is a necessary destination to communicate with other staff and gather materials and information for the day's work. If internet technologies can remove the need for staff to visit the office during this journey, there is potential for a reduction in vehicle kilometres travelled, and improved health and safety outcomes as exposure to risk while travelling is reduced.

Internet technologies that support such a change in daily travel behaviour are not person-to-person. Instead they enable communication between staff and their organisation's internal network as though they were in the office. As staff become increasingly able to communicate with their organisation remotely, they can perform work functions from home and vehicles can become offices. On top of reduced kilometres travelled, shorter travel times free up staff to be more productive. Just a half hour of increased productivity over an eight-hour working day has a considerable financial effect when an organisation has in excess of a thousand staff (as was the case for one interviewed organisation) out in the field each day.

6.2.3 Air travel

Air travel is expected to be most influenced by investment in internet technologies, though the nature of change is difficult to quantify at an organisational level. Video calls can certainly replace the need for staff to travel between regions; however, these same technologies allow organisations to break down geographic silos and work collaboratively across offices. These activities are expected to generate demand for air travel that did not previously exist.

Air travel, more than vehicle travel, is likely to be directly related to company travel policy, the seniority of the traveller and the reason for travel. Managers responsible for teams spread across the country still travel in person to visit staff, as this remains the most effective form of communication and is essential to building a relationship among colleagues. The ability to communicate via video on the internet may mean that managers visit a distant office three times a year instead of four, while holding more frequent team conference calls than they otherwise would have. Physical travel is slightly reduced, while overall communication is greatly increased.

Organisations that deal with external clients were likely to favour in-person communication even if this required air travel. The value of building relationships and trust is a benefit that exceeds the associated financial and time costs of travel. Some organisations did expect video calls to reduce the amount of domestic and international travel required of staff for internal meetings. However, the perceived low quality of the experience meant that no organisations foresaw a situation where video communication replaced in-person contact completely.

6.3 The potential for the internet to shape how people work

Much of the investment that organisations are making in internet communication technologies is focused on employee experience, being a responsible corporate entity, and providing an appealing work environment that attracts and retains staff. Because these policies are generally related to where and when employees work, there is an inherent link to transport demand.

6.3.1 Flexible working arrangements

Flexible working arrangements, such as working from home and flexible changes to work day hours, have long been discussed as having the potential to fundamentally change our notion of the workplace. This flexibility is increasingly made possible by improved internet communication and internet technologies that keep staff connected with each other and to the organisation itself. Each organisation spoken to described both formal and informal opportunities for flexible working available to their staff. In most cases, this involved staff working from home at least one day a week, or shifting their hours in the office to fit around family or other commitments. Openness to these arrangements is increasingly discussed during recruitment; for prospective staff, an organisation's flexibility is reflective of wider corporate culture.

IT support is essential to making any working from home arrangement effective. Staff may need the ability to connect remotely via video or voice with teams in other locations. Multiple staff, all at their homes, may need the ability to connect into the same communication channels as needed. Other internet-enabled technologies, such as remote access to internal file networks, and the opportunity to work collaboratively on shared documents and in shared workspaces, are also seen as essential to creating a quality work experience.

Anecdotally, uptake of full-time working from home arrangements was low across the organisations interviewed, though many cited increasing numbers of staff with formal arrangements to work from home at least one day a week. Extrapolating these trends for a city or region, the potential to reduce commuter trips from five days a week to four has significant implications for transport demand.

Staff at some organisations have adopted flexible hours. Access to emails and company files from home enables staff to work from home in the morning, then travel to the office outside of peak periods. Flexible arrangements allow staff to incorporate family and lifestyle needs into their working day, for example dropping children off at school and picking them up while making up the work hours from home. Under these scenarios, trips still take place but at different times of day, and multiple transport needs can be chained together in a single journey to increase overall efficiency.

Working from home, or telecommuting, is a potentially valuable component of travel demand management initiatives. Reduced demand on urban arterials during peak periods, and an increase in localised trips made between home and neighbourhood amenities, would both reduce congestion and modify daily trip patterns in urban areas.

Despite the acknowledged benefits of increasing working from home opportunities for staff, some organisations also identified barriers to the implementation of such policies for particular staff, tasks and projects. These challenges to implementation are described in section 6.5.

6.3.2 Remote working

Each organisation interviewed has multiple offices spread across New Zealand and, in some cases, overseas. With modern connectivity and communication via the internet it is now possible for staff to be part of a team located in one or more other regions. Teams no longer need to be physically co-located and it is possible to undertake national and international projects across multiple disciplines, locations and time zones with a high degree of success. As discussed above, virtual teams require not just communications technology but also a comprehensive IT support system, company policies that enable these team structures, and most importantly staff who can work effectively in this environment.

The effect of remote working on transport demand is difficult to quantify as transport is still taking place, albeit in a different location to where it otherwise would have been necessary. For example, a staff member in Tauranga working remotely with the rest of their team in Auckland still has transport needs, just not in Auckland. So, while potential transport demand in Auckland is reduced, demand in Tauranga is increased. In addition, it is likely that the remote staff member will travel infrequently to attend vital meetings and events in person, thereby inducing demand for air or highway travel between the two cities.

There is also the idea that improvements in remote monitoring technologies, using mobile phone and wireless networks, will increasingly reduce the need for staff to travel to physical sites. Environmental monitoring can take place using automated technologies, so samples do not need to be collected. Infrastructure monitoring is becoming more common, so staff need only visit a site when incoming information suggests it is necessary.

At an individual level these changes are small, but as remote working becomes better supported and commonplace, there is likely to be an effect on transport demand in regional areas, and demand for transport between regions.

6.3.3 Co-working spaces

Co-working spaces allow individuals, groups and small businesses to lease space in a shared office environment. In New Zealand a number of these spaces have been established, initially in main cities, with a view that over time these spaces will form networks across cities, regions and the country. These physical spaces have proven to be important places for collaboration and innovation, borne out of having a diverse range of people connecting with each other who otherwise would not have interacted. Tenants of co-working spaces share the costs associated with physical office environments, enjoy the social aspects of working alongside others, and benefit from potentially being located nearby to their home, other businesses, customers and suppliers. Co-working spaces also offer daily rates for people to work from an office environment when away from home.

While the physical space is the primary attractor of tenants, working in such an environment is made possible using internet communication technologies and services such as cloud-based systems that allow people to work from anywhere with an internet connection. Currently these spaces are primarily used by individuals and small groups, often serving as an incubator space where ideas are developed into viable businesses. However, there are examples of large established firms looking to this model for their own needs and it is expected that over time the delivery of office space and environment will increasingly be provided by external organisations. It is entirely feasible that the same space will cater to large teams from a single organisation, small stand-alone business units, and a few individuals all under the same roof

sharing communal facilities like meeting rooms, cafes and chill-out areas. Further, as more of these spaces are provided across cities, they become present in many neighbourhoods. There is the opportunity for staff to be geographically spread out, working from a location near home and connecting digitally via the internet to the larger organisation.

A range of potential effects for transportation resulting from co-working spaces were discussed for this research. The primary influence was expected to be much like that of staff working from home or remotely – individuals can work from an office in their local neighbourhood, thereby reducing demand for long commuter trips and generating demand for short local trips. These might take place by different modes and at different times of day, and create demand for strong public transport links between suburbs as opposed to hub and spoke style networks based around travel to and from central city areas.

The agglomeration effect of concentrating many businesses into a single space is expected to directly influence patterns of transport demand. Co-working spaces are likely to be set up close to existing public transport hubs, making them easily accessible at a city level. The flow of travellers is potentially changed as increasing numbers of people travel to a suburban transport hub in the morning, instead of away from it, and vice-versa in the evening.

Co-working spaces generally do not provide car parking spaces, so tenants are more likely to travel via active or shared modes, though in suburban areas where on-street parking may be available for free there is potential for inducement of vehicle trips. New Zealand co-working providers actively promote emerging transportation services. In Wellington the launch of an on demand electric vehicle provider was held at a co-working space, and tenants make use of this service in lieu of having their own vehicle on hand during the day. For entrepreneurs and small businesses, any reduction in transport-related costs is investment back into their business, so it is important that co-working spaces are served by good public transport accessibility.

6.4 Non-transport drivers of internet communication investment

Much of the motivation for investment in internet communication technologies is not transport related. However, transport is influenced by changes in when and where staff work. This section describes three drivers consistently cited by interviewees as shaping their investment in technology and people. These drivers are not mutually exclusive or interwoven into corporate strategies, and encompass:

- reducing the physical property and office space needed to accommodate the workforce
- increasing the efficiency and productivity of staff, and thereby the organisation
- supporting an attractive and environmentally responsible corporate culture.

It is important to note here that interview participants were speaking on behalf of their organisation, often from the perspective of a manager who is driving change. Therefore, discussion around these points generally focused on the expected benefits and not the potential costs.

For example, staff who like to work in the office and have their own desk may be dissatisfied in a fully flexible environment. Further, staff who cannot afford office space and equipment at home cannot participate. Some costs, such as electricity, can be transferred from employer to employee, offsetting some savings gained from reduced transport costs. Workers may also be expected to be on call for longer periods each day, checking emails more regularly outside work hours when their time in the office is not clearly defined.

6.4.1 Reduced property footprint

The opportunity for businesses to reduce their physical footprint by enabling multiple styles of working, some of which do not require staff to be co-located in an office with colleagues, was the most frequently cited change sought by organisations through investment in internet-enabled technologies. Some interview participants considered that providing flexibility in how staff worked day-to-day had the potential to save a significant, and measurable, amount of money annually.

One organisation cited an internal study that suggested 80% of staff could work in an 'agile' way – these are staff who for 69% of their work day are working away from their desk. Matching investment in physical space and equipment to meet varying needs and preferences, such as these agile staff members, is very different from the traditional office environment.

Rather than conventional hot-desking arrangements, organisations focused on providing staff with the technology tools needed to conduct their work from any location. This might include their own desk in the office, communal space in the office, at home, or out and about. There was also still support for staff who preferred or needed to work from the same office desk each day. One company believed that adopting flexible arrangements would save it the expense of having to move premises every few years as the company grew, as was the case previously.

6.4.2 Increased efficiency

Company computer systems have long provided employees with access to shared networks and files, and email and calendar systems are available on multiple devices. Making these systems accessible remotely via the internet, alongside quality person-to-person communication networks, are essential elements to enable flexible working arrangements both within and outside the office.

Interview participants considered that this ability for staff to be productive in a range of environments throughout the day increased overall productivity of the workforce. Organisations expect less downtime, particularly in relation to travel where it is now possible to work and be contactable from taxis, airport lounges and cafes.

There are other opportunities presented to organisations when staff can work from anywhere via the internet. Off-shoring certain roles or centralising departments internationally can reduce cost through the need for fewer employees to carry out a role, or through relatively cheap overseas employees replacing New Zealand based staff. Conversely, investment in internet communication technologies and flexible working arrangements can lead to roles remaining in New Zealand that may otherwise have been relocated offshore. There is an influence on transport demand at a localised organisational level, though the actual impact is difficult to quantify.

The focus of working from home has shifted from 'trusted' senior staff to include staff in technical roles. For instance, a call centre employee was described as able to work from any location so long as they had good access to communication technology and information. Technologies that track productivity metrics can just as easily be implemented for staff working at home, so that these roles are more transparent in their productivity while working out of sight, compared with senior staff. Given the technical roles are relatively lower paid positions, providing the option to work from home means a significant percentage of the salary can be saved due to reduced transport costs (and a smaller corporate wardrobe).

6.4.3 Staff attraction and environmental responsibility

Potential employees are increasingly looking for flexibility in their work environments. To attract quality applicants, organisations reported needing to keep up with their competition in terms of the different

working options provided. They discussed the need to customise working arrangements for individual staff members. One organisation wanted to demonstrate to potential employees that their policies were more than just standard. To do so, they collected and shared positive stories of different working arrangements. The desire for these success stories was a driver for both IT and transport policies. To remain an appealing employer, another organisation looked at the demands of not only the generation currently entering the work force, but those of the generation behind them as well.

One of the ways organisations promote themselves to new employees is by an emphasis on corporate and environmental responsibility. Where organisations were actively looking to reduce the kilometres travelled or number of vehicles travelling to, from and for work, they promoted this as going greener and being more sustainable. This in turn fed into how organisations demonstrated their corporate responsibility and their intentions to work to improve their suburbs and cities. In one case, demonstrating such responsibility with regards to reducing commuter transport trips was a requirement of the particular location in which the organisation was situated.

6.5 Barriers to changing staff behaviour through business investment in internet technologies

6.5.1 Organisational culture and staff expectations

6.5.1.1 Personal connections

Employees' desire to form personal connections with co-workers was most commonly cited as the most difficult, though understandable, barrier to overcome when trying to encourage working behaviours based around internet communications. Great company culture is not built solely around being the most flexible employer or demonstrating strong social and environmental principles. In-person interactions are key to developing the kind of relationships that allow employees to feel engaged and valued by the organisation. This, in turn, has a positive impact on productivity, as engaged employees, working in a way that best suits them, are likely to be more efficient and to stay in their roles longer. Interview participants recognised the trust and connection that develops as a result of direct interpersonal communication cannot be substituted by internet technology. Many noted that this trust and the opportunities for incidental communications provided by being co-located were important for successful project outcomes and for innovation.

Building this sense of connection and belonging in situations where people do not meet others in the office very often is challenging. One organisation countered this by specifically recruiting people who were comfortable working alone and could make strong connections online.

Interviewees recognised that a degree of interpersonal interaction was necessary for the majority of employees. As such, they reported that the increased use of internet technology was unlikely to lead to a large reduction in in-person meetings. Hence, they felt that this was unlikely to impact substantially on travel for meetings, although in one organisation there was some expectation that it could reduce air travel, particularly at the enterprise level.

They did believe that information and communication technology assisted in the development of the organisational culture they were aiming for. For example, ICT was seen to enable a shift in working behaviour away from sitting at a desk for eight hours a day to task-oriented working. One organisation focused on providing a work environment and culture around five Cs: communicate, collaborate, concentrate, contemplate and create.

ICT was seen as having a key role in providing the 'communicate' element and, to some degree, 'collaborate' (with use of tools like SharePoint in addition to video conferencing). The other elements could not be achieved by ICT alone, and required a broader range of supportive measures.

6.5.1.2 Anxiety and uncertainty

Another potential barrier to change is anxiety, uncertainty and lack of information. For example, the introduction of internet technology gives organisations the opportunity to relocate or out-source sections of the organisation to new locations or even overseas. While this can have efficiency benefits at an organisational level, it can lead to uncertainty and anxiety among staff. One interview participant discussed the stress caused to staff by a recent relocation of part of their organisation from the central city to a suburb. Despite the new location being based on public transport access, many young staff were unhappy about the lack of shops and other amenities nearby. The organisation looked to counter this by providing positive stories of increased flexibility in work arrangements and highlighting the empowerment of staff within these new arrangements.

Organisational policies aimed at reducing single-occupancy vehicle trips by encouraging staff to use public or active transport can be hindered by lack of knowledge about the alternative transport options. One organisation attempted to address this by purchasing electric bikes and having a trainer come in to ensure staff were comfortable with their use. They also provided more bike locks, showers and other facilities, as well as parks for scooters, so that cycling and other transport alternatives became more practical. Senior staff led by example, by biking and commuting by public transport. Further attempts to reduce uncertainty were made by having sessions for staff with Auckland Transport, so individuals could find out the best way to commute to and from work. Acknowledging that not all staff were comfortable commuting without their car, the organisation continued to have bookable parks available, as well as free parking for those with disabilities. In general, organisations recognised the need to be open and responsive to staff feedback.

6.5.1.3 Perceptions of flexible working

A common message from interviewees was that 'staff should recognise that they do not need to be at their desk for eight hours a day to be productive'. We can consider this statement from two angles: first, that organisations want staff to be flexible in how they approach their day; and second, that staff should not be seen by others to only be productive when physically present.

The latter perception was referred to by a number of interviewees as potentially being held by older generations in the workplace, who have developed an approach that works for them based on past environments. These staff can be slow to adapt to flexible working environments and alternative transport provisions. When these staff also happen to be in leadership positions, team members may find it difficult to set up flexible arrangements. Organisations recognised the importance of training team leaders and managers so that they were all providing the same opportunities for flexibility to their staff. Having senior leaders driving behaviour change, and demonstrating the desired behaviours (such as flexibility and mobility) themselves, was thought to be a particularly useful way to bring about change.

Likewise, employees have expectations around the technology or opportunities their employer can provide. These expectations may also drive changes, where possible within an organisation's structure and budget.

6.5.2 Physical and task-specific requirements

Having the necessary technologies to work remotely is only part of the picture; there are physical, structural and task-specific requirements that make some roles and/or locations impractical for remote

working. In Australia, one organisation found that successful uptake of work from home arrangements plateaued at 30%, not because of demand but due to restrictions on who can work like this.

6.5.2.1 Security and risk

Security of confidential data, such as customer information or organisational IP, outside the office was identified as an important issue. Roles that require access to and storage of such data will often not be appropriate for remote working, unless the staff member can demonstrate they have an area that complies with all the necessary security standards (for example, a dedicated private office at home or a password protected and encrypted computer). One interviewee reported that the security requirements to enable remote working had accelerated their organisation's move towards a paperless office, as this ensured that staff did not have physical documents stored at home.

These kinds of changes lead to a general change in an organisation's risk profile. Risk focus may change from the physical security of documents to network and cyber security. An organisation's financial risk may decrease, while its security risk may increase. Organisations need to determine at the executive level the balance of risk versus reward.

6.5.2.2 Health and safety

Health and safety is another key issue that organisations identified as influencing whether tasks can be done remotely. The New Zealand Health and Safety at Work Act 2016 imparts organisational responsibility for staff health and safety even in the home environment. Staff therefore require suitable work stations at home as well as at work. One organisation has staff sign documents affirming that they have a suitable workplace prior to allowing them to work from home.

Health and safety is also an issue in flexible office work spaces where employees do not have set desks. Increased movement and interchange of employees increases the risk of infectious disease transfer. One of the organisations spoken to instigated a cleaning and disinfecting regimen, with particular attention to roving desks.

6.5.2.3 Efficiency

Much of the discussion so far has been predicated on the assumption that flexible/remote working arrangements enhance efficiency and productivity. However, this is not necessarily the case with all tasks, locations or situations. Tasks requiring specialist equipment that is not easily portable (such as laboratory work) are not suitable, nor are tasks that require a high degree of interaction with customers and/or other staff members (such as therapists). Nevertheless, for many roles at least some degree of flexibility can be incorporated.

Remote working is only efficient if the technology allowing communication and access to the organisation's network and filing system is reliable and operates effectively in that location. Where access to telecommunications networks is limited, it may not be possible for staff to work remotely, due to delays and frustrations caused by poor quality connections. Some location issues can be overcome by enabling staff to enter data offline in areas where the connection is poor, and upload data upon return to areas with better reception.

A technical issue requiring a greater level of investment to solve is that multi-national organisations are likely to have different systems and technologies across countries. Alignment of these systems can prove a substantial structural and cost barrier. In this sample, multi-national organisations continued to operate separate systems from their overseas offices, although they acknowledged the inefficiencies. Differing regulatory environments may also be a barrier to globally aligning workforce collaboration.

For staff who are working together across different locations, there are still a number of potential inefficiencies. Platforms such as Skype for Business allow people to multi-task, for example by checking

and responding to emails while also in a Skype meeting. The reduced attention paid to the meeting (in comparison to if it took place in person) can make it less productive. Likewise, it can be difficult for individuals on Skype to break into meeting conversations when the majority of the group are co-located, meaning that these meetings may be less effective than if all members of the group were present because not everyone is as able to contribute their ideas. For this reason, many of the organisations interviewed used a combination of Skype and in-person meetings on projects.

6.5.3 Organisational policy and structure

Organisational strategy among those interviewed was generally focused around the employee experience, across three broadly intertwined spaces: human resources, digital happiness and physical environment. Within these spaces, organisations have a number of individual elements that they can directly alter to drive behaviour change and meet goals and targets. One interviewee summarised these elements as:

- site – the physical property the organisation inhabits, investment in technology, and the flexibility of working styles and mobility of people associated with this
- shape – of the organisation, its local, regional, national and international presence, and where staff and assets are located
- skills – capabilities of the workforce, skills and people needed now and in the future
- size – of the workforce, with implications for site and shape
- spend – investment in all the above.

These selected elements of company operation highlight the multitude of decisions that influence how people work, and how people travel for work. These decisions have tangible outcomes for transport demand, yet are often independent of any investment in or use of technologies like internet communication tools.

Among some of the organisations spoken to, there was a belief that information and communication technology (ICT) has a role in delivering and reinforcing organisational policy and structure, but that it does not drive these policies. As one organisation put it: 'It is responding to needs, rather than driving the way we work'. IT managers work to identify which hardware, software and networks will best meet the goals of the organisation, and then demonstrate that this is the case, described as 'prove it, don't promise it'. For instance, an organisation with the goal of workplace flexibility may identify Skype calls and meetings as a means of achieving this goal.

There is a counter argument, however, that ICT can drive high-level policy as well as being directed by it. As cutting-edge technology becomes available, abilities and pursuits not previously an option for the organisation can become possible. If organisational leadership is made aware of innovations, they can influence the organisation's goal direction. The mandate given to chief information officers and IT managers by executive leadership influences the latitude they have to look for new technology to drive organisational change.

Changes to high-level policy or introduction of new ICT, whether goal driven or technology driven, can require change to other corporate policies and/or structures, which in turn require some form of monitoring or feedback. Interview participants described changes to the corporate structure through the introduction of 'people' teams who worked to implement new flexible and remote working policies by helping managers change their mindsets and implement the policies fairly and effectively. In one organisation, the people team supported managers to encourage flexibility in their team through working

from home and updated their parental policies to encourage flexible hours and locations. The team actively encouraged managers to work at understanding employees' needs.

Another organisation altered its structure and introduced a director to oversee the systems integration of geographically dispersed teams formed using Microsoft Teams. At one organisation, staff wanted large computer screens and accompanying set-ups in meeting rooms. However, property (responsible for buying the screens) and technology (responsible for the programme driving remote access) were not linked in the organisation's structure, having different managers, so making it difficult to meet staff and client expectations. In order to be able to quickly update technology, this organisation looked at a new business model in which the fitout of meeting rooms is provided as a service and the organisation itself does not own the hardware. As there are only a few big telecommunications companies providing this service, costs can be compared swiftly, reducing overheads.

In a change of policy and practice, an organisation that implemented working from home initiatives among call centre staff began to actively recruit for candidates suitable to this style of working. Traditionally these roles were considered suited to younger staff with few post-high school qualifications. New hires are increasingly older female workers who are more likely to have access to the quiet, private and secure spaces needed to effectively perform their role from home. Younger people living in shared flats are less able to provide the necessary environment. There is a flow-on effect for career progression, as these entry-level positions are used to develop staff into senior roles over time.

Policy provides formal, top level support for behaviours such as remote working, making it easier for employees to adopt them, and supports culture change in an organisation. It also provides a mandate for IT departments to work towards delivery and measurement of these services. Measurement and feedback demonstrate effectiveness and provide evidence for on-going changes and programmes. For example, a demonstrated drop in kilometres travelled and number of trips made per year would support the business case for the newly implemented ICT systems in one organisation interviewed. Alternatively, risk prevention using ICT can help get policies off the ground. For example, one organisation included remote offices as part of their business continuity plan.

These kinds of practices are also influenced by a range of other organisational policy, so it is often not possible to establish causation, but some organisations have measured correlational data. For instance, one organisation identified a correlation between the increased use of Skype for Business and a decrease in travel. However, this came at a time when a policy was in place to restrict travel for conferences, so the impact of ICT was hard to separate out.

6.5.4 The bottom line

While some of the shifts described above are about staff engagement and behaviour change, the main influences are ultimately business efficiency, productivity and financial considerations. Many initiatives are therefore largely driven by cost savings for the organisation. Those responsible for implementing ICT change look for measures that can add weight to their investment profiles. This can be a beneficial process, where demonstrated financial benefit, such as the example of reduced vehicle kilometres travelled for staff working on site, can accelerate desirable change compared with change sought for reasons less easy to quantify such as staff satisfaction or collaboration.

6.6 Measuring the influence of internet use on transport demand

6.6.1 Case study interviewee's viewpoints

While all organisations could point to their financial monitoring of transport budgets, just two organisations spoken to actively monitored changes in transport demand. Only one of these did so in direct relation to a targeted investment in internet technologies that they expected would drive change. Transport outcomes these organisations tracked were:

- mode of transport for commuter trips (self-reported by staff), particularly the proportion of single occupancy vehicle trips made to and from work by staff each day
- the number and cost of commercial car parking leases held by each office
- vehicle kilometres travelled by staff in work vehicles.

Each organisation spoken to thought it would be possible to track levels of staff transport demand and use of internet technologies made available to staff. However, making an informed judgement of how one is influenced by the other would be a challenging question to answer, even if the data were available. Company trends could be examined over time, but these would need to be looked at within the context of what work staff were doing during a certain period, and each organisation's travel practices and associated policies. At the time of the interviews, one organisation had restrictions in place for non-project related travel. Looking at the data for this period, one could see a rise in the use of internet communication tools and a drop in air travel, but the driver of change at this organisation cannot be directly attributed to internet technology.

At a city or regional level there are even more factors confounding the influence of internet use on transport demand, making it difficult to tease out a causal effect. There is information in the Statistics NZ Business Frame dataset for where businesses and their employees are located, while the New Zealand Census asks the entire population about their employment situation, including where they work (home or other location) and how they travel to work. So, it is possible to track changes in how people are working and commuting in New Zealand at fine spatial scales, albeit at five yearly intervals.

Surveys of internet use are less comprehensive, with small sample sizes that do not adequately allow for comprehensive spatial and temporal analysis of trends over time. As such, it is difficult to link the findings of this work to other sectors such as transportation. Long-term surveys of individual businesses have the same challenge, and previous work has demonstrated that trying to delve into specific analyses such as the influence of the internet on transport demand further reduces sample size and statistical power.

Where businesses are agglomerated and implementing travel demand management policies, such as the aimed reduction of single occupancy vehicle trips among workers in the Wynyard Quarter, it is possible to track organisations' statistics on change. Where there is a modal shift, especially to public transport, this can be picked up via patronage counts. However, once again, tracing changes in public transport use back to organisational policies or use of internet technologies is impractical and unlikely to yield insights of significant value for city network planning.

Some of the interview participants queried the need to understand the scale of effect, so long as the mechanisms and nature of effect are generally well understood. They are happy to engage with transport authorities for the type of change they are promoting, and believe that what they are doing is not novel in New Zealand or overseas. One suggested patterns of land use and occupancy of office space across cities as a key metric against which to match transport infrastructure and service provision. If there is a shift

toward remote working from suburban locations, then transportation decisions such as public transport routes and schedules should adapt to support this.

From a transport network perspective, the key challenge is provision of services and infrastructure that match flexible working environments. Network planners cannot successfully encourage workers to change their commuter behaviour away from car trips if there are no viable and attractive public transport alternatives. In this instance, the best transport outcome for both the staff member and company is to remove the need to travel altogether.

6.6.2 New Zealand Household Travel Survey

While not discussed at any of the case studies or key-informant interviews, it is pertinent to discuss the HTS conducted by the Ministry of Transport. This annual survey of 2,200 randomly selected households captures information about where, when, how and why people travel. Daily travel is recorded using GPS enabled travel loggers, or a daily travel diary that participants complete. Additional information about journey purpose and transport mode are collected to provide a clear picture of travel behaviours among the study group.

The Ministry of Transport is presently analysing this database to see if the information held can provide insight into changes in travel patterns such as those discussed in this report. Anecdotally, early indications are that the database supports some of the suggested changes to travel demand resulting from internet use, such as a reduction in travel for personal activities (ie visiting a bank) and work-related activities.

The HTS has the potential to demonstrate changing travel demand patterns among the study group; however, the cause of change is not currently captured by survey responses. The survey does not follow the same households over several years, so there is no information on how an individual's travel patterns change over time due to external influences.

It would be relatively simple to include a range of questions about how respondents might have substituted, complemented or modified a routine trip through the use of internet technologies in the HTS. Participants might be asked if they had carried out any online activities that day, such as video communication, online shopping or remote working that would otherwise have required a trip.

As the HTS also asks a number of questions about employment situations, it would be possible to include questions about flexibility of hours and days, for example 'Do you work remotely via the internet? If so, how many days a week?'

These indicators would allow for monitoring of trends over time while not taking away from the 'daily travel' nature of the current survey approach. The information would not provide quantitative information in the context of city or regional level changes in transport demand patterns, though there are likely to be alternate sources of this information emerging as the volume and nature of transport data collected grows and our ability to produce insights from this information improves.

Alternate data sources are already emerging and include:

- data from sensors (eg cycle counters, Bluetooth gateways on roads)
- GPS cellphone data captured via installed apps
- WiFi and Bluetooth pings from cellphones
- personal activity trackers

- data generated by transport services themselves (eg real-time public transport positioning and patronage, private mobility services such as taxis, ride hailing and ride sharing)
- freight movements on all roads in real time.

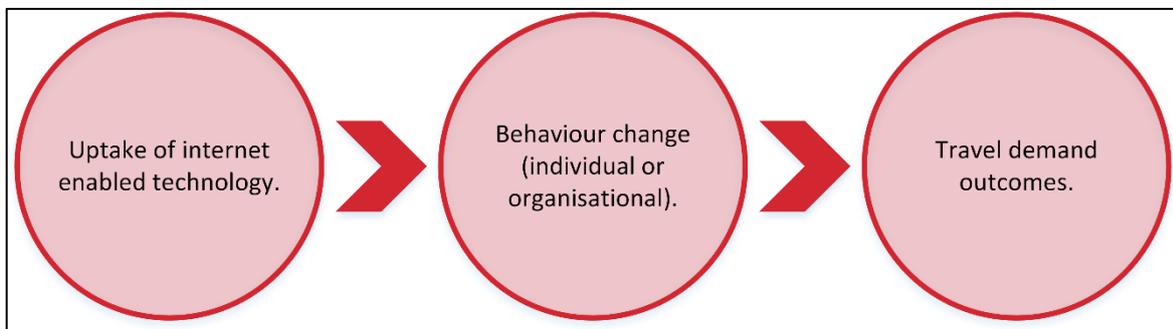
Again, none of these datasets directly inform how internet use is shaping transport demand, though services such as ride hailing and ride sharing are directly accessed via the internet, but they do provide for quality spatial and temporal insights of multi-modal patterns.

7 Conclusions

This research sought to understand the influence that internet-enabled communication technologies are having, and might have, on patterns of transport demand in New Zealand. From an initially broad view of internet influences on transport demand the study focused specifically on business use of internet technologies, and the influence this has for staff transport behaviour.

We identify that work-related travel demand is expected to be directly influenced by internet use as individual trips are substituted, complemented or modified. There are also indirect effects, primarily through opportunities created by internet technologies for different ways of working that in turn influence staff's travel demand. Generally, the influence of the internet on travel demand described by interviewees at the case study organisations could be summarised as operating via a three-step process:

Figure 7.1 Stages of the internet's influence on travel demand for businesses and staff



Quantitative predictions of future trends in internet use are fundamentally uncertain. In the late 1990s, when widespread public use of the internet first took place, the potential for massive changes to society and the global economy were accepted; however, the nature of this influence, and the pace and scale at which change took place over the following decade were not well understood. Even today, as numerous organisations, groups and individuals seek to drive change through innovation in internet-enabled technology, rates of adoption and the quantified impact of new technology on people and business is uncertain. Given these challenges, determining the nature and magnitude of any causal relationship or association on other systems, such as transport, presents a substantial challenge for transport planners and modellers.

Interviewees during the case study interviews all spoke of a range of investments being made by their organisations in internet-enabled technologies. These investments were for the most part simply investing in services that allow the organisation to stay modern and remain competitive. A range of outcomes were discussed that were expected to result from internet use, such as employee satisfaction, improved productivity and efficiency, and a reduction in property and transport-related costs.

Direct outcomes for transport were often not the focus of organisation's motivations for investing in modern internet technologies and services. As summarised in table 7.1, internet communication technologies were generally seen as influencing how people communicate face-to-face (in person or over the internet), where people work (office, home or remotely), and when they need to be physically in the office for work (8am–5pm or more flexibly). As staff adopt new behaviours and working styles around each of these activities, their transport demand is directly influenced.

Because transport outcomes are often not the key driver of investment, interviewees were generally unaware of their organisation quantifying the influence of internet use on transport demand among staff or

monitoring trends over time. This did not diminish the importance interviewees placed upon changing transport behaviours among staff, and the potential outcomes as a result of their organisation's investment and strategies were well understood as summarised below.

Table 7.1 Summary of internet communication technology influences on transport demand cited by interviewees at case study organisations

Internet enabled activity	Nature of influence	Transport demand outcome
Person-to-person communication (eg video calls)	Substitution	Face-to-face communication via the internet replaces the need for in-person meetings that require travel. Overall travel demand, individually and across an organisation, is reduced or in some cases (most likely individual) removed altogether.
	Enhancement	Improved communication via the internet increases the connections being made between people in distant locations. This is likely to generate demand for physical transport between locations that otherwise might not have existed.
Working from home	Substitution	Commuter trips between home and office do not take place when staff work from home.
	Modify	While commuter trips might not take place, the home location becomes the origin for daily travel that would otherwise have originated from the office (eg buying lunch, dropping off and picking up school children). When these trips still take place, they are modified.
Flexible working hours	Modify	Flexible working hours shift the time when travel takes place, thereby modifying individual trips. Often these trips take place outside of peak commuting period.
Remote working (not from home)	Neutral	Teams comprising staff located at different offices may have a neutral effect for transport demand. For example, internet technologies allow an organisation's staff to come together to carry out a project from remote locations, but the transport behaviours of individuals within the team are no different from those they exhibited previously.
	Modify	The ability of staff to work remotely, on site or in the field, away from their organisation's physical office space is not new nor the result of advances in internet technology. Use of the internet has, however, modified how remote staff work. Via the internet employees can better connect with other people and the organisation itself from any location. This enables them to share and receive information from the field, their vehicle or at home, in turn reducing the need to visit an office to perform the same activity. For some roles this can mean daily trips remove an entire leg of a journey freeing up productive time and reducing overall miles travelled.
	Enhancement	There is localised enhancement of travel demand when people choose to live and work in a location, but had the opportunity to work remotely via the internet not existed they would have lived elsewhere for their job. Effectively, people moving to areas for lifestyle choices who work for an organisation based elsewhere increase the population of the region they have moved to and generate increased demand for travel in the area.
Co-working spaces	Modify	Co-working spaces have the potential to modify an individual's transport behaviour and in turn that of their local area. By providing

Internet enabled activity	Nature of influence	Transport demand outcome
		<p>shared office space to individuals, teams and small businesses these spaces become a destination for travel, modifying transport demand for a collective group of people who might otherwise travel to a dispersed array of office spaces across a city.</p> <p>At a city level, the establishment of co-working spaces in centres close to where people live creates the opportunity for individuals to choose to work closer to home, connected to their organisation via the internet, while still enjoying the social benefits that come from working alongside others. In such instances, travel behaviour is modified as individuals still travel to work but perhaps to a location in their neighbourhood centre, and on foot or by bicycle as opposed to a car or the bus.</p>
	Enhancement	<p>Because co-working spaces are primarily suited to individuals and small businesses, they serve a group that has often been excluded from working in a physical office due to cost. The establishment of co-working spaces not just in central cities but also in suburban areas creates demand for transport to these hubs that otherwise might not have existed.</p>

In isolation, it is possible to quantify the influence of internet use on transport demand at a household or business level. At this unit size, one can control for external influences, and benchmark past behaviours to understand how patterns of both internet use and transport demand have changed over time. Once the historical transport demand response to the internet is modelled, the opportunity to look forward to future scenarios becomes a reality.

While interesting, measuring transport demand by individual households or businesses does little to inform city, regional, national or global trends and outcomes. Inferences could be drawn to set model parameters based on findings from people and businesses; however, as the case study interviews demonstrated in this research there are many confounding influences on the relationship between internet use and transport demand at New Zealand businesses.

An alternative approach might be to understand the make-up of New Zealand businesses, and identify which businesses/sectors are most likely to be influenced by the internet-related trends summarised in table 7.1. From this, the scale of impact certain activities could have if applied throughout the workforce can be estimated. As discussed in this report, individuals within a workforce do not change their behaviour based solely on the availability of technology. The rate of uptake by sector and workforce demographics would need to be understood before estimating at city, regional or national level.

This approach aligns with the 'adaptive management' approach presented in the recently published *NZ Transport Agency research report 620* (Byett et al 2017). This is an approach for dealing with transport investment decisions where well-defined distributions for key factors, such as internet use, that directly influence the investment decision are not available. Transport planning under adaptive management phases investments to allow for learning over time. Decisions are not treated as a 'once-only' event, rather they are encouraged to evolve over time in response to uncertainty.

Byett et al (2017) recommend the following steps for investment decisions using an adaptive management approach:

- 1 Define the issue
- 2 Estimate the status quo and business as usual scenario

- 3 Identify key drivers of uncertainty
- 4 Create short-list of alternative investment opportunities
- 5 Draw decision tree for each alternative
- 6 Probe uncertainties
- 7 Crudely estimate indicative payoffs
- 8 Establish threshold(s) that favour one alternative over another.

This approach is qualitative in nature, and does not focus on the monetary value of a given option. Such an approach is well suited to a range of transport investment decisions, the flexibility inherent in the process makes it particularly well suited to decisions around changing trends such as internet influences on transport demand.

Quantifying the influence of internet use on transport demand is not necessarily essential for transport investment decisions. Internet use, in terms of business activities, is the result of investment made by external organisations, often with little thought to how those decisions might affect the city or town's transport system. Transport planners must therefore predict future effects of the internet on travel demand that are a result of decisions they have little to no control over.

It is therefore important that the outcomes created by business investment in internet communication technology, and the changing travel behaviours of the workforce align with the goals of our transport planners and decision makers. Outcomes such as a change in travel demand outside peak periods, substitution of physical travel by digital communication, and more modified daily transport patterns across multiple modes are the same goals transport planners in New Zealand cities have sought to achieve for some time. Multi-modal transport systems that are flexible and adaptive to future change are therefore essential to meet future changes in people's transport preferences and demand.

8 References

- Althoff, T, RW White and E Horvitz (2016) Influence of Pokémon go on physical activity: study and implications. *Journal of Medical Internet Research* 18, no.12.
- Amazon.com Inc (2016a) *Amazon prime now*. Accessed 1 November 2017. <https://primenow.amazon.com/onboard?sourceUrl=%2F> ().
- Amazon.com Inc (2016b) *Amazon prime air*. Accessed 1 November 2017. www.amazon.com/Amazon-Prime-Air/b?ie=UTF8&node=8037720011
- Boston Consulting Group (2001) *The multi-channel consumer: the need to integrate online and offline channels in Europe*. Boston, MA.
- Buente, W and A Robbin (2008) Trends in internet information behavior, 2000–2004. *Journal of the Association for Information Science and Technology* 59, no.11: 1743–1760.
- Byett, A, A Grimes, J Laird and P Roberts (2017) Incorporating and assessing travel demand uncertainty in transport investment appraisals. *NZ Transport Agency research report 620*.
- Casas, J, J Zmud and S Bricka (2001) Impact of shopping via Internet on travel for shopping purposes. Presented at the *80th Annual Meeting of the Transportation Research Board*, Washington DC, January 2001.
- Chao, L (2016) *Online shoppers want delivery faster, cheaper, survey shows*. Wall Street Journal, 13 June 2016.
- Claisse, G (1983) Transport and telecommunications, report on the fifty-ninth round table on transport economics. Presented at the *European Conference of Ministers of Transport*, Paris, 14–15 January 1982.
- Clayton, R (2016) *Dominos delivers pizza by drone*. Stuff. Accessed 1 November 2017. www.stuff.co.nz/business/86529893/dominos-delivers-pizza-by-drone
- Commonwealth of Australia (Australian Communications and Media Authority) (2014) *Six emerging trends in media and communications*. Occasional paper. Accessed 4 April 2018. www.acma.gov.au/-/media/Research-and-Analysis/Research/pdf/Six-emerging-trends-in-media-and-communications_Final-pdf.pdf?la=en
- Couclelis, H (2004) Pizza over the internet: E-commerce, the fragmentation of activity and the tyranny of the region. *Entrepreneurship and Regional Development* 16, no.1: 41–54.
- Crothers, C, A Gibson, P Smith, A Bell and M Miller (2014) *Internet trends in New Zealand 2007–2013*. Auckland: Auckland University of Technology, Institute of Culture, Discourse & Communication.
- Crothers, C, P Smith, PWB Urale and A Bell (2016) *The internet in New Zealand 2015*. Auckland: Auckland University of Technology, Institute of Culture, Discourse & Communication.
- Davison, E and SR Cotton (2003) Connection discrepancies: unmasking further layers of the digital divide. *First Monday* 8, no 3.
- Delbosch, A and G Currie (2015) Does information and communication technology complement or replace social travel among young adults? *Transportation Research Record: Journal of the Transportation Research Board* 2531: 76–82.

- Domino's Pizza Enterprises Ltd (2016) *DRU DRONE by Flirtey*. Accessed 1 November 2017. www.dominos.co.nz/drudronebyflirtey (accessed 1.11.17).
- Farag, S, T Schwanen, M Dijst and J Faber (2007) Shopping online and/or in-store? A structural equation model of the relationships between e-shopping and in-store shopping. *Transportation Research Part A: Policy and Practice* 41, no.2: 125–141.
- Giuliano, G and A Gillespie (1997) Research issues regarding societal change and transport. *Journal of Transport Geography* 5, no.3: 165–176.
- Glass, H, P Davies, E Hefter and G Blick (2014) *The value of internet services to New Zealand businesses*. Sapere Research Group.
- Golob, TF and AC Regan (2001) Impacts of information technology on personal travel and commercial vehicle operations: research challenges and opportunities. *Transportation Research Part C Emerging Technologies* 9, no.2: 87–121.
- Hagerstrand, T (1970) What about people in regional science. Pp 7–21 in *Papers of the Regional Science Association* 24.
- Herring, SC (2004) Slouching toward the ordinary: current trends in computer-mediated communication. *New Media & Society* 6, no.1: 26–36.
- Horrigan, JB and L Rainie (2002) *The broadband difference: how online Americans' behavior changes with high speed internet connections at home*. Accessed 4 April 2018. www.pewinternet.org/2002/06/23/the-broadband-difference-how-online-behavior-changes-with-high-speed-internet-connections/
- Leaman, A (2016) *Hospice Waikato turns to virtual care to reach remote communities*. Stuff. Accessed 4 April 2018. www.stuff.co.nz/national/health/86818857/hospice-waikato-turns-to-virtual-care-to-reach-remote-communities
- Memarovic, N, S Fels, J Anacleto, R Calderon, F Gobbo and JM Carroll (2014) Rethinking third places: contemporary design with technology. *The Journal of Community Informatics* 10, no.3: 13pp.
- Ministry of Transport (2018) *New Zealand household travel survey*. Accessed 6 April 2018. <http://www.transport.govt.nz/research/travelsurvey/>
- Mokhtarian, PL (2003) Telecommunications and travel. *Journal of Industrial Ecology* 6, no.2: 43–57.
- Mokhtarian, PL (2004) A conceptual analysis of the transportation impacts of B2C e-commerce. *Transportation* 31, no.3: 257–284.
- Mokhtarian, PL and I Salomon (2002) Emerging travel patterns: do telecommunications make a difference? Pp143–182 in *Perpetual motion: travel behaviour research opportunities and applications challenges*. HS Mahmassani (Ed) Oxford, UK: Pergamon Press/Elsevier.
- Morgan, J (2015) *Five things you need to know about telecommuting*. Forbes. Accessed 1 November 2017. www.forbes.com/sites/jacobmorgan/2015/05/04/5-things-you-need-to-know-about-telecommuting/
- Murison, M (2016) *Could Pokemon Go affect the travel industry?* Travelshift. Accessed 4 April 2018. <https://travelshift.com/pokemon-go-affect-travel-industry/>
- Niles, J (1994) Beyond telecommuting: a new paradigm for the effect of telecommunications on travel. *National Technical Information Service report DOE/ER-0626*, Washington, DC.

- OECD Observer (2008) *A smaller world?* OECD Observer. Accessed 1 November 2017. http://oecdoobserver.org/news/fullstory.php/aid/2674/A_smaller_world_.html
- Petersen, R (2015) *Why your next package will be delivered by an Uber*. TechCrunch. Accessed 4 April 2018. <https://techcrunch.com/2015/06/28/why-your-next-package-will-be-delivered-by-an-uber/>
- Price, S (2016) *The 4 most powerful social commerce trends*. Yotpo Voice. Accessed 1 November 2017. www.yotpo.com/blog/the-4-most-powerful-social-commerce-trends/
- Rainie, L and P Bell (nd) The numbers that count. *New Media and Society* 6, no.1: 44–54.
- Salomon, I (1985) Telecommunications and travel: substitution or modified mobility? *Journal of Transport Economics and Policy* 19, no.3: 219–235.
- Salomon, I (1986) Telecommunications and travel relationships: a review. *Transportation Research Part A General* 20, no.3: 223–238.
- Siemens AG (2014) *Siemens traffic detectors*. Accessed 11 April 2018. www.mobility.siemens.com/mobility/global/sitecollectiondocuments/en/road-solutions/urban/infrastructure/verkehrsdetektoren-en.pdf
- Statistics New Zealand (2013a) *Information technology's contribution to labour productivity growth*. Accessed 4 April 2018. http://archive.stats.govt.nz/browse_for_stats/economic_indicators/productivity/it-contribution-labour-productivity-growth.aspx
- Statistics New Zealand (2013b) *Household use of information and communication technology: 2012*. Accessed 4 April 2018. www.stats.govt.nz/browse_for_stats/industry_sectors/information_technology_and_communications/HouseholdUseofICT_HOTP2012.aspx
- Thomas, S and PV Jose (2015) Recent trends in E-commerce. *International Research Journal of Engineering and Technology* 2, no.6.
- Want It Now (2016) *About us | want it now*. Accessed 1 November 2017. <http://wantitnow.com.au/about-us>
- Ward, MR and M Morganosky (2002) Consumer acquisition of product information and subsequent purchase channel decisions. Pp231–255 in *Advances in applied microeconomics: the economic of the internet and E-commerce*. MR Baye (Ed), Amsterdam: Elsevier Science.
- Whitmore, A, A Agarwal and LD Xu (2015) The internet of things – a survey of topics and trends. *Information Systems Frontiers* 17, no.2: 261–274.
- World Economic Forum (2015) *Industrial internet of things: unleashing the potential of connected products and services*. Accessed 4 April 2018. www3.weforum.org/docs/WEFUSA_IndustrialInternet_Report2015.pdf

Appendix A: Key informant interview questions

This part of the first stage of research was a semi-structured interview process. As well as a list of six prepared questions, the interviewer asked follow-up questions to elicit further information as appropriate. The interview schedule was:

- 1 What significant internet trends are currently influencing transport demand, or will do so in the future?
 - a Do you think these trends affect New Zealand overall, or are there regional differences?
- 2 What internet-related transport demand factors might be possible to measure at a city or regional level in New Zealand?
 - a What data might be available?
- 3 What attempts have been made, in New Zealand or overseas, to quantify the influence of internet technologies and trends on transport demand?
 - a Are you aware of any transport or economic modelling that estimates current and predicts future impacts of internet trends?
- 4 What is your perspective on the scale of the impact that the internet is having, or will have, on transport demand?
 - a Do you have any sense of overall change in direction (increase/decrease)?
- 5 What do you think about the importance of studying and trying to quantify the influence of the internet on transport demand?
 - a Is it worth doing and is it possible?
- 6 Any further comments?