DEEP INTERVENTIONS FOR A SUSTAINABLE TRANSPORT FUTURE

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ABSTRACT

The dominance of automobility is giving rise to unsustainable outcomes, not least of which is its contribution to climate change. At the same time, business-as-usual transport systems are entering a period of turbulence as a result of influences such as new and disruptive technologies, intelligent systems, new business models, changing consumer expectations, population growth, suburban sprawl, and national commitments to reduce greenhouse gas emissions. An optimal trajectory towards sustainable transport is unlikely to be achieved in a laissez-faire policy environment, and nor is it likely that it will be resolved by any single solution. Rather, it is likely to require carefully crafted interventions that have a good fit with unique national circumstances, and which will work in an integrated way to achieve change consistently throughout the transport system. The research reported in this paper draws on the situated knowledge and experience of New Zealand transport experts to develop a suite of potential interventions for a sustainable transport future for New Zealand. Drawing on the findings of a four-stage Delphi study, which solicited experts' views on interventions that could lead to better outcomes than were being achieved by the current policy environment, this paper concludes that a consistent and integrated commitment is required at all levels of governance and across all parts of the transport system to transition away from automobility and towards sustainable mobility.

KEYWORDS

Delphi Technique; Interventions; sustainable transport; Policy; Experts; mobility culture

1. INTRODUCTION

New Zealand's transport system, like many others internationally, is still dominated by high levels of private vehicle ownership, near-complete reliance on fossil fuels, sprawling urban areas, and other characteristics of what Urry (2004) calls the system of automobility. Unsustainable consequences include environmental impacts, (e.g. greenhouse gas (GHG) emissions (Hopkins & Higham, 2016)), social impacts (e.g. social exclusion and isolation (Lucas, 2012)), and economic impacts (e.g. the cost of congestion (Wallis & Lupton, 2013)). Shifting to more sustainable transport systems will be aided by market-based solutions such as shared mobility businesses and the increasing cost-competitiveness of electric vehicles, but the scale and rate of the transition required is unlikely to occur without carefully designed and integrated government interventions (Geerlings et al., 2012). This paper explores potential interventions for a more sustainable transport future for New Zealand.

New Zealand's current policy environment largely favours the continuation of business-as-usual; For instance, despite a commitment under the Paris agreement to reduce GHG emissions by 30 percent below 2005 levels by 2030 (Ministry for the Environment, 2016), in which low-carbon transport could play a significant role, a major focus of transport policy and funding is still on large highway and motorway projects that prioritise the use of private cars (New Zealand Transport Agency (2017). And unlike most other western nations, the New Zealand government has chosen not to introduce

fuel efficiency standards for vehicle imports (Barton & Schütte 2016). In part, the government's reluctance to take a more directive role may be a result of the strong neoliberal underpinning of successive governments since the mid-1980s, so that market-led solutions are favoured over policy interventions (Kelsey 2015). It is also likely to be influenced by the sheer complexity of attempting to change a transport system that is embedded in path dependencies, involves vested interests in the status quo, and is the outcome of decades of decisions of multiple agencies with differing agendas (Gross et al., 2009; Imran & Pearce, 2015; 2016).

If the New Zealand government was to adopt a stronger leadership role, a key conundrum is where best to intervene to achieve the desired outcome. International experience is that policy interventions are often targeted at specific solutions such as reducing emissions from vehicles or decreasing private vehicle use (Givoni et al., 2013), or are targeted to a specific transport mode (Ogilvie et al., 2007). But it is increasingly clear that technological or infrastructural interventions alone are unlikely to generate change at the scale and speed required. Changing consumer preferences and behaviours are also important (Dietz et al., 2009; Economides et al., 2012; Pietzcker et al., 2014), as is the use of multiple measures and harnessing the synergies between them to improve their effectiveness (Givoni et al., 2013). But what measures should be used? New Zealand cannot simply adopt interventions used elsewhere and expect them to be effective. The variability in transport systems across the globe, the populations they serve, and the political realities, means that while governments can learn from one another (see for example, policy mobility literature), unique solutions will need to be developed to suit New Zealand's characteristics.

The research reported in this paper has drawn on the situated knowledge and experience of New Zealand transport experts to develop a suite of potential interventions for a sustainable transport future for New Zealand. We draw on the findings of a four-stage Delphi study undertaken in 2014 which solicited experts' views on interventions that could lead to better outcomes than were being achieved by the current policy environment. The results remain pertinent as there has been little change since then to the sustainability aspects of New Zealand's transport policy. We first discuss the nature of interventions in transport systems, outline the New Zealand transport context, and introduce the Delphi research method and how it was applied. The results are discussed in four sections: the experts' views on the characteristics of a sustainable transport system for New Zealand; changes needed in the system; priority areas for intervention; and the proposed interventions. We then discuss the implications of these findings for New Zealand and make some broader reflections on interventions that have a more generic application.

1.1. Interventions for a sustainable transport future

Sustainable transport can be described in a variety of ways, but generally refers to desirable combinations of government policies, technologies, infrastructure, and behaviours which minimise adverse social and environmental impacts while retaining or enhancing economic outcomes (Goldman & Gorham, 2006; Henning et al., 2011; Schwanen et al., 2011; Xenias & Whitmarsh, 2013). Banister's (2008) 'paradigm' of sustainable mobility centres on four fundamental ways to achieve this: travel substitution, modal shift, distance reduction and efficiency increases to reduce the negative externalities of the current transport system. Examples of interventions aimed at reducing demand for unsustainable travel include developing infrastructure for low-emission modes, altering consumer preferences, increasing energy efficiency, promoting technological innovations such as electric vehicles and software applications, and increasing loading factors, for example by increasing vehicle occupancy and freight loads (Pietzcker et al., 2014; Sims et al., 2014).

Considering interventions more generically, Taylor et al (2012) identify five main categories of policy instruments for environmental outcomes: direct 'command and control' regulations; economic instruments; information-based instruments; co- and self-regulation; and support mechanisms and capacity building. Interventions can be broadly differentiated between 'pull' and 'push', with the

former encouraging preferences to change by offering attractive alternatives and the latter using mechanisms that make unsustainable behaviours less attractive, and a combination of both is often advocated (Pietzcker et al., 2014). A study conducted in the United Kingdom found transport experts and the public share a similar vision for the future that involves enhancing public transport, investing in cleaner technologies, improving infrastructure for active travel, and instituting economic measures such as congestion charging (Xenias & Whitmarsh, 2013). However, the public favoured bottom-up, 'pull' strategies that make sustainable transport options more attractive, while experts prioritised top-down, 'push' mechanisms. Xenias and Whitmarsh (2013) suggest that discordant preferences could result in resistance from the public for new transport strategies, reinforcing the need for public engagement. Arnott et al. (2014) similarly argue that interventions should be developed via a participatory approach with relevant actors.

Interventions to achieve a sustainable transport system are often difficult to design due to the multi-scalar nature of transport systems, and interactions between transport and other economic sectors (Geels, 2012; Goldman & Gorham, 2006). To be effective, interventions need to simultaneously influence multiple aspects of the transport system: a single-focus policy can concurrently encourage path dependency, path destabilisation, and path creation (Mäkinen et al., 2015). Poorly designed policies can also have unintended consequences. For instance, improving the fuel economy or reducing traffic congestion can result in a rebound effect, inadvertently encouraging driving and vehicle kilometres travelled (VKT) rather than reduced use of fossil fuels (Goldman & Gorham, 2006; Sorrell & Dimitropoulos, 2008; Druckman et al., 2011). A future focus is also important; Banister & Hickman (2013: 283) stress that a longer-term perspective is vital since "many interventions require long lead times, impacts take time to be effective, and different policies when combined to work in the same direction can be more effective". But this should not be done in lieu of more immediate actions; Köhler et al. (2009) argue that it is important to support long-term interventions while also investing in more immediately achievable actions. Designing interventions not only involves negotiating these issues, but also taking into account the specific context and challenges of the transport system in question.

1.2. Transport in Aotearoa New Zealand

New Zealand is a small, geographically isolated country in the South Pacific Ocean consisting of two main islands, North and South. The land area of 269,000km² is comparable to the area of Italy or the United Kingdom, but the population is just 4.4 million. Despite this, New Zealand is highly urbanised; approximately 85% of the population reside in towns and cities, with the Auckland metropolitan area being home to 1.4 million people.

New Zealand cities have low population densities and low public transport use compared to world standards (Coleman, 2010). Eight out of ten New Zealanders drive to work, while around 10% walk or cycle, and less than 5% use public transport (Statistics New Zealand, 2016). There is limited public transport available beyond Auckland and Wellington, where significant investments have been made in bus and rail systems. Domestic freight is similarly dominated by road transport, despite research showing that this has the lowest fuel efficiency per tonne-kilometre compared to coastal shipping or rail (Cenek et al., 2012). Around 70% of freight tonne-kilometres is carried by road, followed by coastal shipping (14.9%), rail (14.6%) and air (0.4%) (Ministry of Transport, 2014c)

New Zealand's road transport system faces a number of sustainability challenges. Greenhouse gas emissions from road transport grew three times as fast as total national emissions over 1990-2013 (Ministry for the Environment, 2015), and most of the increase in total energy-related emissions is due to growing transport emissions (RSNZ, 2016). Transport-related emissions comprise around 44% of New Zealand's energy-related GHG emissions, with approximately 80% of this from the light vehicle fleet (Ministry of Business, Innovation and Employment, 2014, Ministry of Transport, 2015b). This high proportion of transport emissions must be seen in the context of New Zealand's high level (~80% in 2015) of renewable electricity generation (MBIE, 2016), meaning that the emissions from

electricity generation are relatively small compared to most nations. On the other hand, this means that the transport sector has the greatest potential for near-term GHG reductions of all the energy-using sectors (Royal Society of New Zealand, 2016).

New Zealanders are heavily reliant on personal cars for their travel: in 2015, there were over 760 light vehicles per 1000 people, one of the highest rates in the world (Ministry of Transport, 2015b). Over half of new cars registered are second-hand, imported mainly from Japan (Ministry of Transport, 2014b). As noted earlier, New Zealand does not have emissions standards for imported vehicles and the GHG emissions of light vehicles entering the fleet have scarcely changed since 2012 (Ministry of Transport, 2017). The average age of vehicles in the light fleet is 14 years, several years older than Australian, Canadian and US counterparts (Ministry of Transport, 2014b). Traffic congestion nationally rose by 43% between 2008 and 2016, compared to a global average of 23 % over the same period (TomTom, 2017). All of these indicators point to a transport system that is heavily car-dependent and largely inefficient, with unsustainable impacts that include the impacts of GHG emissions on the environment, and particulate emissions on health (Wallis & Lupton 2013).

National and local governments invest more than NZD 4 billion in land transport annually (Ministry of Transport, 2014a). The legislative framework is critical to shaping whether this investment and other decision-making is aligned with sustainable outcomes. In New Zealand, the overarching purpose of the 2003 Land Transport Management Act was "[T]o contribute to the aim of achieving an integrated, safe, responsible and sustainable land transport system" (Section 3, Land Transport Management Act 2003). However, reference to sustainability was discarded in a 2013 amendment to the Act, whereby the same section now read "The purpose of this Act is to contribute to an effective, efficient, and safe land transport system in the public interest" (NZ Government, 2013). This alteration of the core principle of the guiding legislation was one of the drivers for the research reported in this paper, as we were interested in whether this approach aligned with the views of New Zealand transport experts, including those working in national and local government transport agencies.

The Government's main transport strategy has the goal of achieving "an effective, efficient, safe, secure, accessible and resilient transport system that supports the growth of our economy, in order to deliver greater prosperity, security and opportunities for all New Zealanders" (Ministry of Transport, 2011: p.2). The strategy identifies five main challenges: an ageing population, increased urbanisation, the volatility and overall increase in fuel prices, the need to double freight capacity in the next 30 years; and the global response to climate change and energy security potentially resulting in higher transport costs. However, the current funding priority is the continuation of investments in New Zealand's 'roads of national significance' – large highway/motorway projects that are intended to better serve high-population centres (Ministry of Transport, 2015a). This contrasts with scenario-building exercises undertaken by the Ministry for travel demand and freight demand which indicate a high degree of uncertainty about the future cost of fuels and the impacts of new technologies (Ministry of Transport, 2014c, 2014d).

There have been some shifts in policy positions in recent years. Investment in public transport and active transport has increased slightly even though it still only represents around 3% and 1% respectively of the national land transport funding (New Zealand Transport Agency, 2015). Given New Zealand's highly renewable electricity, electric vehicles represent a good opportunity to reduce the carbon-intensity of New Zealand's transport system (Hopkins et al., 2015). In 2016, the New Zealand government introduced a policy package to stimulate electric vehicle uptake (Ministry of Transport, 2016b), although it has been critiqued for its weakness and the lack of evidence that it will be effective (Barton, 2016). The package is certainly far less aggressive than in Norway, a nation of similar population and low-carbon electricity, which leads the world in EV uptake. New Zealand had around 3000 electric and plug-in hybrid vehicles in the fleet in April 2017 (Ministry of Transport, 2017) - less than 0.1% of the fleet.

In its publication on achieving a low-emission future for New Zealand, the Royal Society of New Zealand (2016) outlines a vision for a low-carbon transport system in the year 2050 that includes 40% lower travel demand, widespread uptake of electric and low-emission vehicles, increased use of active and public transport, efficiency gains in air travel leading to a 25% reduction in fuel usage, and rail used for 25% rather than the current 14% of freight. The Royal Society estimates these changes could reduce transport-related GHG emissions by 60% or more. They argue interventions are needed to increase uptake of electric and low-emission vehicles due to the current high market price of such technologies (see also Bakker & Trip, 2013). The Royal Society encourages greater attention to co-benefits, such as improved health outcomes due to active travel or reduced air pollution due to high-density urban housing.

Within this broad context, the research team saw a gap between the scenario-building that was being undertaken by the Ministry of Transport (indicating a range of very different futures) and the growing evidence of the need for significant change in the transport system to address social, economic and environmental problems. It was evident that the current policy framework was mainly replicating the status quo, and that a largely laissez-faire approach was being taken to mobility innovations that had the potential to have a transformative impact. The research focus was therefore on interventions that would be needed to refresh New Zealand's transport policy given the existing problems with business-as-usual, the rapidly changing face of transport innovations, and the high levels of uncertainty about the future.

2. RESEARCH METHOD

2.1 The Delphi Technique

The Delphi technique is a long-established research method (Helmer-Hirschberg, 1967) for helping inform decision-making by drawing on expert viewpoints on complex issues (Hasson et al., 2000). It involves structured process of collection and synthesis of knowledge from a group of experts, and can generate levels of agreement through iterative and anonymous investigation of opinions feedback (Helmer, 1966, Lindstone & Turoff, 1975). In its simplest form, the Delphi technique "eliminates committee activity among the experts altogether and replaces it with a carefully designed program of sequential individual interrogations (usually best conducted by questionnaires) interspersed with information and opinion feedback" (Helmer-Hirschberg, 1967: p.7).

There are many advantages to the Delphi approach; first, it limits the power dynamics which can occur when experts meet in person, whereby key individuals dominate responses, second, this approach can overcome the geographic constraints of bringing together a group of experts, thirdly, anonymity allows panel members to respond more freely, and finally, it can be particularly valuable for issues where there may be a high level of uncertainty or disagreement. The approach typically presents the panel of experts with a series of surveys, starting with open questions and, over a series of stages, identifying convergences and divergences of opinions (Weaver, 1971).

Delphi studies have been frequently used to explore transport futures. Shiftan at al., (2003) used a 2-stage Delphi process to develop two scenarios for the future development of the Tel-Aviv Metropolitan Area in Israel, based on experts' views on the probability and desirability of a menu of policy measures. Key elements in the desired scenario included a highly developed public transport system, better coordination between the spatial development and the transportation system, high parking fees and congestion pricing. A Delphi study of transport experts from 29 countries identified factors that will impact the future of transport including globalisation, urbanisation, funding constraints, and population growth (Schuckmann et al., 2012). Another Delphi study with international transport experts identified influences supporting the status quo (such as the global political economy; vested interests in oil production and consumption; fuel subsidies; innovations in petroleum extraction; and urban planning regulations) as well as influences driving change (such as investments in technological innovations; new sources of autonomy, freedom and prestige; travel substitution technologies; and increasing environmental concern) (Stephenson et al., 2015). The

latter study was a precursor to (and informed) the Delphi study involving New Zealand experts described below.

2.2 Research approach and recruitment

The overarching aim of the New Zealand Delphi study was to gain insights from transport experts into the potential future of New Zealand's transport system, with a particular focus on what influences were already reshaping the status quo, and the interventions needed to achieve a sustainable transport future. Unlike many Delphi studies, the intention was not to build scenarios, nor to build consensus on particular interventions. Rather, it was to pursue a line of questioning that built a chain evidence from the experts' views on the current state of the transport system, through the current and future destabilising influences, to the characteristics of a desired future state, and finally to the interventions needed to get there.

In Round 1 of the study, the Delphi participants were asked (amongst other things) a series of open-ended questions to explore their views on trends, innovations and step-changes that they considered likely to result in changes in New Zealand's transport system. In Round 2, participants were asked to state the likelihood of these trends, innovations and step-changes becoming widespread, and their potential to transform New Zealand's transport system away from business-as-usual (BAU) in the long term, along with expected timeframes. Round 3 asked participants to respond on a Likert scale as to their level of agreement with selected free-text statements from Round 2 regarding how the transport system needed to change. Some of these statement were intentionally chosen as they seemed likely to be contentious. Round 3 also invited the Delphi panel to nominate three trends, innovations and step changes for which they considered interventions were most urgently needed to achieve a transport system that would enable New Zealand to thrive socially, economically and environmentally (a proxy phrase for 'sustainable'). In Round 4, the ten top priority areas for intervention from the previous round were presented, and participants were asked to describe specific interventions that they considered were needed, and which priorities these would address. The results from Rounds 1-3 are reported in detail in Stephenson, Hopkins & McCarthy (2014). Round 1 of the Delphi study took place during May 2014, Round 2 in June, Round 3 in August and Round 4 in September 2014.

For the study participants, we sought individuals who currently worked in transport-related areas and had both experience and expertise. As New Zealand is a small country, the research team knew many of the leading transport experts by name and these were invited, and also asked to nominate others through a snowball sampling approach. Participants were purposively invited from central and local government transport agencies, academics with transport expertise, non-governmental organisations involved in transport, and transport consultancies. We aimed for a good level of experience, representation across sectors, and areas of expertise. Seventy-five experts participated in Round 1, 67 participated in Round 2, 55 participated in Round 3 and 42 participated in Round 4. The participation drop-off was not surprising for a 4-round Delphi with a high cognitive load, and we were please to retain over half of the participants between Rounds 1 and 4. Some participants also joined after Round 1, so the total number of participants was 86 (see Appendix A for characteristics of all 86 participants).

The use of the Delphi results in this paper mainly focuses on the outcomes of Round 4, although earlier findings are also used. All but one of the 42 experts in Round 4 had participated in previous rounds of the Delphi. The Round 4 experts had an average of 14.5 years of experience (with a standard error of $\pm$1.8 years). A wide variety of sectors were represented, with 11 experts working in national and local government transport agencies, nine in independent research, seven in non-governmental organisation, six in academia, five in industry, and the remaining four in other sectors such as consultancy and advocacy.

Analysis of the data included statistical analysis of the quantitative questions and thematic analysis for qualitative questions. All four authors of this paper were involved in aspects of the design,

implementation and/or data analysis. The qualitative material presented in this paper, arising from the free-text responses to Round 4, was coded by two of the authors independently. Six over-arching categories of interventions were identified, and these are used to structure the main part of the results (section 3.4).

3. RESULTS

The results draw from all four rounds of the New Zealand Delphi, but are not an exhaustive description of the overall findings. Instead, we focus on data which present an interrelated chain of insights into the experts' views on sustainable transport, changes needed to the current system, priority areas for intervention, and the proposed interventions themselves.

Section 3.1 presents how the Round 3 participants ranked the characteristics of a sustainable transport system. In section 3.2, we show the range of views held by participants about changes needed to New Zealand's transport system, again derived from Round 3. In section 3.3 we outline how the priority areas for intervention were derived iteratively over Rounds 1-3. Section 3.4 presents the findings on the interventions proposed by the participants. The findings from Rounds 1-3 have been more fully reported in Stephenson et al. (2014), but some highlights are repeated here in order to provide background and framing for the interventions proposed in Round 4.

3.1 Characteristics of a sustainable transport system

The characteristics listed below had initially been identified by international transport experts in the International Delphi mentioned in section 2.1 (Stephenson et al., 2015). In Round 3 of the New Zealand Delphi, we sought experts' level of agreement with these characteristics, using a 5-point Likert scale of 'strongly agree; agree; neither agree nor disagree; disagree; and strongly disagree'. The findings are ordered from the highest level of aggregate agreement to lower levels of agreement:

90% or more 'agree' or 'strongly agree' with the characteristics of:

- An integrated multi-modal transport system in urban areas over 100,000 people
- Cross-modal ticketing systems

80-90% 'agree' or 'strongly agree' with:

- Different transport options for different length trips
- Access to information and communication technologies (ICT) to support travel substitution for rural areas
- A collective, cross-party vision of NZ's future transport
- Full cost of car ownership is evident to the general public so that all transport modes are on a level playing field
- Changing urban form and functioning to reduce need to travel
- Proactively ensuring that alternate travel modes are readily available prior to dis-incentivising personal vehicles
- Targeting transport options to size and density of the population

At least two thirds (66% to 80%) agreed or strongly agreed with:

- Time of use variable pricing for road
- Exploiting NZ's renewable electricity through uptake and incentivising of electric vehicles
- Technologies (apps) to support modal choice
- Car sharing schemes (both businesses and community based)

- Improving environmental credentials of imported cars

For the final five characteristics identified, agreement still outweighed disagreement but there was a more even spread of views and greater uncertainty ('neither agree nor disagree'):

- Targeted design of transport for the needs of different segments of the population (e.g. disabled, non-English speakers etc.)
- Increasing the use of rail for inter-city travel
- Biofuels for freight and long-distance travel
- Electrifying the entire rail system
- Using electrified rail rather than roads for freight transport

These results are interesting because of the very high level of agreement (80% or more) for a number of the characteristics, and the relative lack of importance given by participants on rail, biofuels and targeted design. When triangulated with other data from the Delphi, the findings also show that there is consistently greater interest in changing certain aspects of the transport system over others, as will be discussed further in section 4.

3.2 Required changes to the transport system

In this section, we present evidence as to the range of views held by the New Zealand participants on specific changes needed to the transport system. Figures 1-7 show how participants responded in Round 3 to statements about changes needed to the transport system. The statements were derived from (and paraphrased from) free text comments from Round 2 (n=67), and were presented back to participants in Round 3 (n=55) with a 5-point Likert scale. Note that some questions were worded negatively as this is how they were expressed in Round 2.

There was a high level of disagreement that current trends and new technologies would, of themselves, lead to a resilient transport system (Figure 1) and also high disagreement that that 'the transport system does not need to reduce its reliance on fossil fuels' (Figure 2). Most agreed or strongly agreed that New Zealand should not be undertaking a massive motorway building programme (Figure 3) but should be markedly increasing the investment in active transport and public transport (Figure 4). Strong support was also expressed for a much higher proportion of New Zealand's freight to be carried by rail (Figure 5). There was a far more even spread of views on whether it was more important to focus on efficiency of the current fleet, or increasing adoption of electric and hybrid vehicles (Figure 6) and whether accelerating smart technologies that reduce congestion is the most efficient way to improve the transport system (Figure 7).

Fig. 1: We don't need interventions because current trends and new technologies will naturally lead to a resilient transport system

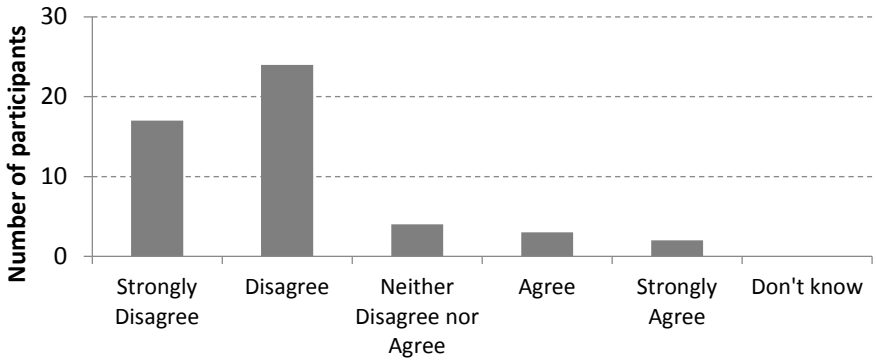


Fig. 2: Our transport system doesn't need to reduce its level of reliance on fossil fuels

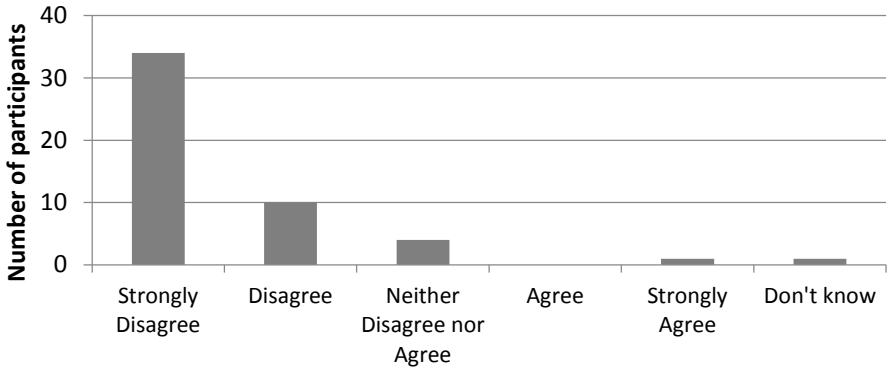


Fig. 3: We should not be undertaking a massive motorway building program

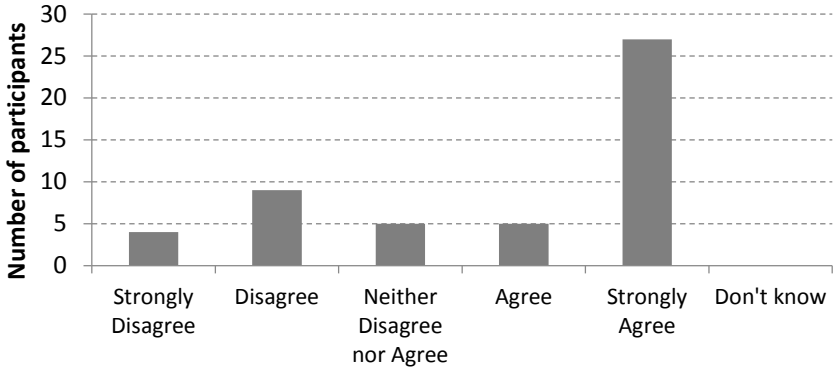


Fig. 4: We should markedly increase investment in active transport and public transport

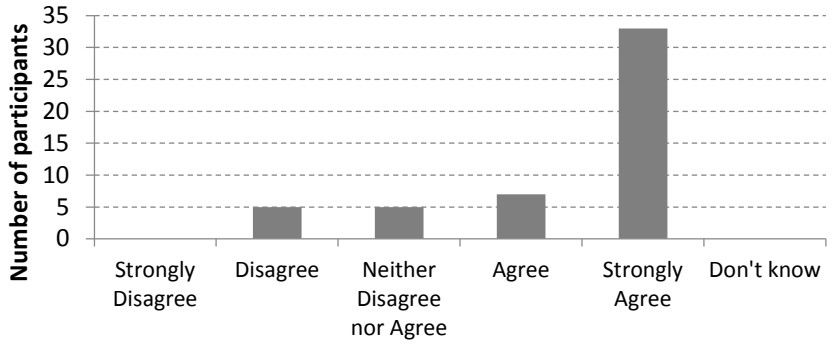


Fig. 5: A much higher proportion of NZ's freight should be carried by rail than is currently the case

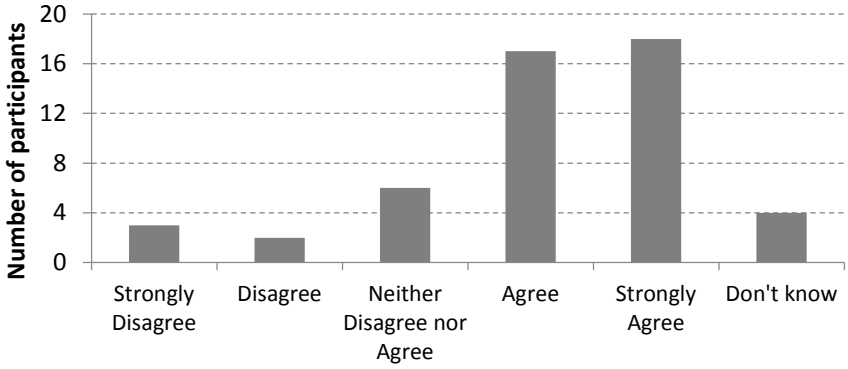


Fig. 6: It is far more important to focus on efficiency within our ICE [internal combustion engine] fleet than expecting lots of NZers to adopt electric vehicles, hybrids and PHEVs [plug-in hybrid electric vehicle]

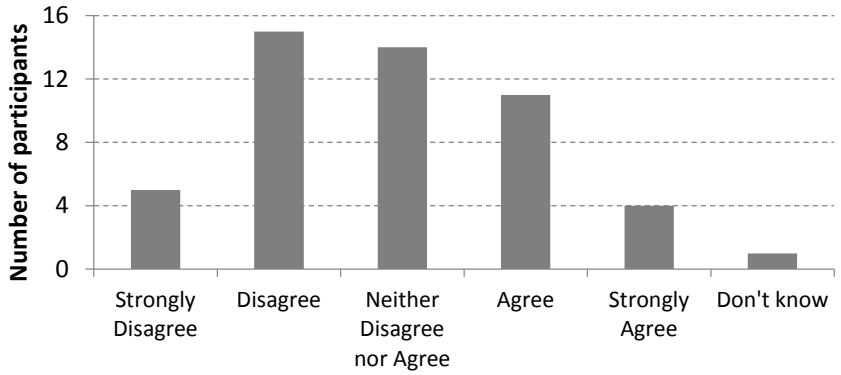
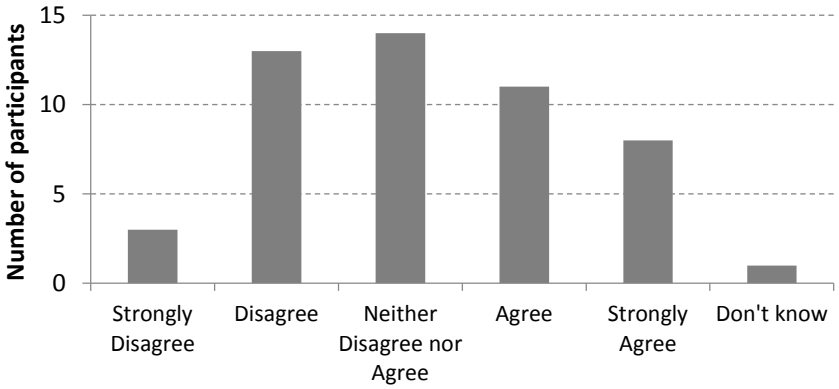


Fig. 7: Accelerating smart technologies that reduce traffic congestion is the most efficient way to improve the NZ transport system



3.3 Determining priority areas for intervention

In Round 1, participants had been asked to describe any trends, innovations, or step-changes that they considered could transform the transport system away from business-as-usual (BAU). BAU was defined in the survey as '*the continuation of transport systems and practices that rely on finite resources and support automobile dependence'*. In Round 2, they were presented with a list of all the trends, innovations, and potential step changes that had been mentioned by at least two people in Round 1. The participants were asked to rate their potential to transform BAU in the long-term.

Rising fuel prices were considered to be the most likely trend to change BAU, followed by urban form that supports active/public transport and increased investment in public transport infrastructure. Innovations considered most likely to change BAU long-term were demand management through road pricing, multi-modal and integrated public transport, and bicycle infrastructure. The three step changes perceived to be most capable of changing BAU were; 1. sustainability becoming a major driver of New Zealand government and business, 2. constraints in the oil supply, and 3. political instability in oil-rich countries.

The direction of the questioning then turned to exploring which of these potential areas of change could or should be marshalled or provided for within the New Zealand context in order to lead to a desired future.

In Round 3, the participants were invited to identify which of the trends, innovations and step changes required intervention in order for New Zealand to thrive socially, economically and environmentally (Fig 8). The ten most frequently identified areas for intervention, in order of frequency, were: increasing investment in public transport infrastructure; urban form that supports active and public transport; increasing investment in active transport infrastructure; multi-modal integrated public transport; bicycle infrastructure; demand management through road pricing; sustainability becoming a driver of policy; decreasing the proportion of transport funds spent on roads; impact of a global price on carbon; and major investment in the rail system.

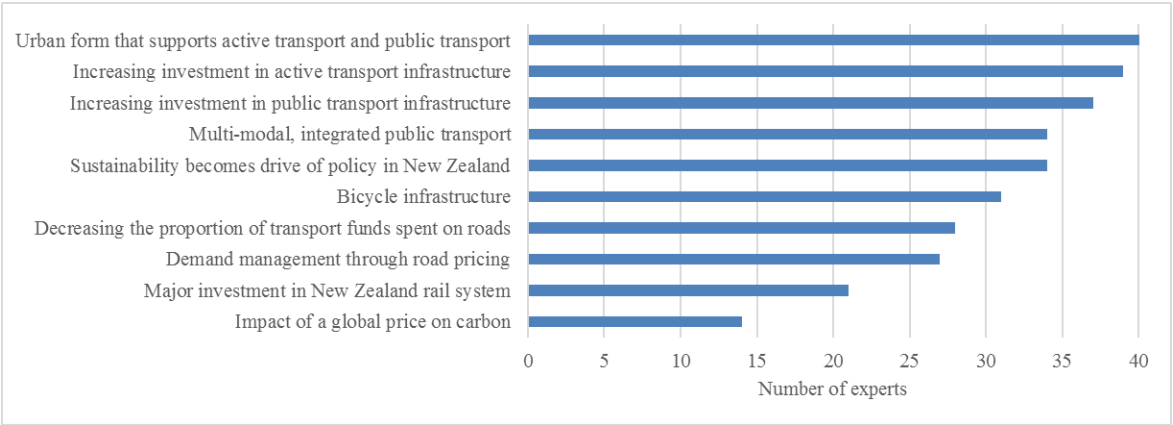


Figure 8. The priority areas for intervention, and the number of experts (n=42) in Round 4 who proposed interventions for each of the priorities.

In Round 4, participants were asked to describe the interventions that they considered were necessary to achieve at least three of the 10 top priorities from Round 3. The bars in Figure 8 represent the number of participants in Round 4 who wrote interventions that were intended to address each priority area.

3.4 Interventions

Participants' descriptions of interventions were free-text, and responses were anything from a bullet point to lengthy paragraphs. Our qualitative analysis categorised the interventions proposed by the Round 4 participants into six overarching themes: policy and legislation; sources of transport funding; methods of funding allocation; infrastructure and design; economic instruments; and education and engagement. These themes were informed by the categories of intervention proposed by Taylor et al. (2012) and Xenias and Whitmarsh (2013), but also were emergent from the qualitative material. Changing the methods of sourcing transport funding, for example, was identified as a necessary intervention by a quarter of participants, but was not mentioned in either of these papers.

The intervention themes are described below; firstly, with a high-level breakdown of the number of participants who proposed similar types of intervention within the theme, followed by an elaboration of the specific interventions proposed. Some interventions could have fitted in more than one category – for example, introducing legislation for regional fuel taxes would be both a legislative intervention and an economic instrument. Where relevant, such overlaps are noted.

3.4.1 Policy and legislation

Table 1: Interventions relating to policy and legislation

Change legislation and policies to improve mode share	27 (64%)
Change legislation and policies for urban form and infrastructure	18 (43%)
Better link urban form and transport policies	8 (19%)
Change legislation and policies to improve cycling safety	7 (17%)
Change legislation and policies for low-emission vehicles	4 (10%)
Use cross-governmental working groups to integrate policy	3 (7%)

Legislative and/or policy changes proposed were linked to all of the priority areas for intervention. Suggested changes to legislation and policies to improve mode share included introducing regulations to support various pricing measures (described in 3.4.2), regulations to restrict private car entry to central business districts, and reduction or elimination of parking provision requirements. Changes to improve urban form included new regulations for development charges and differential property rates to incentivise building denser developments, as well as new policies such as redeveloping urban design codes and best practice guidelines.

Participants also identified the need for better linkages between urban form policies and transport policies. Investments in active and public transport, it was argued, should also be integrated with broader urban form policies. Policy interventions to stimulate the uptake of low emissions vehicles included lower registration fees for lower-emission vehicles and changing policy settings to increase adoption of low-emission vehicles. Changes to improve cycling safety included instituting a one metre clearance law for drivers, and placing de-facto blame for pedestrian and cycle accidents on car drivers, and the adoption of national cycling infrastructure standards.

At an overarching level, participants identified the need for laws to better prioritise sustainability in transport decision-making, including changes to the Land Transport Management Act. Participants also proposed changes to the Resource Management Act (planning legislation) to recognise the links between urban form and mobility. Updating the Government Policy Statement on Land Transport to give greater weight to energy usage and GHG emissions in all decision-making was also proposed. High-level policy should also establish an expectation that the co-benefits of different modes should be accounted for in transport decision-making. The use of cross-governmental (cross-agency) working groups was seen as a key way to improve integration across transport decision-makers, and also between transport and other fields such as health and planning.

3.4.2. Sources of transport funding

Table 2: Interventions relating to changing sources of transport funding

Change the funding system for transport	11 (26%)

Participants who advocated changing the funding system for transport considered that it could address multiple priorities, with several identifying between 3 and 8 priorities. Between them, the participants considered that changing the funding system could address all of the priority areas apart from changing urban form and the impact of a global price on carbon.

A quarter of participants considered that the funding of the transport system should be adjusted to provide a better basis for investment in sustainable solutions, and a variety of different measures were proposed. Currently, the majority of the National Land Transport Fund is derived from fuel excise duties, road user charges and motor vehicle registry fees, all of which are paid by users of road vehicles. A number of participants felt that this creates an expectation that it should be spent on roads, and that this relationship should be altered. One proposal was to redirect these funds to Treasury, and transport funding allocated independently from the income from vehicle users. There were also many suggestions for different sources of funding, including road pricing, carbon taxation, government income from mineral rights, regional or local fuel taxes, goods and services tax, and taxes on rail, airports, port companies, or coastal shipping. One participant advocated for the use of the health budget to partially fund active travel initiatives, thus recognising the health co-benefits. In contrast, another suggested that cyclists should be tax to cover the cost of dedicated cycle infrastructure.

Additionally, participants pointed out that many road-related expenditures can be fully funded out of the National Land Transport Fund whereas public transport projects are usually classified as local projects and receive less national funding. As one participant explained, this may act to reduce the

local authorities' motivations for investing in public or active transport expenditures as a significant amount of the costs need to be sourced from local taxes.

3.4.3. Methods of funding allocation

Table 3: Interventions relating to changing methods of funding allocation

Adopt different criteria to allocate transport funds	28 (67%)
Adopt a broader account of impacts and co-benefits of transport	16 (39%)
Structural and/or cultural changes in funding agencies	14 (33%)
Account for the costs of climate change	12 (29%)
Factor in risks associated with vulnerability to energy markets	2 (5%)

Almost all participants proposed that methods of allocation of transport funds should change. The interventions proposed in this theme collectively addressed all of the priority areas. Most of the participants proposed using different criteria for decision-making, and funding more evenly across modes. Experts' suggestions included cancelling or curtailing investments in major upgrading of 'roads of national significance', only maintaining existing roads, and investing all additional funds in active/public transport. Other proposals were to devote a higher percentage of the budget to public and active transport, funding projects based on GHG emissions per kilometre, and linking Councils' funding to achieving mode-share. One participant felt that the NZ Transport Agency should fully fund important public and active transport infrastructure in the same way it fully funds state highways. Designating transport funding to make townships more walkable was another suggested intervention.

A recurring theme was the need for allocation mechanisms to include a broader account of the impacts and co-benefits of transport investments. It was argued that transport modes could be more fairly compared by factoring in co-benefits and co-costs such as health, emissions, air quality, productivity, and the local economy. Incorporating co-benefits such as reduced emissions and improved air quality was also considered necessary to recognise the true cost of rail versus road. Participants also noted the importance of recognising the co-benefits of low-emission vehicles such as reduced health costs, increased productivity, and improved energy security, as well as lower GHG emissions. One participant emphasised the need to ensure equity and a socially-just transport system, in particular that the burden of emissions costs and other financial measures such as road pricing and tolls are disproportionately experienced by lower socio-economic communities.

Participants also discussed structural and cultural changes they felt were needed in New Zealand's transport agencies to have a better fit with different funding priorities. These ranged from a greater level of allocation control within the Ministry of Transport, to giving local authorities primary control over the funds collected from their users to better match local priorities with spending. Several also referred to the need for a change away from a belief that roads should take priority, to give greater priority to active and public transport or a 'more balanced view'. It was also argued that investment decisions should factor in risks associated with the vulnerability of transport systems to changes in energy markets such as volatile oil prices and the impacts of carbon pricing on oil costs.

3.4.4 Infrastructure and design

Table 4: Interventions relating to changing infrastructure and design

Network design changes to improve mode share	12 (29%)
Enhance connectivity and integration across modes	10 (24%)

Expand passenger and light rail services	9 (21%)
Changes in urban form to support more use of public transit	7 (17%)
Infrastructure for active transport safety	7 (17%)
Technology to improve mode share	5 (12%)
Better links between industrial areas and rail	6 (14%)
Charging infrastructure for low-emissions vehicles	3 (10%)

Infrastructure and design changes were considered to address priorities for increased investment in public transport and active transport infrastructure, multimodal integrated public transport, improved urban form, bicycle infrastructure, and investment in rail. Recommended network design changes included reducing the road space given to cars to make space for segregated cycle lanes, designating priority parking for carpool cars, offering public transport on all arterial routes, and instituting a range of best practices that have been shown to be useful in equalising mode-share (such as maximising kerb radius, removing traffic signals at the opposite side of intersections, and giving priority rights to public/active transport). Interventions for improving connectivity and integration included a 'one ticket system' that allows travel across modes, offering scheduling/real-time apps for public transport, linking public buildings with public transport, offering cheap short- and long-term bicycle hire, installing bicycle carriers on buses, and having smaller buses and taxis.

Participants noted the need for changes in the relationship between suburbs and transport systems, such as offering cheap financing for mixed-use cooperatives and apartments near public transport hubs, or treating suburbs as urban islands with most services located in walking distance so as to reduce to need to travel.

Interventions related to safer active transport included reducing speeds and installing speed cameras and/or GPS-related measures to reduce speeding. Infrastructure changes included using parking as protection for cycle paths, factoring e-bikes into cycle-way design, the installation of additional bicycle parking and pedestrian infrastructure, and designating pedestrian-only zones. Technology-based interventions included developing web-based carpooling apps, more use of speed cameras, and installing e-bicycle charging stations. One participant argued that priority in urban road design should be given to pedestrians, followed by cyclists, public transport, and finally cars.

Rail was raised by several experts as an energy-efficient and low-carbon option for freight and passenger transport. They called for better linkages between rail and industrial areas for freight by positioning industrial areas near railroads, building inland ports and transfer facilities, funding branch lines to large businesses and ports, fixing tunnels that limit freight size, and re-opening disused rails. Expanding passenger and light rail services was also proposed, for example to/from airports and linking housing developments. Public charging infrastructure for electric vehicles and electric bikes was also identified as an important intervention.

3.4.5. Economic instruments

Table 5: Interventions relating to economic instruments

Road pricing	14 (33%)
Pricing carbon	8 (19%)
Fuel efficiency standards	2 (5%)

Proposed economic instruments addressed narrower range of priorities; road pricing assisted with demand management; a higher price for carbon would assist with improving urban form, sustainability policy, evening up transport spend across modes, and making New Zealand less vulnerable to a global carbon price. Fuel efficiency standards were related to sustainability policy.

Economic instruments such as congestion charging, tolls, and road pricing were proposed to as ways to better manage demand on high-use roads. Minimum standards or a graded tax on vehicle imports based on their fuel efficiency usage was proposed to increase the uptake of more efficient vehicles. Interventions were also proposed to increase the cost of carbon so as to better reflect the costs of high-carbon mobility and the co-benefits of low-carbon mobility. Proposed measures for pricing carbon included an improved emissions trading scheme (ETS) and a minimum carbon price.

6. Education and engagement

Table 6: Interventions relating to education and engagement

Re-frame information to the public to emphasise co-benefits	3 (7%)
Better educate engineers and planners	2 (5%)
Consult with mobility stakeholders	2 (5%)

Improving education and communication emerged as a theme. Education for professionals was identified as addressing priorities for urban form, increasing investment in active and public transport, demand management, sustainability and multi-modal funding allocation. Participants proposed interventions to improve professional education, such as emphasising the importance of active/public transport when training engineers and planners. Re-framing information to the public to include co-benefits was argued to be necessary for improving the acceptability of policies that encourage low-emission vehicles and alternatives to private car use such as active and public transport. Participants also sought improvements in the consultation processes between governments and the public, and between them felt that this would help address almost all priorities. They suggested soliciting a wider range of views in the decision-making process, instituting better public consultation processes, and consulting with specific groups such as cycling advocates, freight lobby groups and the Automobile Association.

4. **DISCUSSION**

New Zealand's current policy environment, as described in section 1.2, is largely focused on replicating business-as-usual; that is, the continuation of transport systems and practices that rely on finite resources and support automobile dependence. While some current policies target specific outcomes in some locations (e.g. increasing investment in bicycle lanes; some dense urban developments), the system is still predominantly supporting and investing in unsustainable transport outcomes. There is a notable lack of a clear policy position across all transport-related decision-making that contributes to sustainable and/or low-carbon transport . This can be contrasted with European and Scandinavian transport policies, particularly at the city-level, where policies promoting integrated public transport, smart ticketing, and urban consolidation, for example, have strong political support. Similarly, Norwary's tax regime to incentivise the uptake of electric and hybrid vehicles has been central to the rapid diffusion of this technology (Fridstrøm & Alfsen, 2014)

The characteristics of a sustainable transport system that were strongly agreed on by research participants paint a very different picture to the status quo in New Zealand. The participants almost all agreed that the transport system needs to reduce its reliance on fossil fuels and to take intentional steps to change the current system. Although they identified new technologies and trends that offer near-term opportunities for more sustainable transport, they considered a hands-

off, *laissez-faire* approach towards their uptake would not be adequate to ensure a resilient transport system.

The most highly-ranked characteristics of a sustainable transport system related to promoting active and public travel modes rather than to increased efficiency, reducing the need to travel, or reducing the distances travelled. This can be seen in Table 7 where we contrast the preferred sustainability characteristics with Banister's four areas of action needed to achieve sustainable mobility (2008).

Table 7: Characteristics of a sustainable transport system related to Banister's (2008) actions to achieve sustainable mobility (* are the characteristics that were less strongly supported)

Banister's 4 categories of actions needed to achieve sustainable mobility	**Characteristics supported by NZ Delphi participants**
Promote active and public transport modes	Integrated multi-modal transport system in urban areas over 100,000 people. Cross modal ticketing systems. Having different transport options for different length trips Being proactive so alternate travel modes are readily available prior to disincentivising personal vehicles. Targeting transport options to size and density of the population Making the full cost of car ownership evident to the general public so that all transport modes are on a level playing field Technologies (apps) to support modal choice* Targeted design of transport for the needs of different segments of the population*
Reduce the distances needed to travel for everyday needs	Changing urban form and functioning to reduce need to travel
Reduce the need to travel	Ensuring rural areas have access to ICT to support travel substitution. Changing urban form and functioning to reduce need to travel.
Increase efficiency	Time of use variable pricing for roads* Uptake and incentivising of low-emissions vehicles* Car sharing schemes (both businesses and community based)* Improving environmental credentials of imported cars*

Actions to reduce the need to travel and to reduce distances travelled involve longer-term investments in urban form and ICT infrastructure, which may be less easy to achieve than promoting active and public transport, given New Zealand's dispersed population and widespread low-density suburbs.

The lower support for the sustainability characteristics relating to increasing efficiency (3.1) was echoed in the fact that vehicle efficiency did not emerge as a priority for interventions (3.3) and few interventions were proposed that related to changing the efficiency of the vehicle fleet (3.4). This does not mean that vehicle efficiency was not considered important, as efficiency-related trends and innovations were identified in earlier stages of the Delphi, but they were not given as much emphasis as other factors in driving a shift away from BAU. There may also be another factor at play, which is that achieving efficiency implies interventions that directly impact on people's choices and their finances. These may be seen as less desirable by participants because of New Zealand's strong commitment to a free market: alternate offerings on the market are acceptable, but constraints on choice are not typically favoured.

The high-ranking of "a collective, cross-party vision of NZ's future transport" as a characteristic of a sustainable transport system signals a shared belief in the importance of strong leadership and

governance. This does not appear as one of Banister's four categories of action, and is only mentioned tangentially as part of the need for supportive policy and the importance of getting public buy-in to new policies. Again, this may represent a difference with national approaches to mobility, where New Zealand lags behind the UK and Europe in terms of its overt support for sustainable mobility. The Delphi participants may have been more sensitised to the need for a supportive policy environment than those who work in jurisdictions where this is already the case.

Participants' responses in Round 3 to the changes needed to the transport system (Figure 1-7) suggest a widely shared belief in the need to shift away from a reliance on fossil fuels, and that interventions are needed to achieve a resilient transport system. Most agree that more is needed to be invested in public transport and active transport and less on major new roads, and that there should be more use made of rail. These views align with the priority areas for intervention that were identified through a separate line of inquiry in Round 3 (Figure 8).

Turning now to the interventions, the participants considered that changes are needed in many aspects of the transport system, particularly how it is funded, how these funds are allocated, the underpinning legislation, and how transport agencies enact their roles. A strong theme was the importance of identifying and incorporating co-benefits into funding and allocation decisions, including those related to health benefits and GHG emissions, in order to clarify the relative advantages of different travel modes such as active/public transport, low-emission vehicles and rail. The participants also noted the need for changes to overcome the path dependencies in New Zealand's current transport systems that support continued automobility. These changes include updating policies and legislation to reflect the state of knowledge regarding 'best practices' for designing urban areas to be more walkable and better served by public transit, changing road design to facilitate active/public transport, and improving connectivity via 'one ticket systems'. These proposals have a good alignment with the Royal Society of New Zealand's (2016) recommendations for changes in transport required for transitioning to a low-carbon economy.

The proposed interventions can be roughly divided into two categories: those that seek to change the decision-making environment, and those that are targeted at a specific outcome. The former category is more fundamental to the transport system and was identified by participants as being likely to achieve more intervention priorities than the single-focus interventions. This point emerged unexpectedly from the way participants completed the Round 4 survey. Although we had requested that participants propose interventions for three priorities, only eight out of the 42 participants identified only one priority being achieved per intervention. The remainder of the panel identified between one and ten priorities per intervention that they proposed. Eighteen of the proposed interventions were identified as addressing four or more priorities.

Interventions that addressed multiple priorities included changing funding allocation methods and criteria; changing legislation and policies to give national direction on transport sustainability; more direction on urban form that supports active and public transport; evaluation methods that take co-benefits into account; changing network design codes and standards; a higher price on carbon; and more inclusionary transport planning. What is notable about these kinds of interventions is that they re-set the environment for the long term, recognising that transport decision-making requires a long lead-time and long-term thinking (Banister & Hickman, 2013). They also influence multiple aspects of the transport system (Mäkinen et al., 2015) and, ideally, would set up a consistent framework for transitioning to a more sustainable transport system.

At the same time, investment in specific actions is required to get short-term results (Köhler et al., 2009). The Delphi participants identified many interventions that would have impacts on only one or two priority areas, such as congestion charging, bicycle safety infrastructure, network design changes, and efficiency standards for vehicle imports. Such interventions may be effective to some extent on their own, but risk rebound effects or other unintended consequences unless they are part of an integrated policy and investment environment that provides for consistency and alignment.

Many of the proposed interventions are well aligned with Banister's (2008) areas for intervention for sustainable mobility, but the Delphi participants also proposed additional and more fundamental changes to the systems of acquiring transport funding, to the structure and culture of funding agencies, to transport-related legislation to prioritise sustainability, and to encourage greater cross-agency communication. Furthermore, rather than 'selling the benefits' (Banister, 2008, p78) of sustainable mobility to the public, the proposed interventions are aimed at a more consultative approach with stakeholders and upskilling of practitioners. It is notable that the proposed interventions were focused at the level of transport decision-makers, rather than directed at the general public. This suggests an underlying belief amongst the Delphi experts that the public's sustainable mobility choices will be largely driven by having a supportive alignment of laws, infrastructure, pricing and other policy and investment mechanisms discussed above.

Figure 9: Deep interventions for a sustainable transport future

A key message from the Delphi participants, therefore, is that direct interventions (to increase efficiency, promote active transport etc), are necessary but not sufficient. In order that such first-level interventions do not end up being symbolic or partial while non-sustainable activities continue in other areas (as with Barton's 2016 critique of the government's EV policy package), deeper changes are required. These changes are in aspects of the system that shape all decision-making, influence long-term investments, and affect multiple areas of transport such as funding sources, funding allocations and urban form. More deeply again, transport law and policy needs to be underpinned by sustainability principles (as indeed it was in New Zealand until the 2013 amendment to the LTMA) and government agencies involved in transport, as well as those whose decisions affect mobility outcomes, need to collaborate and ensure that their work is aligned. Finally, and ideally, an all-of-government commitment to sustainable transport is needed in order to avoid the stop-start approaches already seen in the New Zealand context, to give the business sector some certainty around which they can plan their investments, and to show leadership more generally.

While aware of the risks of simplification, we have shown this diagrammatically in Figure 9, showing Banister's four areas for intervention (top row) underpinned by deeper interventions in how transport is governed, funded and aligned. The proposition for deep interventions is not radical – some jurisdictions (e.g. cities including Copenhagen, and Bogatá, and countries including Norwary) have been successful in the implementation of many of the features described, and thus relatively more successful in the delivery of a system of sustainable transport). In the New Zealand context, however, it may be considered radical by government because it would require taking a normative position on sustainability, and delivering significant changes in how decisions are made and solutions delivered.

CONCLUSION

This paper has demonstrated the use of the Delphi method to elicit from transport experts a range of plausible interventions to achieve a more sustainable transport system. The intention was not, as is usual with the Delphi process, to create scenarios or an agreed position on interventions, but was instead to generate a range of interventions that experts believed would achieve priorities that had been derived in previous rounds of the Delphi.

Most of the Delphi panel considered that substantial changes are required for New Zealand to transition to a transport system which will be resilient in the face of existing and emerging constraints, challenges, and opportunities. Interventions are needed to move from the dominance of automobility to achieve a range of mobility solutions aligned with a sustainable future. Areas for intervention include in transport law and policy, transport funding, urban form, mode share, low-emissions vehicles, rail provision, climate change responsiveness, consultation, and education. Other proposed interventions are aimed at altering the processes and decisions undertaken by transport agencies in state and local governments. Changes in overarching Government policy and key pieces of legislation are also required as they determine the environment under which transport-related policies are crafted, and implemented.

Possibly the most surprising finding was that the Delphi panel called for the government to intervene in itself. Having anticipated recommendations on a range of practical policy tools, we were surprised by the high percentage of proposed interventions that would involve deep changes in the governance, legislation and funding of transport. The underpinning message, when combined with results from earlier stages of the Delphi, was that fundamental change is needed to the regulatory and funding environment in New Zealand, as well as a more coherent and integrated approach to sustainability.

Unlike many developed nations, New Zealand's current transport policy environment is fragmented and inconsistent, with many of its signals still supporting automobility. The Delphi study results provide a palette of expert-derived proposals which can be drawn on by future governments for design elements. The most important message is that relying solely on targeted interventions to achieve single solutions are likely to be inadequate given the path dependency of the remainder of the system. Fundamental changes are needed to develop a consistent and integrated approach across all decision-making for a sustainable transport future.

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APPENDIX A: Characteristics of Delphi participants across all four rounds (n=86)

Occupational background

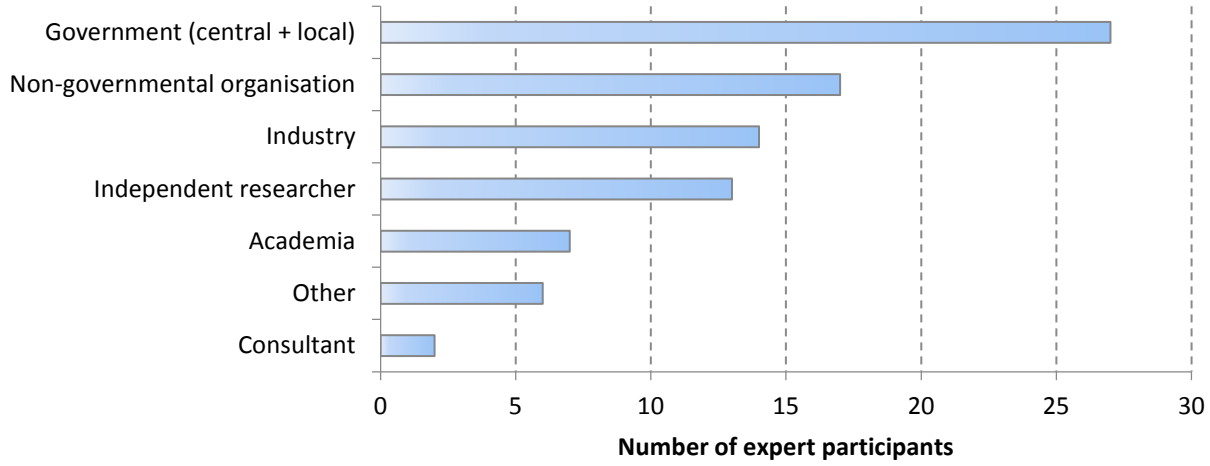

Figure 1. Occupation background

Experience

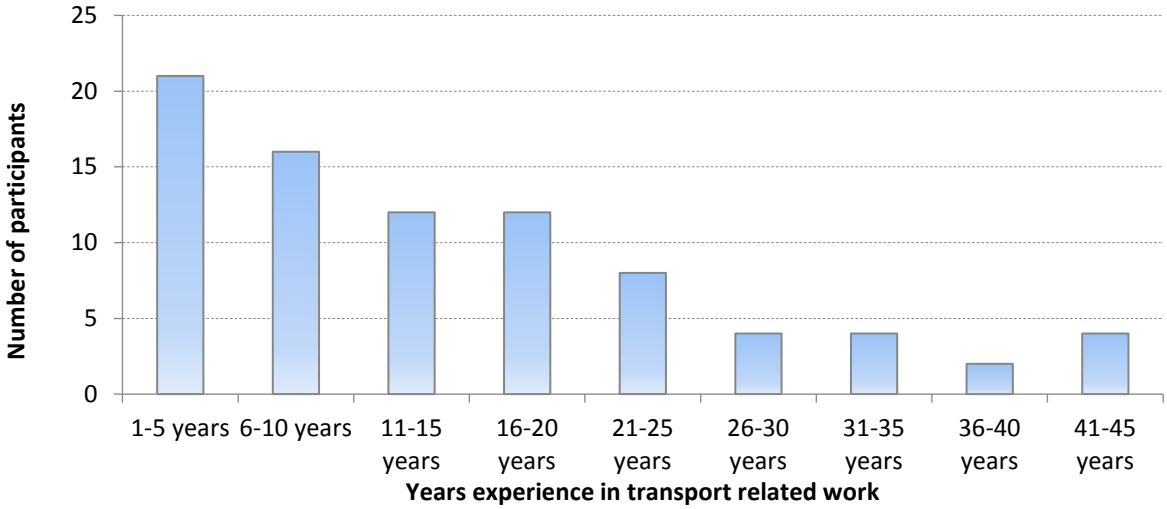

Figure 2. Years' experience in transport related work.

Transport related expertise

Participants self-assessed their degree of expertise in a number of key transport-related areas (figure 3). In addition to the predefined areas of expertise as listed in the figure, other transport-related areas of expertise nominated by participants included land use planning, modelling, aviation, fuel supply risk, logistics, public health impacts, strategy development, transport links to biodiversity, makeup of vehicle fleet, electric vehicle transport, peak oil and cost-benefit analysis.

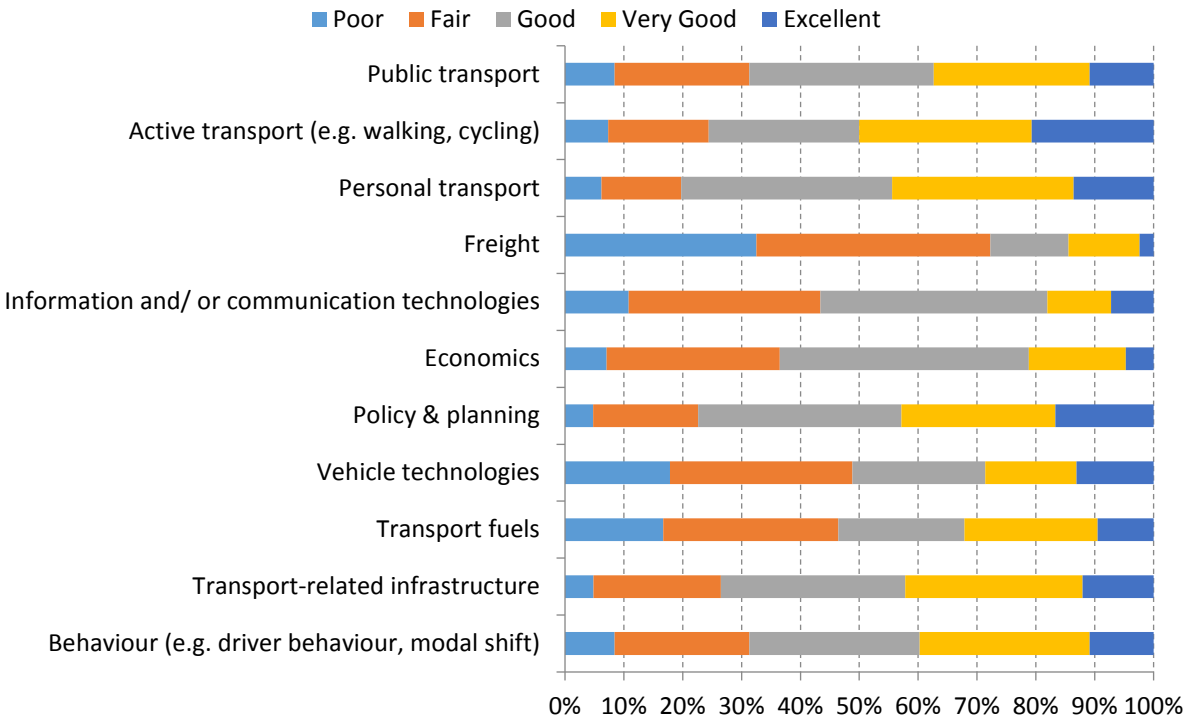

Figure 3. Self-assessment of transport related expertise.