Implementing *Smart Road Tolling* to reduce transport-based Carbon Emissions in New Zealand

The low hum of engines fills the air on the Auckland motorway as lines of cars inch forward. Carbon dioxide floods out exhaust pipes as drivers and passengers wait helplessly, caught by rush hour traffic. Traffic congestion is an all too common scene in urban cities around New Zealand such as Auckland, Wellington and Christchurch. Main routes in these cities get clogged up during peak hours, leaving cars stationary. It has been proven that cars stuck in traffic emit significantly more greenhouse gases (GHGs) compared to free-flowing traffic[1]. While the resultant loss of convenience from congestion has a direct impact on consumers, the pollution and excess greenhouse gas emissions has a far-reaching impact on society.

Driving a personal car is a staple in the Kiwi lifestyle with 92.1% of households in New Zealand having at least one car[2] . This has detrimental impacts on our greenhouse gas emissions, with StatsNZ reporting that 42.6% of GHG emissions (by consumption) are from road transport in 2018[3]. To combat GHG emissions, the New Zealand government has set out goals to achieve zero net carbon emissions by 2050. A policy solution that this essay will be recommending to reduce the environmental impact of traffic congestion is creating a Smart Road Toll system for sections of highly congested State highways across New Zealand.

When considering the issue of traffic congestion on roads, it is important to identify that personal and commercial drivers are consumers in the market for roading, while the government is often the producer of roading. Depending on the type of road (i.e. State highway or local road), either the central government or local governments are responsible for building and maintaining the roads.

From a classical economics perspective, the demand for roading follows the typical downward sloping demand curve. However, the supply of roading is vertical (perfectly inelastic) in the short run, as there are a fixed number of roads. Roading is commonly seen as a pure public good: it is non-excludable by price as an authority cannot control who uses the roads and it is also non-rivalrous as one car does not compete with another for space on the road. However, the categorization of roading as a pure public good often fails when the number of cars on a road reaches or exceeds the carrying capacity. At this point, congestion occurs, and roads become a rivalrous good as each car has to compete for the limited space on the road. As a result, an economic concept, the tragedy of the commons, can occur where the collective action (road use) of individuals acting in self-interest can deteriorate the common roading resources. Alongside the loss of convenience caused by congestion, the CO_2 emission by cars can soar during peak hours, as cars stall while still emitting greenhouse gases. This depletes another common resource, the environment, contributing to

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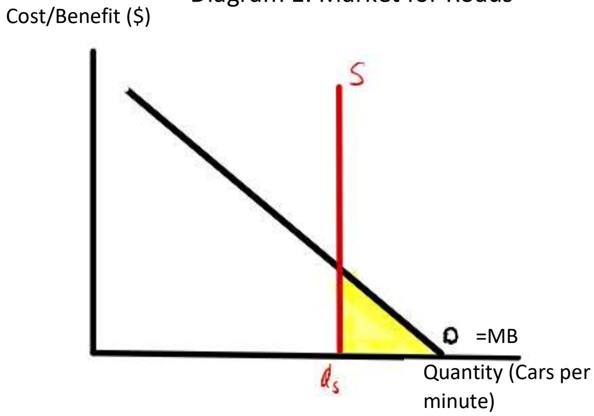
[1] Barth, M., & Boriboonsomsin, K. (2008). Real-World CO2 Impacts of Traffic Congestion. *UC Berkeley: University of California Transportation Center*. Retrieved from https://escholarship.org/uc/item/4fx9g4gn

[2] https://autofile.co.nz/nz-car-ownership-tops-global-ranking-

[3] https://www.stats.govt.nz/methods/about-consumption-based-greenhouse-gas-emissions-statistics

Diagram 1: Market for Roads



climate change and acid rain. This cost to society is illustrated through the deadweight loss illustrated by the yellow region in **Diagram 1**. In Diagram 1, roading is being consumed beyond the carrying capacity, Qs, causing excess pollution. This shows an example of market failure meaning there is a case for government intervention to provide a more efficient outcome.

Implementing road tolls would use the price mechanism to pass the cost of pollution back onto consumers. Currently, in New Zealand, we only have a few toll roads in the North Island and these are all fixed price toll roads, charging all consumers the same rate. The issue with conventional tolling is that the demand for using the road fluctuates according to many factors including time of the day, special events, weather etc. As such, fixed price toll roads are ineffective as they either undercharge or overcharge consumers to use the road. Often times, toll roads in the North Island are seem empty, which is clear evidence of the price mechanism overcharging consumers. This is disastrous as the government will not gain the desired return on investment that was calculated when initially building the roading asset. The optimal system would maximise the efficiency gains of a new road while minimising congestion issues.

The proposal of the Smart-Tolling system will charge a variable price for using the toll road. The smart-toll roading system would set a predetermined target for the desired travel time on a highway. The system would then estimate travel times on that road for the next 15 minutes. There would be a per minute charge on any excess travel times as this would denote congestion on the roads. For example, the standard travel time for a car to travel through Blenheim Road, Christchurch might be 10 minutes. However, if on a Monday morning, the estimated travel time is 25 minutes, there would be a per minute charge for the extra 15 minutes of congestion that is caused. Only the consumers who value using the road at the toll price would use it while others would switch to substitute goods such as using public transport or walking to work/school. Drivers who discretionarily travel through highways during peak hours will also be disincentivised from travelling, as they will likely not value their travel at the toll price. Alternatively, there would also be an incentive for workers to carpool during their commute as a toll is lower when split among many people. These actions would help to decrease congestion and establish eco friendly habits. The reduction of congestion through the Smart Tolling system would reduce the total time that cars spend on roads, thus reducing the gross greenhouse gas emissions through personal travel. However, the Smart Toll system would also be efficient as only the “excess” travel time incurs a toll, encouraging consumers to still utilise the roads when there is low traffic.

The design for the Smart-Toll system wouldn’t be difficult to implement. It is only necessary to convert state highways into toll roads in the busiest sections of Auckland, Wellington, Christchurch and Hamilton. In these cities, the cost of implementing the system would be outweighed by the benefits of lower congestion and lower GHG emissions. The largest spending for the government would be the Capital Expenditure on toll gates and Registration Plate readers at the entry and exit points at each of the state highways. Alongside this, it would be necessary to install a variable pricing system that predicts future travel times and uses this to produce appropriate toll prices. However, this should not be an issue, as travel time predictor signboards are already a part of the NZTA's assets, as seen in the Wellington CBD. It would only be necessary to come up with the per minute charge for the toll roads. However, this would need to be done through background research and trial/error to model the price elasticity of demand for each of the cities (how responsive consumers are to changes in price). For ease of payments, the road toll booths would simply record the registration number of each car as they drive past the entrance and add a fee to the associated account. The account holder in charge of the car could then pay for the road tolls in full, at the end of the month, much like an electricity bill.

Variable pricing methods would be a new feature on New Zealand roads, however they are seen in some places around the world already. States in America such as California have implemented variable pricing that is based on congestion and is updated every 6 minutes[4]. The study in the International Journal of Transport Economics[5] has completed an analysis of many roads that have adopted variable pricing tolls throughout the world. This study has found that marginal cost pricing (economically efficient pricing) is seldom achieved so the number of cars on the road will generally deviate from the optimal quantity. The pricing errors will likely get minimised over time as the mathematical modelling of consumer demand gets more accurate.

Aside from this, a far more pressing issue with the design for variable pricing system used in other countries is the apparent imperfect information that consumers receive. In many states in the US, toll prices are set "dynamically". Consumers know the maximum that they can be charged but only know how much they actually have to pay a few minutes in advance, as they roll up to the payment booth[5]. This defeats the purpose of dynamic pricing, as consumers do not have many alternative methods of transport given the few minutes' notice they receive of the toll price. Practically, many people won't drive back home and catch the bus if the toll price is higher than expected. From an economic perspective, this is an example of imperfect information as consumers don't have full knowledge of the toll price when they have to make a transport decision at home. Once consumers roll up to the toll booth, their demand for the toll road would be very inelastic as alternative options such as walking, biking or bussing aren't feasible anymore. As such, consumer demand is much less responsive to the toll price, which means that congestion and GHG emissions aren't fully reduced.

As part of the Smart-Toll system, I believe that the method to ensure perfect information is to have a mobile app system that people can download. In the Smart-Toll mobile app, there will be real-time updates for what the toll price is currently along with predictions for what the toll-price will be in 20 minutes time. Before people leave their home, they can check the current/predicted toll-prices and see if driving is the most rational choice. It would be best if the Smart-Toll app also provided the cost of using public transport such as buses or trains so that the consumer can easily compare the relative price of either option. During peak hours, the smart-toll app would show that driving is relatively more expensive than other options due to the toll. As consumers tend to minimise losses, there would be an incentive for people to choose a relatively less expensive option such as bussing. The pricing information is provided electronically and future price predictions are given so consumers can make the best transport decisions. Consumers that do not value driving at the toll price will choose alternate options which will reduce traffic and congestion on main roads.

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[4] https://ops.fhwa.dot.gov/publications/congestionpricing/sec2.htm

[5] https://www.jstor.org/stable/pdf/42747809.pdf?refreqid=excelsior%3Ad57d93adb4710b81316bedaa4809aff8

Reductions in congestion will mean that greenhouse gas emissions from personal driving will also be reduced, leading to more positive environmental outcomes.

The Smart-Toll system would have to be equitable as toll roads could stop some low-income earners from driving to work. This can also be accomplished through the Smart-Toll app that people would have downloaded. The designers of the app could have a section where users can input their Community Service Card details if they have one. This would filter people who are typically low-income earners. Users who have a card could then be eligible for a discount on the total road toll they have to pay. In this system, there is still an incentive for low-income earners to find alternative means of transport. However, the toll they must pay for causing congestion is more progressive.

To lower GHG emissions in the long term, the Smart-Toll app can be designed to encourage more people to purchase electronic cars or hybrid cars. Currently, there are a large proportion of petrol cars in New Zealand. However, Smart-Toll apps can then be designed so that cars which have a hybrid system receive a discount for toll fees and cars with an electric engine receive an even more significant discount. This will encourage people who purchase cars in city environments (where toll roads are to be implemented) to purchase hybrid or electric cars, as they will receive regular savings. This will significantly reduce the greenhouse gas emissions. Furthermore, people who purchase brand new electric or hybrid vehicles could also be given a certain number of “road toll credits” to go towards paying for their road tolls. This would incentivise consumers to purchase new electric or hybrid vehicles instead of buying second-hand vehicles or brand-new petrol vehicles. As a result, the proportion of electric/hybrid vehicles in the market would increase. Overall, the GHG emissions from personal driving in New Zealand would decline over time as more low emission vehicles will appear due to the Smart-Toll app.

It is crucial that there is government intervention to solve the issue of traffic congestion. Traffic congestion has become an increasingly prevalent issue in urban cities throughout New Zealand. The social costs of traffic congestion- greenhouse gas emissions and excess road usage- are often unaccounted for by the public. This essay has highlighted the variable pricing toll road system to reduce congestion and greenhouse gas emissions. An integral part of this policy setting is the development of a Smart-Toll mobile app that gives real-time updates on toll prices and targets specific groups to subsidise road tolling for. The former ensures that there is perfect information in the road market, making it far easier for consumers to make rational decisions and switch to public transport or other means of transport. The latter ensures the policy is equitable for low-income earners and incentivises people to purchase hybrid/electric cars through toll credits. The Smart-Toll system is a future-focused policy setting that aims to reduce congestion, move towards a fully electric vehicle fleet, and reduce our Carbon emissions. The future-focused nature of the Smart-Toll system will be a big step forward in New Zealand achieving net zero carbon emissions by 2050.