EcoNZ@Otago

A MAGAZINE ABOUT CONTEMPORARY ECONOMIC ISSUES FOR EVERYONE

ISSUE 42 | FEBRUARY 2019

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FROM THE EDITORS

This is a special birthday issue of *EcoNZ@Otago* – as the University of Otago celebrates its 150th birthday this year. Happy Sesquicentenary!!! Economics was one of the first subjects taught at Otago – by Duncan MacGregor, one of Otago's first three professors appointed in 1871. As well as being an economics professor, MacGregor was trained as a surgeon, and was the first person at Dunedin Hospital to apply Joseph Lister's revolutionary methods of antiseptic surgery. Otago's first student in 1871, who studied Political Economy (as Economics was known in those days) under Prof MacGregor, was Robert Stout, who went on to be NZ's Prime Minister from 1884 to 1887. Right from our earliest beginnings 150 years ago, the staff and students of Otago's Department of Economics have been interested in the 'real' world. That admirable tradition is continued by the articles in this issue of *EcoNZ@Otago*.

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IN THIS ISSUE

Electric or petrol/diesel? Which car would you choose?

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You have probably heard of the Nissan Leaf (left), which runs on electricity supplied by a large battery. Like the Nissan Pulsar (right) and other similar hatchbacks, many of the Nissan Leafs on NZ roads are second-hand from Japan. Leafs look and drive much like petrol or diesel-powered hatchbacks. A big difference, however, is that driving a Leaf in NZ contributes less to global warming than driving the same distance in an otherwise similar petrol-powered car.

FOSSILISED FUELING

Petrol and diesel are extracted from oil, which was formed from plankton growing tens or hundreds of millions of years ago in warm shallow seas. This plankton, like other plants, used the energy in sunlight to harvest carbon from carbon dioxide (CO_2) gas in the atmosphere via photosynthesis.[1] Oil, like firewood, consists of a lot of flammable carbon, but the carbon in oil (and natural gas and coal) is often termed 'fossil' carbon as it was extracted from the atmosphere very long ago.

Burning fossil fuels increases the concentration of CO_2 in the atmosphere. Since 1960, for example, that concentration has increased by more than 25%. CO_2 is a potent 'greenhouse gas': even though it appears invisible to us, it captures heat and emits some of it back toward the earth, thereby warming the planet. While we humans have been enriching ourselves by powering the industrial revolution with fossil energy, we have inadvertently started to warm earth's climate.

Global warming is already causing significant changes: higher sea levels, more extreme weather, changes in local climates and corresponding changes in natural ecosystems. Changes like these can be very costly to our economic, social and natural systems: e.g. many people live in low-lying areas near the sea, our housing and infrastructure are not built to withstand weather extremes, and agricultural production systems are tuned to local environmental conditions.

At this stage it seems imperative to reduce CO_2 emissions from fossil carbon. One way is to wean ourselves off oil as an energy source. We would, of course, like to do that at the least cost possible, perhaps by developing a neat technology that fits with

1 For more information, see https://energyeducation.ca/encyclopedia/Oil_formation.

our current lifestyles. Enter the battery-electric car, known more generally as a battery-electric vehicle.

BEVs VERSUS ICVs

There is a variety of battery-electric vehicles (BEVs) available in NZ. However, sales of internal-combustion vehicles (ICVs) – both new and second-hand imports – are much higher than sales of BEVs.[2] The Ministry of Transport reports that in 2018 only 2.51% of new registrations of second-hand cars and 0.96% of new-car registrations were BEVs.

Part of the explanation for this low take-up of BEVs is that most are hatchbacks, which is a popular style, but many car buyers are looking for something else. Even so, take-up seems slow. Why?

The answer must be that, despite their similar appearance, BEVs differ from ICVs. Indeed, each type of drive system has its advantages and disadvantages:

- **Upfront purchase cost.** BEVs are more expensive to buy than otherwise similar ICVs mainly because their large batteries are expensive. For example, 2014 Nissan Leafs advertised on Autotrader cost about $7,000 more on average than similar 2014 Nissan Pulsars.
- **Running cost.** BEVs are less expensive to run. The battery can be recharged at home. Monitoring of BEVs by NZ researchers at 'Flip-the-fleet' indicate efficiency of about 6.75 km per kilowatt hour (kwh) of electricity.[3] The 1.8 litre Pulsar gets about 15 km per litre of petrol. Assuming 20¢ per kwh of electricity and $2 per litre of petrol, driving the Leaf currently costs about $3 per 100km and the Pulsar more than four times as much at about $13.33.[4]
- **Greenhouse-gas emissions.** BEVs reduce NZ GHG emissions because less than 20% of the electricity generated in NZ is from using fossil fuels.[5]
- **Travel distance between re-fuelling.** Most BEVs have less range then ICVs, less than 200 km relative to more than 500 km between refuelling.
- **Time required to refuel/recharge.** BEVs take longer to recharge: overnight at home or at a public fast-charge station in 30-60 minutes.
- **Maintenance cost.** BEVs require less maintenance because their drive systems are simpler than ICV systems.
- **Confidence the vehicle will work as advertised.** Car buyers may have less confidence in BEVs because BEVs are still novel and unfamiliar.
- **Cost of a one-off major repair.** BEVs most likely have relatively reliable mechanical systems, but the cost and availability of battery replacement is an issue.

A SURVEY OF POTENTIAL CAR BUYERS

Which of the above disadvantages of BEVs relative to ICVs discourage New Zealanders from going electric? Which advantages of BEVs are most attractive? To find out, we invited 300 Dunedin home owners, randomly selected from public records, to complete an on-line survey. Ninety households completed the survey.

The survey, known as a stated-choice survey, presents each participant with a series of choices, each involving two hypothetical cars where one car is better on one attribute and worse on another attribute than the other car. To choose one of the cars, the participant has to make a trade-off between the two attributes considered. Combining all of these choices allows the survey software, called 1000minds (www.1000minds.com), to quantify the relative strength of preference the householder has for each attribute. Participants also answered questions about themselves and their household.

The characteristics of our participants vary in line with what we would expect if a random sample had been drawn from the population instead. It is possible that the survey attracted people who were more interested in the subject. Indeed, a relatively large proportion of participants had recently purchased a car or planned to buy one soon.

Table 1 reports sample-average results. The left-hand column lists the attributes. The number in parentheses is the base, i.e. worst possible level of that attribute. The "Level" column lists the levels of each attribute in increasing order of desirability for that attribute.

Table 1. Relative strength of preference for attributes: mean, minimum and maximum values

Attribute	Level	Mean	Min	Max
Purchase price (base: $30,000)	$25,000	5.5	0.5	17.6
	$20,000	10.4	1.5	27.8
	$15,000	**16.9**	2.3	40.5
Fuel cost per 100 km (base: $20)	$10	9.1	1.5	17.5
	$3	**17.7**	5.8	37.4
Hours of city driving (base: 2.5 hours)	3.5 hours	5.2	0.5	18.7
	10 hours	**5.9**	1.0	19.2
Time to refuel/recharge on drive from Dunedin to Queenstown (base: 60 minutes)	30 min	8.7	0.4	28.6
	0 min	**9.4**	0.9	29.2
CO2 emissions/year (base: 2 tonnes)	0.4 tonnes CO_2	**13.0**	0.4	32.2
Annual maintenance cost (base: $750)	$350	8.8	1.4	23.0
	$100	**15.6**	3.9	36.6
Confident works as advertised (base: 80% confident)	>95% confident	**8.1**	0.5	23.2
One-off major repair cost (base: $10,000)	$7,000	5.5	1.0	15.9
	$4,000	**13.6**	3.9	33.1

2 For models available in NZ: https://driveelectric.org.nz/individuals/ev-models-and-where-to-buy.
3 Flip the Fleet website: https://flipthefleet.org.
4 However, the relative running cost of BEVs is likely to increase in the future, as BEV drivers do not currently pay the road user charge. Current government policy indicates that road user charges will be introduced when the stock of BEVs reaches 2% of the light vehicle fleet.
5 Producing a BEV, however, generates relatively more GHGs: GHGs emitted over a BEV's entire life cycle from production to disposable are about 40% of petrol cars; see www.energywise.govt.nz/on-the-road/electric-vehicles.

Consider the first attribute in Table 1: purchase price. Most second-hand BEVs and comparable ICVs sell in the range of \$15,000-\$30,000. The base value is \$30,000 because the other prices listed in the Level column are lower and therefore more desirable, all else the same.

A hypothetical car that has the base value of all attributes has an overall value of 0. The "Mean" column reports the increase in strength of preference (SoP) for each level of each attribute averaged across all 90 participants. The numbers in bold, corresponding to the best level of each attribute, sum to 100.

As expected, preferences work both for and against BEVs. Raising purchase price from \$15,000 to \$30,000, holding all else the same, reduces the mean SoP for the car by 16.9 out of 100 points. Having to spend time charging while traveling put off these households who are also keen to avoid a one-off cost the size of a new battery. Off-setting these negatives are strong preferences for the low running costs BEVs offer, and for reducing CO_2 emissions.

NOBODY'S AVERAGE ...

The last two columns in Table 1 show the minimum and maximum values of relative SoP across all participants in the sample. The rather large differences between the min and max suggest considerable heterogeneity in preferences across the 90 participants. Not surprisingly, these people vary in relative strength of preference for cars.

We can investigate this variation by looking for 'market segments': groups of people with similar patterns in the distribution of relative SoP across attributes. Table 2 shows results from using a standard computer clustering routine called 'k-means', where k refers to the number of clusters.

To keep things simple, we clustered only on the relative strength of preference for the best level of each attribute. For example, \$15,000 is the lowest (best) purchase price included in the survey. The "Mean" column reproduces from Table 1 the mean relative strength of preference for the corresponding attribute across all 90 participants.

We experimented with 2, 3, 4, 5 and 6 clusters. Given the number of clusters chosen by the researcher, the clustering routine works by systematically allocating each participant to the cluster with others who have the most similar pattern in their relative strength of preferences. We report the 4-cluster solution because it seems the most interesting.

The numbers in the four columns on the right show by how much the average strength of preference for each attribute differs in the cluster from the overall sample mean. To see how to interpret the numbers, consider those for Cluster 1. SoP for a low purchase price is 12.5 points higher in this cluster than for the sample as a whole; the people in Cluster 1 are unusually keen to avoid a large upfront expenditure on a car.

Because all SoP values sum to 100, all the differences from the mean for each cluster must sum to zero; if the participants in the cluster put more than average weight on one attribute, they must put less weight than average on others. So, the sum of the numbers in red off-sets the sum of the numbers in black.

If the participants in this survey are reasonably representative of NZ home owners, what does this mean for demand for BEVs?

The householders in Cluster 3 appear the **most** likely to be interested in a BEV: they are especially keen to reduce GHG emissions and like the lower running cost of BEVs. They are relatively less bothered about longer re-charge times while travelling and are less concerned about the as-yet unknown aspects of EV ownership. This is the smallest cluster but still important at 17% of the sample.

The householders in Cluster 4 also have preferences favourable to BEVs. They are the least put off by a higher purchase price but are also the least attracted to low running costs. They are relatively concerned about CO_2 emissions. However, people in this cluster need to be convinced that BEVs will work as advertised. Demand in this large segment could grow as BEVs prove themselves.

Preferences in Cluster 2 seem less conducive to purchasing a BEV. They are distinguished by relatively strong concern about recharging times and indicate less concern about GHG emissions. They like low running costs but are sensitive to high purchase prices. It seems that technological improvements are required to reduce purchase prices and reduce charging times.

Table 2. Estimates of 'segments' in the market for hatchback attributes

			Cluster difference from mean			
Attribute	**Level**	**Mean**	**1**	**2**	**3**	**4**
Purchase price	\$15,000	16.9	**12.5**	−0.2	−0.5	−5.6
Running cost/100 km	\$3	17.7	0.4	3.4	3.4	−3.5
Hours of city driving	10	5.8	−1.0	−1.1	−0.9	1.8
Minutes to refuel	0	9.4	−3.9	**7.7**	−5.4	−1
Tonnes of CO2 emissions	0.4	13.0	−7.2	−5.5	**11.7**	2.5
Maintenance cost	\$100	15.6	1.7	0.2	−3.4	0.3
Confidence works as advertised	>95%	8.1	−4.6	−4.1	−3.3	**6.3**
One-off major repair	\$4,000	13.5	2.1	−0.4	−1.6	−0.8
Number of participants		90	18	21	15	36
% participants		100%	20%	23%	17%	40%

The householders in Cluster 1 appear the **least** likely to be interested in a BEV: costs are their big concern. They, as the others, like low running and maintenance costs but are very keen to avoid the corresponding high purchase price. They also express the least concern for reducing CO_2 emissions.

POLICY IMPLICATIONS

So much for the marketing research ... What might these results imply for public policy?

The NZ government has committed to reduce GHG emissions by 5% below 1990 levels by 2020 and by 50% by 2050. Toward these ends, it has adopted a target of 64,000 BEVs by 2021.

Probably the policy most helpful for meeting this target has been to exclude BEVs from the road user charge (RUC), which saves a significant $6.70 per 100 km in running costs. The government also funds information campaigns, supports and helps coordinate the roll-out of public charging infrastructure and has provided authority to make bylaws that give BEVs access to special vehicle lanes, such as bus lanes.[6]

WHAT NEXT?

Given NZ's commitment to reducing GHG emissions, should more be done? For example, some other countries subsidise BEV purchases, give BEVs access to restricted lanes and subsidise BEV parking. In contrast, the key advantage in NZ, BEVs' exemption from the RUC, is due to expire when BEVs reaches 2% of the NZ fleet.

Perhaps purchase prices in NZ will fall as suppliers continue to improve BEV technology. Supporting public infrastructure will continue to develop with government assistance. And specialty service providers will appear as BEV numbers and demand increases. But will this be enough?

QUESTIONS TO THINK ABOUT

1. Do you prefer a battery-electric vehicle (BEV) or an internal-combustion vehicle (ICV)? Why? Which of the attributes discussed in the article and represented in Table 1 are most important to you?
2. Do you think the price of BEVs should be subsidised by the government? Why or why not?
3. What other policies could be used by the government to encourage people to switch from ICVs to BEVs?

USEFUL WEBSITES

Flip the Fleet: https://flipthefleet.org

Drive Electric: https://driveelectric.org.nz

EECA Energywise, Electric Vehicles:
www.energywise.govt.nz/on-the-road/electric-vehicles

6 Learn more about BEVs and NZ government policy here: www.transport.govt.nz/multi-modal/climatechange/electric-vehicles.

Population ageing, global warming and the Sinbad Century[7]

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Gather around and listen to a story! It's a tale, that if told better, might be worthy of Scheherazade herself ... It involves life and death, great threats and missed opportunities, difficult problems and difficult solutions, and an ending that could be happy or sad. It might even be the story of the 21st Century – the Sinbad Century.

Scheherazade

Source: https://commons.wikimedia.org/wiki/File:Scheherazade.tif

THE DEATH OF DEATH

The story begins with the greatest success story of the last 200 years: the decline of death. Globally, average life expectancy at birth has increased from just 20-30 years in 1800 to 70 now.

This increase in life expectancy is not just due to reduced infant mortality, for age-specific death rates have fallen at all ages. One measure of this is life expectancy at age 20, which has increased from 55 in most pre-industrial countries to 85 in most rich countries.

Another measure is the additional life expectancy conditional on reaching 65 years. This is still increasing: in England, where the big increase in life expectancy first took place, male life expectancy conditional on reaching 65 years has increased from 14 extra years in 1988 to 18 extra years now, and female life expectancy has increased from an extra 18 years to an extra 21 years over the same period. Similar improvements are occurring in Japan, where life expectancy at birth should soon be 90, the highest in the world.[8]

The decline of death has led to a huge increase in the world's population, from 1 billion in 1800 to 7.5 billion today. In recent years,

7 This article is a shortened version of a paper presented to the Hugo Group CEO Retreat, Millbrook Estate, Queenstown, in August 2018.
8 The demographic data are largely sourced from He et al. (2016) and the United Nations (2017). Additional NZ and Australia data are from Statistics New Zealand and the Australian Bureau of Statistics.