Simulating the Welfare Impacts of Improving Access to Māori Medium Education using Logit School Demand

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Abstract

A multinomial logit (MNL) model of school choice by Māori primary school-age students' families is implemented using aggregate school market share (i.e. ward-level roll share) data for 2016-2020. School choice is assumed to depend on differentiated price and non-price school attributes, the latter including whether schools teach exclusively or predominantly in the Māori language. Those that do – Māori Medium Education (MME) schools – are further distinguished based on whether they teach in accordance with specific Māori philosophies, such as Kura Kaupapa Māori (designated KKMTAM) schools that teach in accordance with a philosophy known as Te Aho Matua. KKMTAM and other MME schools, like public English Medium Education (EME) schools, do not charge tuition fees. However, families incur travel costs in accessing each school type, with students of MME schools, and especially KKMTAM schools, facing higher average travel distances than students of EME schools. This provides a price variable for school choice, and its inclusion in the MNL model enables estimation of willingness to pay (WTP) and consumer surplus. Results include Māori students' WTP to attend KKMTAM schools, relative to attending EME schools, is large, and greater than that to attend other MME schools. A policy simulation is conducted in which KKMTAM schools' students are assumed to face travel costs no greater than those of students in local EME schools. Such improved "access" to KKMTAM schools is estimated to increase consumer surplus by $357 per student per year.

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1 Introduction

Access to free education is a right largely taken for granted by most students and their families. However, students with particular learning needs – for example, those with a disability, or a desire for tuition in a minority language – can face access barriers due to a lack of appropriate support, or simply because schools offering the services they require are not well-located relative to where they live and hence impose high travel costs. This is particularly so for students in New Zealand wishing to study exclusively or predominantly in te reo Māori (the Māori language), and to embed such "Māori Medium Education" (MME) as part of their learning and practice of mātauranga Māori (Māori traditional knowledge, pedagogy, and skills) and of Māori culture more generally.

Schools teaching exclusively or predominantly in English (English Medium Education, or EME) have largely been the norm for more than a century in New Zealand, but MME schools have been developed only since the 1980s, and largely in parallel to the EME system. As such, MME schools have not developed to the same degree as EME schools, with the result that Māori students either have no local MME schools, or must travel greater distances, and with fewer subsidised transport options, than students of EME schools. Indeed, a recent review of schooling in New Zealand concluded that "[a]ccess to te reo Māori for all learners/ākonga is ... not easily available. Without this, te reo Māori cannot function as one of this country's official languages, or part of our everyday life" (Tomorrow's Schools Independent Taskforce (2019, p. 50)).

Improving the accessibility of MME schooling by Māori students can be motivated on multiple grounds. First, MME schooling is associated with superior educational outcomes for Māori students, relative to outcomes for Māori students in EME (Ministry of Education (2022)). Unsurprisingly, this includes outcomes such as a greater likelihood of attaining high school standards in te reo Māori and mātauranga Māori. However, it also includes better outcomes in terms of staying longer in secondary education, being more likely to leave high school with advanced qualifications, and a greater likelihood of enrolling in tertiary education soon after leaving school (as well as enrolling in higher level tertiary courses).

Second, improving access to MME schools enables government to better discharge its obligations under international conventions/declarations and Te Tiriti o Waitangi (the Treaty of Waitangi). For example, the Waitangi Tribunal has found that te reo Māori is a taonga (treasure) that the Crown has an active duty to protect under Te Tiriti o Waitangi (Waitangi Tribunal (1986)). Research into the long-term viability of te reo Māori emphasises the importance of investing in language immersion education, especially for school-age learning (Barrett-Walker et al. (2020)). Together, these considerations point to a role for government in supporting the provision of MME schooling options to Māori students.

Furthermore, New Zealand is signatory to the UN convention on the rights of children,[1] and declaration on the rights of indigenous peoples.[2] The former affirms the right of children to education that is directed to the development of their cultural identity, language and values (e.g. see Dalziel et al. (2019, p 3)). The latter affirms the rights of Māori "to revitalize, use, develop and transmit to future generations their histories, languages, oral traditions, philosophies, writing systems and literatures" (Article 13) and to "establish and control their educational systems and institutions providing education in their own languages, in a manner appropriate to their cultural methods of teaching and learning" (Article 14). It further obliges government to work with Māori to ensure Māori children have access to education "in their own culture and provided in their own language" (Article 15). These too imply a role for government in supporting the provision of accessible MME schooling options.

Third, improving the accessibility of MME schooling can be expected to generate additional social benefits over and above those discussed above, and more generally contribute to improved wellbeing. For example, thriving minority languages, fostered by minority language medium education, are associated with students enjoying gains in both cognitive skills and their abilities in dominant languages (Council of Europe (2020, p. 16)). Moreover, the protection of minority languages is recognised as contributing to the maintenance and development of cultural wealth (e.g. Council of Europe (1992)). Relatedly, the abilities of Māori in te reo Māori, and their groundedness in Māori culture more generally, are frequently used as indicators in wellbeing measurement frameworks applied in New Zealand (Dalziel et al. (2019)).

This paper explores the welfare implications of improving access to a particular class of MME schools. Specifically, a multinomial logit (MNL) discrete choice demand model of school choice by Māori primary school-age students' families is implemented using aggregate school market share (i.e. ward-level roll share) data for 2016-2020 available from administrative sources. School's are assumed to be differentiated in the minds of families of potential students, with school choice assumed to depend on price and

[1] `https://www.ohchr.org/en/instruments-mechanisms/instruments/convention-rights-child`.

[2] `https://social.desa.un.org/issues/indigenous-peoples/united-nations-declaration-on-the-rights-of-indigenous-peoples`.

non-price school attributes. Non-price attributes include whether schools teach exclusively or predominantly in the Māori language. Those that do – Māori Medium Education (MME) schools – are further distinguished based on whether they teach in accordance with specific Māori philosophies, such as Kura Kaupapa Māori (designated KKMTAM) schools that teach in accordance with a philosophy known as Te Aho Matua.[3]

KKMTAM and other MME schools, like public English Medium Education (EME) schools, do not charge tuition fees. However, families incur travel costs (comprising travel time cost and direct transport costs) in accessing each school type, with students of MME schools – and especially KKMTAM schools – facing higher average travel distances than students of EME schools. This provides a price variable for school choice, and its inclusion in the MNL model enables estimation of willingness to pay (WTP) and consumer surplus. To assess the welfare implications of improving access to KKMTAM schools, a policy simulation is implemented in which the travel costs for KKMTAM schools' students are assumed to be no greater than those of students in local EME schools (counterfactual), instead of being higher on average (factual).

Results include that the WTP of Māori families to have their primary-age children attend KKMTAM schools, relative to attending EME schools, is estimated to be $19,234 per student per year. This compares with a WTP of $15,665 per student per year to have their children attend other MME schools (again, relative to attending local EME schools). These results indicate that Māori families distinguish KKMTAM schools from other MME schools, and more specifically that the philosophical distinctives of KKMTAM schools (i.e. Te Aho Matua) – as well as other attributes of KKMTAM schools that are not captured by other measured school attributes – provide measurable value to such families.

The policy simulation results in an estimated change in expected consumer surplus of the families of KKMTAM schools' students amounting to $357 per student per year. It also predicts that the rolls of KKMTAM schools would increase by 7.1% on average as a consequence of the assumed reduction in travel costs. This indicates that improving access to KKMTAM schools, by reducing their travel costs to be no greater than those of local EME schools, improves the wellbeing of KKMTAM schools' students and their families, and stimulates demand for KKMTAM schooling.

[3]Details of how the Ministry of Education classifies MME schools are available at: `https://www.educationcounts.govt.nz/directories/maori-medium-schools`. In short, MME schools are those taught in Māori Language Immersion Levels 1-2, meaning tuition is in te reo Māori at least 51% of the time (Level 2) or at least 80% of the time (Level 1). Students of KKMTAM schools are taught exclusively in te reo Māori.

Discrete choice demand models have been applied to analyse a range of issues relating to students' educational choices. Studies include how targeted vouchers affect school choices and poorer students' educational outcomes when students and their families in Chile face school fees in addition to travel costs (Neilson (2017)), how travel distance affects college choice in the US (Jepsen and Montgomery (2009)), and how students select their graduate business school (Montgomery (2002)). Other such studies analyse preferences for higher education (Czajkowski et al. (2020)), and the role of preferences in public school choices (Hastings et al. (2006)).

Discrete choice models have also been applied to measure aspects of cultural value (see Allan et al. (2013) for an overview). Meade (2021) applies a novel (binomial) discrete choice approach to value a specific aspect of Māori culture, namely the value of attendance at biennial national Māori performing arts festivals.

To the author's knowledge, this is the first New Zealand study to analyse school choice using discrete choice demand modelling, and does so using administrative data. It is certainly the first to distinguish the impact of Māori language immersion level and other attributes of Māori language immersion schools on Māori students' school choices. It is also the first to formally analyse how changes to students' travel costs affect student welfare, using estimated demand parameters to measure the change in expected consumer surplus resulting from a policy simulation in which the travel costs of KKM-TAM schools' students are assumed to be no worse than those for students of local EME schools.

The balance of this paper is structured as follows. Section 2 sets out details of the methodology used, while Section 3 describes the study's data and sources. Section 4 presents the main results of the demand estimation, including estimated demand parameters, and estimates of students' families' WTP for different school types. Section 5 then presents details and results of the study's policy simulation, while Section 6 provides a concluding discussion.

2 Methodology

2.1 Decision Context

Māori families with a primary-aged (years 1 to 8) child are assumed to make a discrete choice as to which single school (whether KKMTAM, other MME, or EME), from among a number of local schools, they will enrol their child. If data were available on family-specific choices of schools for each of their children, different specifications would be possible, including those that account for dynamics (e.g. how attendance at a given school by older children in the family affect school choices for younger children in that family). Given the absence of such data, however, in this application it is assumed that Māori year 1 to 8 students each choose their own school, or that their families separately select to which school they send each of their children in this age cohort.

Attention is restricted to full primary schools (years 1 to 8), and to the years 1 to 8 rolls of composite (years 1 to 15) schools. The relevant administrative catchments for students and families making such choices are taken to be wards in which there are at least one KKMTAM or other MME school, and in which there is at least one EME school. In cases where the relevant ward is recorded as being "Area Outside Ward", I instead use the relevant district (i.e. territorial authority) as catchment. A school choice "market" is taken to be a ward-year (or district-year where the ward is not recorded).

2.2 Indirect Utility and Choice Probabilities

The MNL specification in Berry (1994) is adapted to consider public school choices for years 1 to 8 Māori students and their families. MNL models have known limitations, such as making restrictive predictions regarding substitution patterns between different alternatives, and imposing that all decision-makers have the same average "tastes" (i.e. not allowing for different decision-makers with different tastes to make different choices).[4] However, they are relatively simply to implement, and often form a foundation for more sophisticated analyses.[5]

Specifically, the indirect utility of Māori years 1 to 8 student i ($i = 1 \ldots I_t$) (i.e. "consumer i") in ward-year (or where the ward has value "Area Outside Ward", district-year) t ($t = 1 \ldots T$) (i.e. "market t") from choosing to enrol at public school j ($j = 1 \ldots J_t$) (i.e. "product j") is:

$$u_{ijt} = \delta_{jt} + \varepsilon_{ijt} \tag{1}$$

The ε_{ijt} term is assumed to be an *iid* Type I Extreme Value error term that captures random taste variation across students/whānau. Following the approach of Girotti and Meade (2017, p. 8), the mean utility from students choosing school j in market t, δ_{jt}, is defined to be:

$$\delta_{jt} \equiv \beta_{TC} TC_{jt} + \beta_{KKM} KKM_{jt} + \beta_{MME} MME_{jt} + x_j \beta + \xi_{jt} \tag{2}$$

[4]E.g. see Train (2009).

[5]E.g. see Girotti and Meade (2017).

where TC_{jt} is the average travel cost (comprising travel time cost and direct transport costs) of students attending school j in market t, KKM_{jt} is a dummy variable equalling 1 if school j in market t is a KKMTAM school (and 0 otherwise), MME_{jt} is a dummy variable equalling 1 if school j in market t is a MME but not KKMTAM school (and 0 otherwise), x_{jt} is a vector of other observed (by the researcher) attributes of school j in market t (assumed exogenous), and the β terms are the mean of student "taste" (i.e. preference) parameters to be estimated.

The last term in (2), ξ_{jt}, is the mean of student evaluations of unobserved school attributes such as school quality (i.e. other than their mean evaluations of KKMTAM school quality as captured via KKM_{jt}, and of other MME school quality as captured by MME_{jt}).

With ε_{ijt} distributed as assumed above, the probability that students choose school j in market t – i.e. school j's predicted market share in market t – takes the usual MNL form (Berry (1994, p. 250)):

$$s_{jt} = \frac{exp\left(\delta_{jt}\right)}{\sum_{k=0}^{J_t} exp\left(\delta_{kt}\right)} \tag{3}$$

2.3 Outside Option

Since choice probability (3) is the result of comparing mean indirect utility terms δ_{jt}, it is necessary to normalise one of these terms. Conventionally, and without loss of generality, mean utility of the "outside" good in market t, denoted δ_{0t}, is normalised to have value 0 (e.g. see Berry (1994, p. 250)).

In usual product markets such an "outside" good represents the choice that consumers make when they decide not to choose any of the "inside" goods in that market (here, one of the schools in that market). Since students of the relevant age cohort are required to attend school, this means the "outside" good must involve some schooling option in that market. Following Neilson (2017, p. 20), any school in a given market can be taken as the outside option without loss of generality. For this application, the largest EME school in each market t is chosen to be the relevant outside option, with its mean utility normalised to equal 0 ($\delta_{jt} \equiv 0$). I.e. if a Māori years 1 to 8 student in market t does not choose to attend an available KKMTAM school, MME other than KKMTAM school, or some other EME school, then they are assumed to attend the largest EME school in their market.

2.4 Transformation and Estimation

With the above normalisation ($\delta_{0t} \equiv 0$), the predicted market share of the "outside" option in any given market t (i.e. the largest EME school in that market) is:

$$s_{0t} = \frac{exp\,(\delta_{0t})}{\sum_{k=0}^{J_t} exp\,(\delta_{kt})} = \frac{1}{\sum_{k=0}^{J_t} exp\,(\delta_{kt})} \tag{4}$$

As such, Berry (1994, p. 250) shows that the following transformation using (3) and (4) results in a simple linear specification that can be taken to data in order to estimate the required student "taste" parameters, β_{TC}, β_{KKM}, β_{MME} and β:

$$ln\,(s_{jt}) - ln\,(s_{0t}) = ln\,(exp\,(\delta_{jt})) - ln\,(1) = \delta_{jt}$$

In other words, given known market shares of each school in each market – i.e. their shares of years 1 to 8 Māori student rolls – as well as their KKMTAM status, MME other than KKMTAM status, and other observable school attributes (socio-economic decile, isolation index, roll size, etc), the required "taste" parameters can be estimated by applying standard statistical estimation techniques such as linear regression or panel linear regression to the following equation:

$$ln\,(s_{jt}) - ln\,(s_{0t}) = \beta_{TC} TC_{jt} + \beta_{KKM} KKM_{jt} + \beta_{MME} MME_{jt} + x_j \beta + \xi_{jt} \tag{5}$$

with ξ_{jt} playing the roll of a statistical error term.

In conventional market settings, "consumers" face product prices set by producers (i.e. firms), rather than the financial cost they face being travel cost TC_{jt}. Since firms can adjust their prices in response to "shocks" not observed by the researcher (i.e. realisations of the error term ξ_{jt}), this violates the assumption of conditional independence of explanatory variables and the error term. Such endogeneity normally necessitates use of estimation techniques such as two-stage least squares using instrumental variables in order to produce unbiased estimates of the required "taste" parameters. In the present setting, however, schools are assumed to have limited ability to materially change the travel distances and overall travel costs of students and their whānau in response to unobserved shocks. So standard estimation techniques should be able to be safely applied.

2.5 Willingness to Pay for KKMTAM Schooling Attributes, and for Other MME Schooling Attributes

In the school demand/choice model specification (5), the resulting estimates of "taste" parameters β_{TC}, β_{KKM}, β_{MME} and β can be interpreted as "marginal utilities" of the corresponding school attributes – i.e. the incremental well-being enjoyed by students from being able to enjoy an extra unit of each of those attributes. In particular, the estimate:

- $\hat{\beta}_{TC}$, which is predicted to be negative (i.e. increased travel cost for a given school should be associated with reduced market share, all other things being equal), is the negative of students' average marginal utility of income (since travel cost TC_{jt} is a financial variable);[6]

- $\hat{\beta}_{KKMTAM}$ measures students' average marginal utility attaching to those features of KKMTAM schools, relative to EME schools, that are not otherwise captured by other observed school attributes such as the roll size, decile, isolation (etc) of those schools; and

- $\hat{\beta}_{other\,MME}$ measures students' average marginal utility attaching to those features of other MME schools, relative to EME schools, that are not otherwise reflected in other observed school attributes such as the roll size, decile, isolation (etc) of those schools.

As such, students' dollar willingness to pay (WTP)[7] for school attributes such as schools being KKMTAM, or being other MME, can be expressed respectively as the negative of the ratio of the marginal utilities of these attributes, and the marginal utility of income,[8] i.e.:[9]

$$WTP_{KKMTAM} = -\frac{\hat{\beta}_{KKMTAM}}{\hat{\beta}_{TC}} \tag{6}$$

$$WTP_{other\,MME} = -\frac{\hat{\beta}_{other\,MME}}{\hat{\beta}_{TC}} \tag{7}$$

Note that these WTP measures are derived from the willingness of Māori years 1 to 8 students and their families being willing to incur travel costs in order to access KKMTAM or other MME schooling. This is to be contrasted with their willingness to expend these amounts through direct monetary payments, which would be affected by financial ability to pay considerations.

[6]E.g. see Train (2009, p. 56).

[7]Since the school demand/choice model is implemented using annual data on school choices, WTP is more precisely in dollars per student per year.

[8]Dividing by the marginal utility of income converts marginal utilities measured in utility terms into monetary amounts. E.g. see Train (2009, p. 56).

[9]E.g. see Train (2009, p. 309).

Table 1: Summary Statistics for Price and Non-Price School Attributes

Statistic	N	Mean	St. Dev.	Min	Max
KKMTAM	2,407	0.119	0.324	0	1
other_MME	2,407	0.084	0.278	0	1
roll_total	2,407	166	169	3	1,512
roll_maori_share_2022	2,407	0.488	0.358	0.002	1.000
maori_roll_est_1to8	2,407	51.8	46.5	0.4	324.2
var_funds_per_stud	2,407	9,207	4,688	4,742	54,133
FTTE	2,407	10.8	10.7	0.3	142.3
actual_classroom_area	2,407	765	754	0	6,211
actual_gymnasium_area	2,407	41	173	0	1,508
standard_teaching_spaces	2,407	9.805	8.401	0	61
specialist_teaching_spaces	2,407	0.812	2.771	0	27
decile	2,407	4.323	2.919	1	10
isolation_index	2,379	1.238	1.089	0.010	4.980
s_0_t	2,407	0.244	0.128	0.072	0.746
ln_sjt_on_s0t	2,407	−1.348	1.077	−5.594	2.550
tot_annual_TC	2,378	850	874	66	13,934
tot_annual_TC1	2,388	743	498	66	4,998

3 Data

3.1 Non-Price School Attributes

Table 1 presents summary statistics for school-level non-price attributes and other non-price variables, and school-level average travel costs, for 2016-2020 (for public full primary and composite schools only).[10] These non-price and price attributes are assumed to be relevant for how Māori families chose which schools they sent their years 1 to 8 children to in these years.

KKMTAM is a dummy variable indicating whether or not a particular school is a KKMTAM school in the relevant year (taking the value 1 if it was, and 0 otherwise). The variable was constructed based on information provided by the national body representing KKMTAM schools, Te Rūnanga Nui o Ngā Kura Kaupapa Māori o Aotearoa. It captures attributes of KKM-

[10]Details of school types and year levels can be found at: `https://www.education.govt.nz/school/new-zealands-network-of-schools/about/types-of-schools-and-year-levels/`.

TAM schools not otherwise captured by measured other attributes of those schools.

Similarly, $other\_MME$ is a dummy variable, indicating if a particular school was classified by the Ministry of Education as being a MME school in the relevant year, but was not also a KKMTAM school that year (taking the value 1 if so, 0 otherwise). It captures the attributes of MME schools that are not also KKMTAM schools which are not captured by those schools measured other attributes. School-level Māori language immersion levels (MME, etc) for each year were obtained from the Ministry of Education directly.

School-level total roll sizes ($roll\_total$) and Māori roll shares for the 2022 year ($roll\_maori\_share\_2022$) were obtained from the Ministry of Education's *Education Counts* website.[11] Māori student rolls at the years 1 to 8 level for each school ($maori\_roll\_est\_1to8$) in 2016-2020 were estimated using the 2022 Māori roll shares, and year-level rolls also available at the school level from *Education Counts*. These variable provide a measure of the size of schools, and the extent to which their students are Māori.

Variable funding per student ($var\_funds\_per\_stud$) comprises total teacher salary funding and operational funding for each school,[12] divided by total roll. Full-time teacher equivalents measures the full-time equivalent teachers per school. Each of these variables provide a measure of each schools' non-buildings resourcing, with variable funding available from *Education Counts*, and school-level $FTTE$ obtained directly from the Ministry of Education.

The next five variables in Table 1 ($actual\_classroom\_area$, etc) provide school-level building areas (in m^2) or number of teaching spaces, for different types of room/space, obtained directly from the Ministry of Education. They provide additional measures of how well schools are resourced, and the variety of facilities they offer to their students.

The final two non-price school-level attributes in Table 1, also sourced from *Education Counts*, are *decile* and $isolation\_index$. Until 2023, the Ministry of Education used *decile* as an index of school communities' socio-economic status, taking values 1 to 10. Additional funding was allocated to schools with lower status (i.e. lower *decile* value). This variable captures the socio-economic status of each school's community. [13] The final non-price

[11] `https://www.educationcounts.govt.nz/home`.

[12] Details of different types of school funding can be found at: `https://www.educationcounts.govt.nz/statistics/funding-to-schools`.

[13] Details of the *decile* measure can be found at: `http://parents.education.govt.nz/secondary-school/secondary-schooling-in-nz/deciles/`. From January 2023 it was replaced with a new equity index, with details at: `https://www.education.govt.nz/our-work/changes-in-education/equity-index/`.

school attribute, *isolation_index*, is an index constructed by the Ministry of Education to measure the remoteness of a school (i.e. from major population centres),[14] which is also assumed to be a potential non-price attribute relevant to families' school choice decisions. Both indices were obtained from *Education Counts*.

3.2 School Price Attributes – Travel Costs

As discussed in the introduction, all schools under consideration do not charge fees for attendance. However, families incur direct travel-related expenditures, and opportunity costs of their own time (i.e. when parents accompany children to school) – together, travel costs – when choosing whether to send their children to the most local school, or more distant schools (e.g. if those more distant schools offer desirable non-price attributes not offered by local schools).[15] Such travel costs represent a monetary cost – i.e. an implicit price variable – attaching to families' school choices.

To estimate average total annual travel costs per student for each school (*tot_annual_TC* in Table 1), recent school-level average student travel distance data obtained directly from the Ministry of Education was augmented with:

1. Average hourly earnings data for Māori, by region and by year, for 2016-2020, available from Statistics New Zealand;[16]

2. Years 1 to 8 student transport mode shares by region (i.e. private passenger vehicle, walking, public transport, etc), using 2014 survey data published by the Ministry of Transport;[17]

3. Average travel speeds in km/hour by transport mode, as published by the Ministry of Transport, which can be inverted to measure required travel hours per km for each mode;[18]

[14]Details can be found at: `https://www.education.govt.nz/our-work/changes-in-education/equity-index/faq-isolation-index-changes/`.

[15]Some parents will derive utility from accompanying their children to school, and others might mitigate their travel time costs by sharing school drop-offs with other trips (e.g. to work). Incorporating such refinements is left to future work.

[16]`https://nzdotstat.stats.govt.nz/OECDStat_Metadata/ShowMetadata.ashx?Dataset=TABLECODE7472&ShowOnWeb=true&Lang=en`.

[17]`https://www.transport.govt.nz/statistics-and-insights/household-travel/why/`.

[18]`https://www.transport.govt.nz/statistics-and-insights/household-travel/`.

4. Petrol and diesel vehicle running costs per km by year, as published by Inland Revenue Department;[19] and

5. The number of half days per year that schools were required to be open, by year, as published by the Ministry of Education, which affects the total number of daily trips per year.[20]

Specifically, I estimate total annual travel cost per student tot_annual_TC for a given school as:

$$(\tau + \upsilon) \times 2 \times D \tag{8}$$

where τ is average travel time cost per trip and υ is average vehicle running costs per trip (in each case, for the given school), while 2 is the assumed number of trips per school day, and D is school open days per year.

Travel time cost per trip τ for a given school is calculated as:

$$\tau = d \times \pi \times h \times w \times 0.33 \tag{9}$$

where d is the average student travel distance for that school (in kilometres), π is the assumed passenger vehicle share for years 1 to 8 school trips, h is the assumed hours required to travel one kilometre, w is the average wage of Māori in the relevant school's region (varying also by year), and 0.33 is the share of average hourly wages assumed to represent travel time opportunity cost.[21]

Only school trips involving private passenger vehicles are assumed to incur travel time costs (i.e. the travel time cost of the adult who drives that vehicle, with no time cost imputed to students themselves). This implies that other types of school trips, including those involving either public transport or transport provided by schools themselves, without connecting passenger vehicle trips, are assumed to involve no travel time cost.

Private passenger vehicle running costs per trip υ are calculated as:

$$\upsilon = d \times \pi \times c \tag{10}$$

[19] Specifically, IRD's "Tier 2" km rate. E.g. for 2020, https://www.ird.govt.nz/income-tax/income-tax-for-businesses-and-organisations/types-of-business-expenses/claiming-vehicle-expenses/kilometre-rates-2020-2021.

[20] https://www.education.govt.nz/school/school-terms-and-holiday-dates/school-terms-and-holidays-archive/#2009To2000.

[21] Best practice for travel cost models of recreational demand (e.g. Lupi et al. (2020)) recommend that the cost of travel time be estimated as 33% to 50% of average hourly wages. For conservatism, the lower end of the range is adopted. Assuming that travel time cost per hour is a fraction of hourly wages allows for travel time to potentially have benefits as well as costs.

where c is petrol and diesel vehicle running costs per km. As for travel time costs, only trip running costs for the share of trips involving private passenger vehicles are imputed.

For the study's policy simulation (discussed in Section 5), counterfactual travel cost for KKMTAM school j in market t, $tot\_annual\_TC1_{jt}$, is assumed to be:

$$min\left(tot\_annual\_TC_{jt}, \bar{TC}_t\right) \tag{11}$$

where $\bar{TC}_t$ is the average of students' travel costs to EME schools in market t. Thus counterfactual travel cost for a given KKMTAM school in any year is either the average travel cost for their local (i.e. ward- or district-level) EME schools that year, or their own average travel cost that year, whichever is the lesser.

Finally, only travel costs have been considered as the relevant price attribute of the public schools under consideration. Many public schools solicit donations from families of their students, though they are not able to enforce such donations. Moreover, many schools rely on parents volunteering of their time when delivering their services to students, though data is not available on the extent to which this varies across schools and school types. Measuring such other sources of school choice explicit price and/or implicit time cost is left to future work.

3.3 Markets

As discussed in Section 2.2, a market is defined to be a ward-year, or where a ward is recorded as being "Area Outside Ward", the relevant district-year instead. More precisely, for any given year, only wards (or districts) in which there is at least one MME – either KKMTAM or other MME – school, and at least one EME school, are included in the sample. This results in 68 wards (or districts) being retained when defining markets.

4 Results

Results of the school choice model estimation are presented in Table 2. In all four models considered, the estimated coefficient on annual travel cost is negative as expected (families of Māori years 1 to 8 students dislike travel costs), and significant. This is particularly so for model 3, although the estimated coefficient is the same across all models.

The estimated coefficient on KKMTAM, measuring the impact on Māori families' school choice utility due to differences between KKMTAM and EME

Table 2: Results of Multinomial Logit School Choice Model

	Dependent variable: $ln(s_{jt}) - ln(S_{0t})$			
	(1)	(2)	(3)	(4)
tot_annual_TC	-0.0001*	-0.0001*	-0.0001***	-0.0001*
	(0.00003)	(0.00003)	(0.00002)	(0.00003)
KKMTAM	0.274**	0.276**	1.311***	0.281**
	(0.139)	(0.134)	(0.134)	(0.138)
other_MME	0.122	0.116	1.067***	0.126
	(0.123)	(0.120)	(0.130)	(0.122)
roll_total	0.003***	0.003***	0.002***	0.003***
	(0.0004)	(0.0003)	(0.0004)	(0.0004)
roll_maori_share_2022	2.303***	2.296***		2.254***
	(0.204)	(0.196)		(0.155)
var_funds_per_stud	-0.0001***	-0.0001***	-0.00005***	-0.0001***
	(0.00001)	(0.00001)	(0.00001)	(0.00001)
FTTE/roll_total	2.749*	2.536	0.529	2.861*
	(1.611)	(1.609)	(1.723)	(1.645)
actual_classroom_area/ roll_total	0.005	0.001	0.007	0.004
	(0.024)	(0.024)	(0.029)	(0.024)
actual_gymnasium_area/ roll_total	0.005	0.004	0.017	0.005
	(0.023)	(0.022)	(0.029)	(0.023)
standard_teaching_spaces/ roll_total	-2.037	-1.749	-2.383	-1.975
	(1.747)	(1.750)	(2.137)	(1.742)
specialist_teaching_spaces/ roll_total	0.547	0.942	-0.118	0.623
	(2.394)	(2.394)	(2.882)	(2.392)
decile	0.008	0.005	-0.080***	
	(0.016)	(0.015)	(0.014)	
isolation_index	-0.002		0.170***	-0.002
	(0.037)		(0.042)	(0.037)
Observations	2,350	2,378	2,350	2,350
R^2	0.574	0.576	0.428	0.574
Adjusted R^2	0.571	0.573	0.425	0.571
F Statistic	242***	267***	146***	262***
df	(13, 2332)	(12, 2361)	(12, 2333)	(12, 2333)

Note: * p<0.1; ** p<0.05; *** p<0.01.
All models include year fixed effects. Standard errors are robust.

schools that are not captured by other measured school attributes, is positive and also significant in all four models. The corresponding coefficient for other MME schools is also positive, but only significant for model 3. It is also less than the corresponding coefficient for KKMTAM schools, indicating that families of Māori years 1 to 8 students value MME schools' relative to EME schools, and more so for KKMTAM schools than for other MME schools. This further indicates that attributes of KKMTAM schools that are not shared with other MME schools – including their distinctive philosophical approach, Te Aho Matua – are perceived as being valuable by such Māori families.

Other significant results are that the estimated coefficient on school roll size are positive and significant, indicating that Māori families prefer schools to be larger, all other things being equal. Likewise, schools' variable funding per student is also highly significant, though unexpectedly with a negative sign. Conversely, none of the variables measuring the impact of classroom space availability on the utility from school choice are insignificant, and not uniformly positive.

Māori roll share is positive, and significant, indicating that Māori families prefer their children to attend schools that have higher proportions of Māori students. However, this variable is perhaps collinear with the decile and isolation index variables, since they become significant, and highly so, when the 2022 Māori roll share variable is omitted (e.g. because they are positively correlated with 2022 Māori roll share) in model 3. In that model, *decile* is significant and negative, indicating that Māori families dislike sending their children to schools with higher socio-economic deprivation, all other things being equal. Conversely, Māori families prefer sending their children to schools in more remote areas, as indicated by the coefficient on *isolation_index*.

Model 3 was used to estimate WTP using equations (6) and (7), since that model has the most significant coefficients on both travel costs, and the dummy variables $KKMTAM$ and $other\_MME$ that capture the utility impact of otherwise non-measured attributes of MME schools (relative to EME schools). Using the estimated travel cost coefficient to a greater level of accuracy (-6.8134e-05) versus the -0.0001 figure presented in Table 2, and adjusting to December 2022 dollars,[22] the WTP results are as shown in Table 3. These estimates of WTP to attend MME schooling – not to be confused with their ability to pay – indicate that Māori families particularly value the attributes of MME schools not captured by their other measured attributes, and more so for KKMTAM schools than for other MME schools.

[22]Using CPI data available from: `https://www.rbnz.govt.nz/-/media/project/sites/rbnz/files/statistics/series/m/m1/hm1.xlsx?sc_lang=en`.

Table 3: Estimated Willingness to Pay for Māori Medium School Attendance

	\$/Student/Year (Dec-22 \$)
WTP_{KKMTAM}	$19,234$
$WTP_{other\,MME}$	$15,665$

5 Counterfactual Policy Simulation

5.1 Method

Estimating a school demand/choice model such as (5) enables policy simulations to be undertaken, in which the welfare impacts of changes such as changes in prices (here, travel costs, TC_{jt}) can be assessed in monetary terms.

Specifically, if we suppose that actual travel costs are denoted TC^{0}_{jt}, but that a policy change (e.g. choices regarding how many schools to build, and where) results in "counterfactual" travel costs denoted TC^{1}_{jt}, then the resulting impact of that change on a given Māori years 1 to 8 student's wellbeing in market t can be measured as their change in expected consumer surplus,[23] which is in monetary terms,[24] i.e.:

$$\Delta E\left(CS_{it}\right) = -\frac{1}{\hat{\beta}_{TC}}\left\{ ln\left(\sum_{j=0}^{J_t} exp\left(\hat{\delta}^{1}_{jt}\right)\right) - ln\left(\sum_{j=0}^{J_t} exp\left(\hat{\delta}^{0}_{jt}\right)\right)\right\} \quad (12)$$

where:

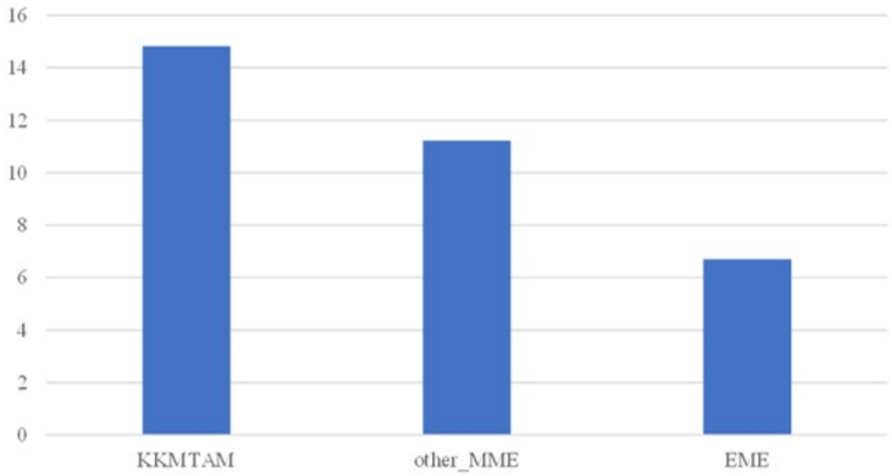
$$\hat{\delta}^{1}_{jt} = \hat{\beta}_{TC}TC^{1}_{jt} + \hat{\beta}_{KKM}KKM_{jt} + \hat{\beta}_{MME}MME_{jt} + x_j\hat{\beta} \quad (13)$$

$$\hat{\delta}^{0}_{jt} = \hat{\beta}_{TC}TC^{0}_{jt} + \hat{\beta}_{KKM}KKM_{jt} + \hat{\beta}_{MME}MME_{jt} + x_j\hat{\beta} \quad (14)$$

[23] E.g. see Train (2009, pp 55-57).

[24] As for WTP, in this application this is the change in expected consumer surplus per student per year.

Figure 1: Average Student Travel Distances by School Type (km)



The terms (13) and (14) can be estimated using predicted values of $ln\left(s_{jt}\right) - ln\left(s_{0t}\right)$ computed using TC^1_{jt} and TC^0_{jt} respectively in (5).

To compute overall expected consumer surplus impacts of the relevant policy change, the above estimate per year per student i in market t can be aggregated using suitable counts of each such student in each such market.

5.2 Welfare Impacts of Making KKMTAM School Travel Costs No Worse than those of Local EME Schools

Figure 1 shows average student travel distances by school type, using data supplied by the Ministry of Education. As can be seen, KKMTAM schools have the highest average travel distances, followed by other MME schools. EME schools have lower average travel distances than either type of MME school This motivates consideration of improving the accessibility of MME schools – KKMTAM schools especially – which will have the effect of lowering their students' average travel distances (among other things), and hence their families' annual travel costs.

As for the WTP estimates presented above, model 3 in Table 2 was used to estimate the welfare impacts of the above policy simulation. Table 4 presents the key results. Averaging across markets, the change in the expected consumer surplus of Māori families with a child at KKMTAM schools in markets enjoying a counterfactual reduction in annual travel costs (i.e improvement in KKMTAM school accessibility) is \$357/student/year in December 2022 dollars. The mean increase in expected KKMTAM enrolments

Table 4: Results of Policy Simulation

$\Delta E\left(\bar{C}S_{it}\right)$	357	$/Student/Year (Dec-22 $)
Mean increase in KKMTAM rolls	7.1%	For all KKMTAM schools
Mean increase in KKMTAM rolls	10%	For KKMTAM schools enjoying reduction in annual travel costs

with the assumed counterfactual change in travel costs averaged 10% for those KKMTAM schools enjoying a travel cost reduction, and 7.1% across all KKMTAM schools (i.e. including those which were not assumed to enjoy a reduction in travel costs).

6 Discussion

This study estimates a MNL model of school choice using aggregated (i.e. market-level) roll shares and other administrative data, along with travel costs as the relevant monetary choice attribute. The model assumes schools are differentiated in the minds of Māori students' families. Among other non-price dimensions, they are assumed to be differentiated in terms of whether they are MME or EME, and with MME schools further differentiated between KKMTAM schools (teaching according to the Te Aho Matua philosophy) and other MME schools.

Having recovered structural estimates – here, the parameters of Māori families' years 1 to 8 school demand – a policy simulation was conducted to estimate the welfare impacts of assuming counterfactual travel costs, in which families of KKMTAM students faced travel costs no worse than those of local EME schools. This illustrates how administrative data can be combined with structural estimation based on microeconometric foundations – in this case using only standard regression techniques – to assess the possible demand and welfare implications of policy interventions (here, changing travel costs faced by KKM families). Since the resulting estimates are in monetary terms, they can be used in cost-benefit analyses to provide more formal assessments of policy interventions.

Among the MNL model's limitations is that it estimates only average preferences of of decision-makers – here, of Māori families with years 1 to 8 students. To understand heterogeneity in such families' preferences regarding KKMTAM and other MME schools, more sophisticated approaches are required, including nested logit, random coefficient logit, or latent class models (e.g. see Train (2009)). A promising approach with the available market-level administrative data is to estimate a random coefficient logit model using non-linear optimisation techniques such as that in Berry et al. (1995),[25] as was adapted and applied in Neilson (2017). Such an approach can recover the parameters of distributions over decision-makers' taste parameters, not just mean preferences, and can be expected to reveal variation around metrics such as WTP, and change in expected consumer surplus, for different decision-makers. Allowing for such heterogeneity in preferences enables more refined welfare analysis, including distributional assessments. Refinements like these are left to future work.

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