Evaluating the Weights and Factors Used in the New Zealand School Decile Funding System

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Abstract: In New Zealand, the primary means of addressing the disparities that exist in educational outcomes by socio-economic status of students in public schools is the "decile" funding system. The country's Ministry of Education uses census data on five socio-economic characteristics of the households containing school-aged children in the immediate meshblocks of the children attending each public or public-integrated school in the country. These five characteristics are the proportion with household income below an adjusted level, the proportion of adults with no educational qualifications, the proportion of adults in low skill occupations, the proportion of families in crowded households, and the proportion of households receiving a benefit. Each school's relative (percentile) ranking for each of the five characteristics is then summed to create on overall socio-economic score. Schools with the highest ten percent of scores (the most disadvantage) are rated as "decile 1" schools, the next highest ten percent are rated "decile 2" schools, and so on. Government funds for schools are adjusted by decile, such that funding per student is highest for the lowest decile schools.

In this paper, we use data from the New Zealand Ministries of Education and Health, the Police, and the 2001 and 2006 censuses to look for evidence whether the decile funding system is using the best weights possible on the five socio-economic characteristics currently in the decile funding formula, and whether other neighbourhood level factors should also be included. To do this, we conduct school fixed effects regressions to examine the residual effects of the five factors on school leaver qualification achievement rates in the presence of the current funding system. We also explore whether additional factors such as health, crime, languages spoken, marital status, immigration status, and other factors have additional significant explanatory power on qualification achievement rates. We find that of the current five factors, low household income continues to have a strong residual effect on school achievement rates while the remaining four do not, suggesting the relative weight on low household income should be increased. We also find that school catchment measures of urban/rural status, home ownership, and several alternative measures of family instability also have additional explanatory power regarding variation in school leaver qualification achievement rates.

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I. Introduction and Literature Review

New Zealand has much to be proud of regarding its education system. Among OECD countries in 2008, New Zealand ranked second in the percent of public expenditures that went to education. Yet because New Zealand is not one of the wealthier OECD countries, its spending per student is in the bottom third of the OECD (Ministry of Education 2010). How effective is this spending? An international standardized comparison of 15 year olds' acquisition of reading, math, and scientific literacy carried out by the Programme for International Student Assessment (PISA) showed that in 2009 New Zealand was ranked 5th overall of 34 OECD countries.[1]

As in many countries, student achievement in New Zealand varies on average by socio-economic status and ethnicity. There is evidence, however, that disparities in student achievement vary more by these factors in New Zealand than in other countries. A good review of the literature on this issue, and New Zealand's response to is, can be found in the honours research project by John Hughes (2013). We summarise here findings of important papers highlighted in that thesis.

The same 2009 PISA results showing high average achievement by New Zealand students also showed that reading performance differed more between those of different socio-economic backgrounds here than in any other OECD country, and that overall the gap between the highest and lowing performing students was amongst the highest in the OECD (Ministry of Education 2010). Wide disparities persist also on average by ethnicity, in particular between Asian, European, Maori and Pacific students. For example, the proportion of students identifying as Asian who left high school with at least National Certificate of Educational Achievement (NCEA) Level 2 qualifications in

[1] Evidence from the 2012 PISA results show New Zealand to be dropping in OECD and broader rankings, owing in part to stronger showing by Asian countries.

2012 was 87%, compared to 79.6% for Europeans, 64.8% for Pacific, and 54.6% for Maori (Ministry of Education 2013).[2]

The Ministry of Education has identified the unequal achievement distribution as "the greatest challenge facing the schooling sector" (Ministry of Education 2011a). Disparities in achievement, and more particularly low achievement among disadvantaged students may be seen as perpetuating excessive poverty or inequality in simple moral terms, or it can be viewed in terms of efficiency cost. One OECD report estimates that bringing the 11.2% of New Zealand students with Programme of International Assessment scores below 400 up to that level would raise GDP per capita by .42% (OECD 2010). Internationally, Hanushek and Woessman (2012) and Hanushek and Kimko (2000) have found that labour force quality as measured by aggregate levels of science and mathematics scores is strongly related to economic growth. The education finance literature commonly combines moral and cost considerations together under the concept of "adequacy" – that all children deserve the opportunity to gain some minimal level of education, and that it costs more to educate some students than others.[3] This implies the need for "differences in resource allocation based on legitimate differences between individuals" (Underwood 1995). Given that the Ministry of Education judges the high school leaver qualification of NCEA Level Two to be "a benchmark, which young adults need to complete to have a basic prerequisite for higher education and training, and for many entry level jobs" adequacy in New Zealand might involve resourcing disadvantaged students via schools to the point they could achieve at least this qualification (Ministry of Education 2011b, p. 41).

[2] While students can leave high school in New Zealand with different levels of qualification (for example, NCEA Level One, Two, or Three), NCEA Level Two is considered the minimum qualification young adults need to complete to have a basic prerequisite for higher education and training, and for many entry level jobs.

[3] For example, Guthrie and Rothstein (2001) define educational finance adequacy as "sufficient resources to ensure students an effective opportunity to acquire appropriately specified levels of knowledge and skills." Empirically, many studies have indeed found that the cost of educating disadvantaged students is higher (see for example Downes 1994 and Reschovsky and Imazeki 2001). Ladd and Fiske (2001) propose causal explanations why.

Of course, even with agreement that reducing the effects of socio-economic disadvantage on educational outcomes is desirable, identifying which schools are in need of extra funding is not straightforward. In many local level school districts of the United States, for example, policy makers rely on a limited range of administrative data on the socio-economic conditions of the specific students/families enrolled in each school (Rivkin, Hanushek and Kain 2005). In contrast, the main funding system used to address disparity in New Zealand relies on a broader range of socio-economic characteristics available from the census, but only of the immediate 'meshblocks' (tracts) in which schools' students' families' live, not the students/families themselves. The New Zealand Post-Primary Teachers' Association (PPTA 2013) has criticized the current funding formula, partly for factors it omits (e.g. ethnicity), and partly for how parents, teachers and schools serving advantaged students use schools' publicised rankings in the system to increase rather than offset disparities.

So how is current funding used in New Zealand to mitigate the effect of students' socio-economic status on their educational outcomes? Introduced in the 1990's, one of the longer standing programmes designed for this purpose has been the "decile" funding system.[4] Under this system, schools teaching students from neighourhoods identified by the census as disadvantaged receive more funds per student than schools teaching students from more advantaged neighbourhoods. We turn next to consider this funding system in more detail.

II. Current Practice and a Theory of Optimal Funding

The Ministry of Education implements the decile funding system as follows. Approximately one year after the release of new census data, the Ministry matches the home addresses of the students of each state and state-integrated school to their corresponding census "meshblocks."[5] (A "meshblock" is the smallest boundary unit of the New Zealand census, typically consisting of 100-

[4] More formally, government funding categories adjusted for disadvantage include the main "Targeted Funding for Educational Achievement", as well as Special Education Grants, a Priority Teacher Supply Allowance, Resource Teachers of Learning and Behaviours, and for funding social workers in schools.

[5] For funding years based on the 2001 census, a sample of students from each school was mapped to meshblocks, while for funding years based on the 2006 census, every student was mapped.

200 people.) The Ministry then collects census data for the meshblocks relevant to each school, but filters the meshblocks to include only those households within them containing school-aged children (aged 5-17). This filtered meshblock census data is then aggregated up to school level, using weights for each meshblock in proportion to the number of the school's children who reside there. For the years relevant to our study (2007 and 2011 school outcomes based on the 2001 and 2006 census variables), the Ministry constructed five socio-economic variables at school level.[6]

1. **Low household income**: the proportion of households with Jensen's equivalised (composition adjusted) income below a cut-off set at the 20th percentile nationally.
2. **No education qualification**: the proportion of adults with no formal education qualifications among households containing school-aged children.
3. **On a benefit:** the proportion of adults receiving any of the Domestic Purposes, Invalid's, Job Seeker, or Sickness Benefits among households containing school-aged children.
4. **Low skill occupation**: for years using the 2001 census, the proportion of those working (aged 15 or older) in low skill occupations according to the NZSCO99 v1 classification system. For the years using the 2006 census, the proportion of those working (aged 15 or older) in low skill occupations according to ANZSCO v1 classification system.
5. **Household crowding**:[7] for years using the 2001 census, the average number of household members per bedroom of households containing school-aged children. For years using the 2006 census, an 'equivalised' measure that adjusts for the age/gender distribution of household members before dividing by the number of bedrooms, and sets a threshold ratio above which households are deemed 'crowded'.

[6] Until 2004, a sixth variable was also used, which was the relative combined percentage of each school's roll which was identified as Maori, Pacific Islander, or a refugee.

[7] For household crowding measures, household size to room ratios are calculated at individual household levels before being aggregated up to meshblock, and then school catchment levels.

For each of the five variables separately, the Ministry then ranks each school's meshblock weighted average values relative to that of all state and state-integrated schools in New Zealand. A school serving students from disadvantaged backgrounds might, for example, be found in the 80th percentile for low household income, 90th percentile for adults with no education qualifications, 70th percentage for households on a benefit, 75th percentile for working adults having low skilled occupations, and 85th percentile for household crowding. The Ministry then sums each school's five percentile values to create a socio-economic status (ses) score (e.g. 80+90+70+75+85 = 400). It thus assigns equal weights to each of the five factors' relative scores at each school.

Finally, the Ministry ranks schools by their overall socio-economic status score. Schools with the highest ten percent of score values (i.e. schools serving the most disadvantaged students) are assigned decile 1, schools with the next ten percent are assigned decile 2, and so on. Because funding per student changes more progressively between the lowest deciles, and to blunt sharp changes to funding based on shifting census results, the Ministry further divides deciles 1 to 4 into 12 'funding steps', so that the 'decile' funding model could more accurately be thought of as an '18 step' funding model.

Funding for each state or state-integrated school among various government categories is adjusted by the funding step assigned to that school, generally starting two years after a census. Commonly, that funding step remains in place five years, until two years after the following census, when the exercise is updated.[8]

The Ministry's current method of assigning funding to each state and state-integrated school based on their relative socio-economic status can be well-motivated by simple economic theory.

[8] Individual schools can appeal their funding step assignment year by year if they believe the demographics of their students are not being accurately reflected. The information provided on the Ministry's website suggests that there is equal likelihood of one's decile rank being upscaled or downgraded after the appeal procedure.

Suppose that there are N schools in New Zealand. Each school *i*'s 'production' of students achieving NCEA Level 2 or better, Q_i, can be modelled as depending on 1) the socio-economic status of its students, 2) the money the school receives from the Ministry of Education, and 3) the effectiveness of each school's specific teachers, Board of Trustees, etc. If we assume that there are just two dimensions of socio-economic status among a school's catchment that affect student outcomes, s_1 and s_2, then school *i*'s production function could be written as

$$Q_i = f_i^{\alpha} * s_{1i}^{\beta} * s_{2i}^{\gamma} * q_i^{\theta} \qquad \text{for i = 1,...., N schools.} \qquad (1)$$

Here f_i refers to the funds school *i* receives, and s_1 and s_2 refer to the two relevant socio-economic dimensions of school *i*'s catchment, and q_i stands for the quality of school *i*'s teachers/trustees. The Greek letters α, β, γ and θ refer to the relative importance of government funding, socio-economic factors 1 and 2, and teacher/trustee quality, to the school's production of graduates with NCEA level 2 qualifications.

The Ministry of Education, reflecting the views of government and society, cares about the qualification achievement rate of school leavers. Since these achievement rates are mediated by individual schools, this can be represented as the Ministry caring both about the *average* achievement rate of schools (wanting it to be as high as possible, given the Ministry's total funding budget), but also about the *variance* (or dispersion) of achievement rates across schools, not wanting disparities to be too large. This trade-off between concern over a high average and low variance can be represented by a "social welfare function" for the Ministry of Education of the form

$$\text{Social Welfare} = \left(\sum_{i=1}^{N} Q_i^{\rho}\right)^{\frac{1}{\rho}} \qquad (2)$$

The specific value judgement the Ministry has in being willing to "trade off" a high average achievement and limiting the disparity of achievement is captured by the Greek letter ρ. At the extremes, if the Ministry cared *only* about average achievement rates, it would set ρ=1. If the Ministry cared *only* about eliminating disparity in achievement, or raising performance at the poorest performing school, it would set ρ to a large negative value, reaching negative infinity. More

typically, if the Ministry cared about both a high average and limited disparity, it would set ρ at an intermediate value. In general, the more the Ministry cared about limiting disparity relative to increasing average achievement, the lower the value of ρ.

Whatever trade-off the Ministry chooses, its problem can then be modelled as choosing the best amount of funding for each school, f_i, to maximise social welfare, subject to its total education funding budget *B*, ($\sum_{i=1}^{N} f_i \leq B$), and subject to each school's education 'production' function. This can be represented as the Ministry choosing f_i for all *i* = 1,…,*N* schools to

Maximise $(\sum_{i=1}^{N} Q_i^{\rho})^{\frac{1}{\rho}}$

Subject to $\sum_{i=1}^{N} f_i \leq B$ (3)

And subject to $Q_i = f_i^{\alpha} * s_{1i}^{\beta} * s_{2i}^{\gamma} * q_i^{\theta}$ for *i* = 1,…,*N* schools

Solving this "constrained optimisation" problem, it can be shown that the Ministry will maximise society's welfare by setting the funding for school *i* as a function of the socio-economic status of its catchment relative to the socio-economic status of other schools' catchments. If we think of school *i* separate from the remaining *j* = 1,….,*N-1* schools, then school *i*'s optimal funding can be expressed as

$$f_i^* = \frac{B}{1+\sum_{j=1}^{N-1}\left(\frac{s_{1i}^{\beta} s_{2i}^{\gamma} q_i^{\theta}}{s_{1j}^{\beta} s_{2j}^{\gamma} q_j^{\theta}}\right)^{\frac{\rho}{\alpha\rho-1}}} \quad . \qquad (4)$$

While the math of equation (4) may appear complex, its meaning is fairly intuitive. School *i*'s optimal funding will be higher if the total Ministry of Education budget (*B*) is higher. Equation (4) also says that if the Ministry of Education cares enough about reducing disparity in school outcomes to set ρ to any negative value (from the possible range of minus infinity to 0), then school *i*'s funding should increase if its catchment has a low socio-economic status relative to other schools. (In such a case, it

also implies that school *i*'s funding should increase if the quality of its teachers or trustees q_i is low relative to that of other schools, assuming such quality is observable to the Ministry.)

While in general the decile funding system used by the Ministry of Education can be supported by standard economic modelling, this does not imply that the specific implementation of the formula is as good as it could be. To illustrate from equation (4), optimal funding for each school might depend on teacher or trustee quality at that school, which the Ministry may not be able to observe. Similarly, optimal funding for each school will require the Ministry to correctly identify *which* dimensions of socio-economic status of school catchments affect (or at least reliably vary with) achievement rates, and to weight those dimensions correctly in terms of their relative importance to educational outcomes (the relative values of α, β, γ and θ.) It is to these practical problems that we now turn.

III. Empirical Estimation Strategy

Any attempt to evaluate empirically the factors and weightings used in the current decile funding formula must take the following constraints into account:

a. There is a funding formula already present that is affecting school achievement rates. It is precisely schools serving disadvantaged students that receive greater funding per student. There is therefore a likely endogeneity between school achievement rates and the funds they receive. This endogeneity must be addressed by accounting for the socio-status of the students that schools serve when they receive their current funding.
b. School leaver qualification achievement rates for a given school in a given year are presumably affected by the funding received by the school in that year, but also in the previous several years that the students attended the school.

c. There are features of the quality of each school's teachers, principal, facilities, and board of trustees, that while unobserved to researchers or the Ministry, almost certainly affect school achievement rates. These unobserved features may be stable over time, or not.
d. The Ministry of Education funds students at a higher level in their upper high school years (years 11-15)
e. Schools receive funding from other non-government sources, such as parental fees ("donations"), fundraising, international full fee students, bequests, etc. These too may effect student achievement.
f. Fewer categories of expenses are funded for state-integrated schools than for state schools, with higher tuition rates for parents making up the difference. (Fully private schools receive no funds from the Ministry, and generally charge yet higher tuition to parents.)

Taking these constraints into account, our empirical estimation strategy is to conduct school fixed effects regressions regarding the proportion of school leavers at each school achieving NCEA Level 2 qualifications or better. We compare individual schools' leaver qualification achievement rates (LQAR's) in 2007 and 2011, based on average funding the school received per student from 2004-2007, and 2008-2011, which in turn were based on census results in 2001, and 2006. We examine to what extent the current five factors (in relative, percentile form) used in the funding model can *still* explain residual variation in schools' LQAR's, after controlling for the funds schools receive under the current system. To the extent that the various factors differ in their residual effects on school achievement rates, we take this as suggestive evidence that the current weights used in the funding system could be improved. Similarly, to the extent that *additional* neighbourhood factors (also in relative, percentile form) not currently in the funding formula can further explain variation in schools' LQAR's, we take this as suggestive evidence that the Ministry might want to include such factors in future revisions of the funding formula, to better target funds to schools with those socio-economic factors that predict low LQAR's. More formally, we regress

$$LQAR_{i,t} = \beta_0 + \beta_1 AveFundingStep_{i,\bar{t}} + \beta_2 AveGovFundsPerSt_{i,\bar{t}} + \beta_3 AveOthFundsPerSt_{i,\bar{t}}$$
$$+\beta_4 \Pr opStudents11-15_{i,\bar{t}} + D_1 Integrated_{i,t} + \beta_5 LowHHIncome_{i,t-6} + \beta_6 LowSkillOccup_{i,t-6} \quad (1)$$
$$+\beta_7 HHCrowding_{i,t-6} + \beta_8 LowEduc_{i,t-6} + \beta_9 OnBenefit_{i,t-6} + \beta_{10} OtherNeighVar_{i,t-6} + \alpha_i + u_{i,t}$$

where *i* = 1,…,N schools, *t* = 2007 or 2011, and $\bar{t} = (2004 + 2005 + 2006 + 2007)/4$ or $(2008 + 2009 + 2010 + 2011)/4$.

Note that while the average funding step assigned to a school, and its average government funds received per student, will be positively correlated, the correlation will not be perfect, given that not all school funding categories are adjusted by funding step. Of prime interest here is whether the coefficients β_5, β_6, β_7, β_8 or β_9 differ significantly from each other, and whether any additional school catchment variables β_{10} are significant in explaining variation in school LQAR's. Other neighbourhood-based variables we investigate by theme are:

a. Crime and General Health (Proxied by Mortality Rates)

- total recorded offences per 10,000 population, mapped from 282 New Zealand Police Station boundaries to schools' meshblocks
- age- and sex- adjusted mortality rates as a proxy for health, from the New Zealand Ministry of Health, mapped from 2019 area units to schools' meshblocks. Version 1 is the age- and sex- standardized mortality rate, while Version 2 is the ratio of deaths to expected deaths given national levels and the area units' age and sex distribution.

b. Rural vs. urban

- proportion of school's students' meshblocks that are "rural or secondary urban"
- proportion of school's students' meshblocks that are "rural"

c. Residential stability

- average years since arrival in New Zealand for immigrants in schools' catchment
- proportion of school's meshblocks' individuals not at same residence 5 years earlier
- proportion of schools' meshblocks' individuals not born in New Zealand
- proportion of households in schools' meshblocks not owner-occupied

d. Family stability

- proportion of schools' meshblocks children living in single parent families
- proportion of adults in schools' meshblocks not partnered (neither married nor *de facto*)
- proportion of adults in schools' meshblocks whose legal marital status is not married (i.e. single, separated, divorced or widowed)
- proportion of partnered adults in schools' meshblocks who are not legally married

e. Labour force

- proportion of individuals 15 year+ in schools' meshblocks who are unemployed
- proportion of individuals 15 year+ in schools' meshblocks who are not in the labour force
- proportion of individuals 15 years + in schools' meshblocks unemployed or not in LF

f. Ethnicity, Language, and Religion

- proportion of schools' meshblocks' reported ethnic affiliations Maori
- proportion of schools' meshblocks' reported ethnic affiliations Pacific Islander
- proportion of schools' meshblocks' reported ethnic affiliations Maori or Pacific Islander
- proportion of schools' meshblocks' individuals who cannot speak English
- proportion of schools' meshblocks' reported religious affiliations that are "Christian", "No Religion", or "Other Religion"

It is important to note that many of these factors may be considered proxies for unobserved individual level characteristics that influence students' success at school. Moreover, even if it were socially undesirable for the Ministry to include any of the above additional factors in revisions to the funding formula, a correct estimate of the residual effects of the current five factors ($\beta_5 \ldots \beta_9$) requires that other relevant effects be included in (1) to minimize omitted variable bias.

While the fixed effect term α_i in equation (1) controls for time-invariant unobserved school characteristics that are affecting LQAR's, we also control for time-varying unobserved school characteristics by adding specifications with a lagged dependent variable, $LQAR_{i,t-1}$.[9]

Finally, challenges arise because several aspects of the funding formula implementation changed between the years using the 2001 census and the years using the 2006 census. For the years 2004 to 2007, the Ministry of Education mapped the 2001 meshblock characteristics of a *sample* of students from each school, whereas for the years 2008 to 2011, the Ministry mapped the 2006 meshblock characteristics of the entire *population* of students at each school. Second, for household crowding, the Ministry switched from a simple ratio of "household size/number of bedrooms" to an equivalised crowding index. Third, to measure employment in low skill occupations, the Ministry switched from a crude measure of "low skill" based on the NZSCO99 occupation classification system to more sophisticated ways of measuring skill using both the NZSCO99 and ANZSCO classification systems. Given that our estimation strategy requires us to follow schools using the most consistent measures possible, we have done as follows: 1) for crowding, we have calculated the more sophisticated equivalised crowding measure for the 2001 census, 2) for low skill, we have calculated the less sophisticated occupation classification system for the 2006 census. We have not adjusted for the change from school sample- to school population-based mapping to meshblocks, seeing no feasible way to do so.

IV. Results

We begin by providing descriptive statistics for our data. Recall that in all cases, the unit of observation is each state or state-integrated school containing students in years 11-15. Table 1 describes all variables tried in our analysis over both waves pooled, using a 'common sample' of non-

[9] A lagged dependent variable is included in empirical papers to (a) allow observed X's to have effects that extend beyond the current period, (b) to correct for serial correlation, and (c) control for omitted variables.

Table 1: Descriptive Statistics for All Variables, Pooled Over 2007 (2001 Census) and 2011 (2006 Census)

Variable	N	Mean	St. Dev.	Min	Max
LQAR NCEA2 or Higher (Paper based)	789	0.707022	0.190335	0	1
Lag LQAR NCEA2 or Higher (Paper based)	790	0.64853	0.224316	0	1
Ave Funding Step (High = fewer $) last 4 years	834	11.43345	5.049908	1	18
Ave Real Gov't Funds Per Student last 4 years	810	7772.544	2614.824	3826.964	22281.85
Ave Real Other Funds Per Student last 4 years	810	1242.508	752.3647	138.1345	5250.229
Ave Proportion of Roll Yrs. 11-15 last 4 years	825	0.417833	0.175394	0	0.9
Dummy - School is Integrated?	840	0.220238	0.414654	0	1
Low Household Income (Percentile)	808	51.81559	26.27727	0	99
Low Skill Occupation (Percentile)	808	52.70792	25.76596	1	99
Household Crowding (Percentile)	808	52.81559	25.103	0	99
No Educ Qualif. Adults (Percentile)	808	50.19554	27.59912	0	99
On Benefit (Percentile)	808	53.16955	26.11071	0	99
Crime Offences Per 10000 (Percentile)	808	51.46658	25.92614	0	99
Age-standardized Mortality Rt (Percentile)	808	51.53094	25.98887	0	99
Ratio deaths/expected Mortality (Percentile)	808	51.53342	25.98525	0	99
Rural or Secondary Urban (Percentile)	808	49.63614	26.92909	0	85
Rural (Percentile)	808	50.72772	27.94556	0	88
Yrs Since Arrival in NZ (Percentile)	807	50.89715	25.71307	0	99
Not Same Res. 5 Yrs Ago (Percentile)	808	49.7797	24.42019	0	99
Share not born in NZ (Percentile)	808	50.18936	27.0511	0	99
Share not own home (Percentile)	808	50.67203	24.23051	0	99
Share children in fam w 1 parent (Percentile)	808	50.82797	24.26105	0	99
Share not partnered (Percentile)	808	50.0755	24.55135	0	99
Share not married (Percentile)	808	50.38243	24.94531	0	99
Share of partnered not married (Percentile)	808	50.97153	25.7391	0	99
Share unemployed (Percentile)	808	52.39356	24.88673	0	99
Share not in labour force (Percentile)	808	51.26609	25.04667	0	99
Share unem or not in LF (Percentile)	808	51.36262	25.35817	0	99
Share ethnic affiliation Maori (Percentile)	808	51.47153	27.43963	0	99
Share ethnic affiliation Pacific (Percentile)	808	52.88985	26.02718	0	99
Share ethnic aff Maori or Pacific (Percentile)	808	51.80446	26.15261	0	98
Share can't speak English (Percentile)	808	52.78218	25.54695	0	99
Share Christian Affiliation (Percentile)	808	48.7203	24.74992	0	99
Share No Rel Affiliation (Percentile)	808	49.8354	25.61518	0	99
Share Other Rel Affiliation (Percentile)	808	52.51609	25.83989	0	99

Table 2: Descriptive Statistics for Main Variables, Pooled Over 2007 (2001 Census) and 2011 (2006 Census)

Variable	N	Mean	St. Dev.	Min	Max
LQAR NCEA2 or Higher (Paper based)	751	0.710611	0.191331	0	1
Lag LQAR NCEA2 or Higher (Paper based)	744	0.651263	0.223862	0	1
Ave Funding Step (High = fewer $) last 4 years	751	11.66578	4.950958	1	18
Ave Real Gov't Funds Per Student last 4 years	751	7691.106	2506.25	3826.96	22281.9
Ave Real Other Funds Per Student last 4 years	751	1269.896	760.8392	160.337	5250.23
Ave Proportion of Roll Yrs. 11-15 last 4 years	751	0.437889	0.154307	0	0.89255
Dummy - School is Integrated?	751	0.22237	0.416116	0	1
Low Household Income (Percentile)	751	50.46605	25.96081	0	99
Low Skill Occupation (Percentile)	751	51.67909	25.66309	1	99
Household Crowding (Percentile)	751	52.50067	24.90627	0	99
No Educ Qualif. Adults (Percentile)	751	48.67111	27.14916	0	99
On Benefit (Percentile)	751	51.77896	25.77087	0	99
Rural or Secondary Urban (Percentile)	751	49.84554	26.47646	0	85
Share not own home (Percentile)	751	50.5992	23.98906	0	99
Share not partnered (Percentile)	751	49.91212	24.22649	0	99
Share ethnic affiliation Maori (Percentile)	751	50.65113	27.24889	0	99

private schools containing upper year students. Table 2 describes only those variables that are included in our main extended model regressions, with the exact sample of schools used in those regressions. For both tables, note that the socio-economic variables are in relative percentile form (just as they are when they enter the funding formula), and that percentiles are calculated (just as done by the Ministry) based on a larger population of schools that includes primary and intermediate schools.

One issue of concern, both for the validity of the current funding formula, and of our estimation exercise, is the extent to which the current five socio-economic factors are sufficiently uncorrelated with each other. At the logical extreme, if the five measures of disadvantage were perfectly or very highly correlated, there would be no benefit to using five rather than one factor in the funding formula. In addition, our ability to estimate separate residual effects of each factor on LQAR's would be compromised; coefficient estimates would have large variances (making us too likely to accept they have no residual effect), and be sensitive to small changes in the data. Fortunately for the Ministry, pairwise correlations between the five factors (over all schools over

which scores are calculated) are moderately high, but not extremely so. In our pooled sample based on the 2001 and 2006 census, the highest correlation is 0.845, between the percentiles for low household income and the proportion on a benefit.[10] Not quite as fortunately for our estimation, pairwise correlations between the five factors over only those schools containing students in years 11-15 are slightly higher. The highest correlation, again between the percentiles for low household income and the proportion on a benefit, is 0.913.[11]

Some final preliminaries concern using fixed effects vs. pooled cross section specifications, and using robust standard errors. While fixed effects specifications as in (1) have the considerable advantage that they control for *unobserved* school quality characteristics that affect LQAR's, they have the drawback that the effect of constant or barely changing *observed* school characteristics (like being integrated) may not be identifiable. For every specification, we thus also present analogous pooled cross section regressions in Appendix I, though recognizing they will suffer from considerable omitted variable bias. Second, by comparing results using regular standard errors (that assume homoscedasticity) with those from using robust standard errors (that assume hetero-scedasticity of unspecified form), we find that standard errors change enough to cause a few variables to pass from having significant to insignificant effects. We thus assume heteroscedasticity is present in the data, and use robust standard errors throughout.

All of our main results are presented in Table 3. Our baseline model (1) restricts the neighbourhood measures to only the five used in the current funding formula. Model (1) results show that a $100 increase in government funding per student in each of the four years prior to leaving school would increase the proportion of school leavers achieving NCEA Level Two or better

[10] The next highest correlations are between percentile of households receiving a benefit and having no education qualifications (0.764); percentile with low skill occupations and no education qualifications (0.737); and percentile with low household income and no education qualifications (0.737).

[11] For our restricted sample of schools containing year 11-15 students, the next highest correlations are between percentile receiving a benefit and no education qualification (0.858), percentile low income and no education qualification (0.837), and percentile low skill occupation and no education qualification (0.818).

Table 3: Fixed Effects Regressions for Proportion of Schools' LQARs of "NCEA Level 2 or Higher"

Variable	Model 1 Baseline	Model 2 Baseline with Lag	Model 3 Extended	Model 4 Extended with Lag
Ave Funding Step (High = fewer $) last 4 years	0.00431	-0.00249	0.00798	0.00191
	[0.00920]	[0.00800]	[0.00902]	[0.00813]
Ave Real Gov't Funds Per Student last 4 years	3.88e-05***	2.20e-05**	4.06e-05***	2.42e-05***
	[1.06e-05]	[9.98e-06]	[9.14e-06]	[8.95e-06]
Ave Real Other Funds Per Student last 4 years	-1.70E-05	-2.50E-05	-2.48E-05	-3.14e-05*
	[1.81e-05]	[1.76e-05]	[1.81e-05]	[1.74e-05]
Ave Proportion of Roll Yrs. 11-15 last 4 years	1.256***	0.806**	1.246***	0.794**
	[0.395]	[0.337]	[0.384]	[0.332]
Low Household Income (Percentile)	-0.00225**	-0.00155	-0.00199**	-0.00142
	[0.00107]	[0.00104]	[0.000923]	[0.000924]
Low Skill Occupation (Percentile)	0.000416	0.000101	0.000201	-6.53E-05
	[0.00107]	[0.000934]	[0.00101]	[0.000907]
Household Crowding (Percentile)	0.000149	0.00022	7.03E-05	0.000138
	[0.000346]	[0.000319]	[0.000347]	[0.000326]
No Educ Qualif. Adults (Percentile)	0.00285	0.00298	0.00298	0.00313*
	[0.00190]	[0.00189]	[0.00190]	[0.00186]
On Benefit (Percentile)	-0.000165	-0.000649	-0.000156	-0.000622
	[0.00155]	[0.00159]	[0.00138]	[0.00140]
Share adults not partnered (Percentile)			-0.00217***	-0.00202***
			[0.000513]	[0.000531]
Share Rural or Secondary Urban (Percentile)			-0.00147***	-0.00132***
			[0.000503]	[0.000504]
Share not own home (Percentile)			0.00128**	0.00133**
			[0.000600]	[0.000651]
Share ethnic affiliation Maori (Percentile)			0.000727	0.000574
			[0.000712]	[0.000710]
Lag LQAR NCEA2 or Higher (Paper based)		0.272***		0.271***
		[0.0762]		[0.0667]
Constant	-0.212	0.0222	-0.179	0.0364
	[0.177]	[0.157]	[0.190]	[0.178]
N (observations)	751	744	751	744
N (schools)	409	404	409	404
R^2 (within)	0.300	0.348	0.356	0.399

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

by .3 percentage points (at sample mean, from 71.06 to 71.36 percent). When government funds per students are controlled for, the average funding step assigned to each school does not have significant residual effects on LQAR's.[12] Surprisingly, within-school variation in real non-government funds per student does not have a significant effect on LQAR's. Consistent with the Ministry of Education providing more funding per student for year 11-15 students, (and also possibly to the beneficial effects for upper year students of having more such students at their school), schools with a one percentage point higher share of year 11-15 students also have 1.26 percentage point higher LQAR's on average.[13]

Turning to the key issue of the residual effects of the five socio-economic factors, model (1) reveals that the percentile of the schools' students' meshblocks with low household income persists in having a negative association with schools' LQAR rates. In particular, with the current funding regime in place, an increase in one percentile in low household income lowers LQAR's by .225 percentage points. None of the other four factors has a residual effect on LQARs that is statistically significant. (In fact, three factors – occupation, education, and crowding, have the 'wrong' sign, but are not significantly different from zero.) Taken in isolation, this would suggest that the factor of relative 'low household income' should receive a higher weight in the decile funding formula than its current equal weight with the other four factors.

Shifting to model (2), we include the one year lag of school LQARs. In simple linear fixed effects, introducing a lagged dependent variable creates the statistical problem that it could be correlated with the school fixed effects term α_i, making coefficient estimates inconsistent (Greene, p. 307, 2003). Even so, adding lagged achievement helps to account for unobserved school characteristics that affect LQAR's over time. With lagged LQAR's controlled for, government funds

[12] We cannot use this result to disprove that high decile schools use their assigned decile to attract better teachers or more able students, because such unobserved school characteristics are picked up by the fixed effect.

[13] This finding likely also reflects an urban/rural distinction, as comprehensive year 1-15 schools in rural areas have proportionately fewer year 11-15 students.

per student and proportion of students in years 11-15 continue to raise LQAR's, while low household income ceases to have a significant residual effect in lowering them.

To pursue the second primary objective of this research, we then tried adding each of the 21 additional neighbourhood variables listed in section 3, to see if any had additional explanatory power regarding school LQAR's. For each candidate variable, our method was to use the two filters of 1) whether including a given variable reduced the Akaike information criterion score (Greene 2003), and 2) whether the given variable was significant at the 5% level or better. Variables that passed both tests were retained in our 'extended' model (3). In the case of measures of family stability, three similar measures performed well: the proportion of schools' meshblocks' adults in households containing school-aged children who were not partnered, the proportion whose legal marital status was "not married" (i.e. divorced, separated, or single), and the proportion of children living in families with one parent. Of these, the variable that lowered the Akaike information criteria score the most was the proportion non-partnered, so we used that. Other factors that passed both filters were the proportion of schools' meshblocks that were "not main urban" (i.e. that were rural or secondary urban), and the proportion in schools' meshblocks who did not own their own home. One variable that passed neither filter was the proportion reporting a Maori ethnic affiliation. We have chosen to retain this final variable to demonstrate this, because cross section regressions (in Appendix IA) and simple descriptive statistics and observer commentary might suggest that Maori affiliation would be negatively associated with LQAR's.

In our resulting extended model (3), we see that government funds per student and proportion of roll in years 11-15 continue to raise LQAR's, while low household income continues to lower them. But we also see that a one percentile increase in the proportion of non-partnered adults in the schools' meshblocks containing school-aged children decreases LQARs by .2 percentage points. A one percentile increase in the proportion of the schools' meshblocks classified as rural/secondary urban decreases LQARs by .1 percentage points. More surprisingly, we find lower

home-ownership rates associated with *higher* LQARs; a one percentile increase in the proportion of the schools' meshblocks households who did not own their own homes increased LQARs by .1 percentage points. As mentioned, despite conventional wisdom to the contrary, with socio-economic disadvantage and unobserved but stable school quality characteristics controlled for, we find no evidence that the share of schools' meshblocks claiming Maori ethnic affiliation had any significant residual effect on LQARs. The results of Model (3) suggest that, in addition to the five factors contained in the current funding formula, the Ministry might want to consider also accounting for

1) family stability, in the form of the proportion of school meshblocks containing school-aged children where the adults are either "not partnered", or "single parent", or whose current legal marital status is "not married"

2) the rural/secondary urban/main urban status of school meshblocks

3) the proportion of households in school meshblocks that are owner-occupied.

Conversely, the Ministry's decision from 2005 onward to remove ethnic affiliation as an additional consideration from the decile formula looks well-supported, despite the apparent disparities in LQARs by simple ethnic grouping. Finally, model (4) shows that when we add a lag of school LQAR to the extended model, government funds and proportion of roll in years 11-15 remain significant, as do the percentile non-partnered, not main urban, or who own their own home. As when the lag was added to the baseline model, however, the proportion with low household income loses its significant residual effect.

4.a. Do Crime and Health Have Residual Effects on Achievement Rates?

A specific undertaking of the project was to investigate the effects on school achievement of neighbourhood characteristics not sourced from the census. As mentioned, we collected data on total recorded offences per 10,000 people from the New Zealand Police at police station level in

Table 4: Fixed Effects Regressions Testing for Crime and Health Proxies

VARIABLES	Model 1 Mortality Measure 1	Model 2 Mortality Measure 2
Ave Funding Step (High = fewer $) last 4 years	0.00576	0.00576
	[0.00900]	[0.00900]
Ave Real Gov't Funds Per Student last 4 years	3.84e-05***	3.84e-05***
	[1.05e-05]	[1.05e-05]
Ave Real Other Funds Per Student last 4 years	-2.09E-05	-2.09E-05
	[1.86e-05]	[1.86e-05]
Ave Proportion of Roll Yrs. 11-15 last 4 years	1.259***	1.259***
	[0.394]	[0.394]
Low Household Income (Percentile)	-0.00234**	-0.00234**
	[0.00101]	[0.00101]
Low Skill Occupation (Percentile)	0.000279	0.00028
	[0.00109]	[0.00109]
Household Crowding (Percentile)	0.000125	0.000125
	[0.000349]	[0.000349]
No Educ Qualif. Adults (Percentile)	0.00306*	0.00306*
	[0.00186]	[0.00186]
On Benefit (Percentile)	0.00011	0.00011
	[0.00146]	[0.00146]
Rate of overall crime per 10000	8.48E-05	8.48E-05
	[0.000373]	[0.000373]
Mortality 1: deaths/expected deaths	-0.000618	
	[0.000387]	
Mortality 2: Age- and sex standardized		-0.000617
		[0.000387]
Constant	-0.207	-0.207
	[0.177]	[0.177]
N (observations)	751	751
N (schools)	409	409
R^2 (within)	0.305	0.305

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

2001 and 2006, as well as data from the Ministry of Health on age- and sex-adjusted expected and actual mortality rates at the area unit level for the same years. Adjusted mortality rates serve as a proxy for general health in students' families, which might affect their studies.

The results of trying both measures are provided in Table 4. In general, neither crime nor the mortality rate has a significant residual effect on LQAR's. It is hard to know if this is because they truly have no residual effect on LQAR's not already captured by existing measures of disadvantage, or because both measures were available only at levels much coarser than meshblock – either the much coarser police station boundary (crime), or the somewhat coarser area unit boundary (mortality). We note that, of the two, mortality rates were much closer to having discernible negative effects on LQAR's, being not far off from significance at the 10% level despite the aggregated loss of information. Based on this suggestive evidence, it might be worthwhile for the New Zealand census to include some measure of general health in future rounds, so that this information could be available at meshblock level for the decile funding exercise.

5. Discussion and Conclusions

New Zealand is acknowledged to have a very strong publicly funded education system, made all the more impressive by the modest sums spent by the government on education in comparision to wealthier OECD countries. Yet concerns persist about the relatively strong effect of socio-economic status on student outcomes. These concerns are addressed through New Zealand's "decile" funding system, which adjusts per-student funding per school according to five socio-economic factors. We have tried to use some standard econometric techniques to estimate whether the five factors used in the current funding system are optimally weighted, and whether other neighbourhood-based socio-economic factors ought to be included. We have done this using school fixed-effects regressions that estimate the residual effects of the five factors, and other factors, on the school leaver qualification achievement rates of each state or state-integrated school, with the current funding system already in place. Using school-fixed effects regressions (that follow

individual schools over time) is important, as it enables us to control for unobserved but stable school quality characteristics (of teachers, trustees, and facilities) that doubtless affect student achievement.

Using this approach, we have found that the only socio-economic factor of the five currently in the funding model to retain a significant residual effect on achievement rates with the current funding system in place is the percentile of low-income households served by each school. In particular, a one percentile increase in a school's rank for serving low-income households is associated with a .2 percentage point decrease in its NCEA Level Two or better qualification achievement rate, all else equal. This might suggest that future revisions to the funding formula put greater weight on low household income, relative to the other four factors.

In our investigation of whether other observable neighbourhood factors should be added, we considered 21 additional ones to see if they had additional explanatory power regarding achievement rates. In the negative, we did *not* find that the relative share of Maori or Pacific ethnic affiliation had explanatory power once existing socio-economic factors were controlled for, despite the large variation in achievement rates that appear in New Zealand between ethnic groups when these other factors are ignored. We similarly did NOT find that achievement rates varied by relative crime or adjusted mortality rates, though the latter was 'near' significance at the 10 percent level, and neither neighbourhood measure was available at a level nearly as detailed as meshblock.

In the positive, we found three additional neighbourhood factors that in relative (percentile) form had residual negative explanatory power for schools' qualification achievement rates:

1) family instability as measured either by share of households containing school-aged children with non-partnered adults, or share of children in families with a single parent, or share of households containing school-aged children with adults whose legal marital status was 'not currently married' (i.e. single, divorced, or separated)

2) rural or secondary urban rather than main urban status of meshblocks containing children attending schools

3) households with school-aged children being owner-occupied rather than rented.

The negative direction of effect for home-ownership is unexpected, and may reflect unobserved neighbourhood factors correlated with home-ownership, such as a lower price of housing in more economically depressed areas, or areas with less well-regarded schools. The significant residual effect of these additional factors might suggest that some or all of them should be considered for inclusion in future revisions of the decile funding formula.

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Appendix IA: Cross Section Regressions for Proportion of Schools' LQARs "NCEA Level 2 or Higher"

Variable	Model 1 Baseline	Model 2 Baseline with Lag	Model 3 Extended	Model 4 Extended with Lag
Ave Funding Step (High = fewer $) last 4 years	0.000286	-0.000894	0.000887	-0.000581
	[0.00425]	[0.00350]	[0.00423]	[0.00342]
Ave Real Gov't Funds Per Student last 4 years	1.65e-05***	9.50e-06**	1.67e-05***	9.28e-06**
	[5.54e-06]	[3.86e-06]	[5.30e-06]	[3.75e-06]
Ave Real Other Funds Per Student last 4 years	1.11E-05	-3.95E-06	1.23e-05*	-3.11E-06
	[7.16e-06]	[5.97e-06]	[7.27e-06]	[6.23e-06]
Ave Proportion of Roll Yrs. 11-15 last 4 years	0.0364	-0.105**	0.0436	-0.0955*
	[0.0618]	[0.0504]	[0.0611]	[0.0498]
Integrated rather than State School?	0.103***	0.0525***	0.105***	0.0562***
	[0.0162]	[0.0138]	[0.0158]	[0.0134]
Low Household Income (Percentile)	-0.000291	-0.000834	-0.000554	-0.00108*
	[0.000713]	[0.000558]	[0.000712]	[0.000559]
Low Skill Occupation (Percentile)	0.000133	0.000504	-0.00023	0.000204
	[0.000483]	[0.000409]	[0.000529]	[0.000468]
Household Crowding (Percentile)	0.000651**	0.000196	0.000603**	0.000162
	[0.000280]	[0.000227]	[0.000294]	[0.000239]
No Educ Qualif. Adults (Percentile)	-0.00282***	-0.00203***	-0.00242***	-0.00176***
	[0.000705]	[0.000533]	[0.000742]	[0.000585]
On Benefit (Percentile)	-0.000828	0.000298	-0.000452	0.000641
	[0.000785]	[0.000560]	[0.000808]	[0.000564]
Share adults not partnered (Percentile)			-0.000814**	-0.000840***
			[0.000365]	[0.000280]
Share Rural or Secondary Urban (Percentile)			0.000133	-0.000224
			[0.000350]	[0.000305]
Share not own home (Percentile)			0.00114***	0.000759**
			[0.000385]	[0.000326]
Share ethnic affiliation Maori (Percentile)			-0.000604*	-0.000298
			[0.000350]	[0.000330]
Lag LQAR NCEA2 or Higher (Paper based)		0.486***		0.484***
		[0.0487]		[0.0474]
Constant	0.681***	0.462***	0.670***	0.483***
	[0.103]	[0.0907]	[0.105]	[0.0905]
N	751	744	751	744
R^2	0.314	0.555	0.328	0.564

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Appendix IB: Cross Section Regressions Testing for Crime and Health Proxies

VARIABLES	Model 1 Mortality Measure 1	Model 2 Mortality Measure 2
Ave Funding Step (High = fewer $) last 4 yea	0.000632	0.000631
	[0.00424]	[0.00424]
Ave Real Gov't Funds Per Student last 4 yeai	1.66e-05***	1.66e-05***
	[5.60e-06]	[5.60e-06]
Ave Real Other Funds Per Student last 4 yea	1.12E-05	1.12E-05
	[7.21e-06]	[7.21e-06]
Ave Proportion of Roll Yrs. 11-15 last 4 years	0.0393	0.0393
	[0.0619]	[0.0619]
Integrated rather than State School?	0.105***	0.105***
	[0.0159]	[0.0159]
Low Household Income (Percentile)	-0.000311	-0.000311
	[0.000722]	[0.000722]
Low Skill Occupation (Percentile)	5.20E-06	5.41E-06
	[0.000482]	[0.000482]
Household Crowding (Percentile)	0.000638**	0.000638**
	[0.000287]	[0.000287]
No Educ Qualif. Adults (Percentile)	-0.00266***	-0.00266***
	[0.000718]	[0.000718]
On Benefit (Percentile)	-0.000773	-0.000773
	[0.000793]	[0.000793]
Rate of overall crime per 10000	-7.62E-05	-7.63E-05
	[0.000233]	[0.000233]
Mortality 1: deaths/expected deaths	-0.000275	
	[0.000266]	
Mortality 2: Age- and sex standardized		-0.000274
		[0.000266]
Constant	0.690***	0.690***
	[0.103]	[0.103]
N	751	751
R^2	0.315	0.315

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1