DEPARTMENT OF ECONOMICS AND FINANCE

COLLEGE OF BUSINESS AND ECONOMICS

UNIVERSITY OF CANTERBURY

CHRISTCHURCH, NEW ZEALAND

Evaluating the Returns to Funding Different Measures of Student Disadvantage: Evidence From New Zealand

***NOTE**: This paper is a revision of University of Canterbury WP No. 30/2014, "Evaluating the Weights and Factors Used in the New Zealand School Decile Funding System"*

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WORKING PAPER

No. 10/2015

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Evaluating the Returns to Funding Different Measures of Student Disadvantage: Evidence From New Zealand

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May 6th, 2015

Abstract: Much of the education finance literature is concerned with evaluating policies that seek to lessen the effect of economic disparities outside schools on the disparity of student outcomes within them. Examples include school finance reform to reduce schools' reliance on local wealth, special education funding for students with physical or learning disabilities, and affirmative action admissions and support. A national funding programme used in New Zealand for all elementary and high schools provides a rare opportunity to evaluate the effectiveness of targeting alternative measures of socio-economic disadvantage. New Zealand targets five deprivation factors of the immediate neighbourhoods in which a school's students live: low household income, lack of educational qualifications, employment in low skill occupations, household crowding, and the proportion receiving welfare. We use school fixed effects regressions to evaluate whether some disadvantage factors are more effective in raising achievement than others, and secondarily whether other measurable factors such as family structure, health or ethnicity retain strong negative covariance with achievement rates. We find that the marginal effectiveness of targeting "low skill occupation" is comparatively high, and of targeting "receiving welfare" is comparatively low, such that New Zealand would raise achievement rates if it raised the weight on the former and lowered it on the latter. In addition to the five disadvantage factors used, we find that single parent status, rural/urban status, and home ownership co-vary significantly with achievement rates.

JEL Classifications: H52, I22, I24, I28

Disclaimer: The census data in this study was provided by Statistics New Zealand under conditions designed to give effect to the security and confidentiality provisions of the 1975 Statistics Act. Results presented are the work of the authors, not Statistics New Zealand.

Acknowledgements: We thank the following for their help in providing data for this project: Marian Loader, Michael Parkin, Raewyn Glover, and Tony Booth (Ministry of Education); Kirsten Nissen, Fiona Wharton, Joy O'Connell, Andrew McClaren and Rosemary Goodyear (Statistics New Zealand); Christopher Bowie (data from the Ministry of Health); Gavin Knight, Cameron Dewe, and Obert Cinco (New Zealand Police). For helpful feedback on our paper we thank Bob Reed, Andrea Menclova, Julie Berry-Cullen, Berk Osler, Jane McChesney, and seminar participants at the University of Otago, the New Zealand Ministry of Education, and Victoria University at Wellington. We acknowledge financial support from the School of Business and Economics at the University of Canterbury.

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1. INTRODUCTION

One of the enduring priorities in the education finance literature has been evaluating policies that seek to raise the achievement of disadvantaged students. Crafting public education systems that build human capital among disadvantaged students has been widely seen by policy makers or courts as crucial for offsetting self-perpetuating inequality of income and wealth, family stability, neighbourhood amenities and opportunities in higher education and employment. The argument is sometimes cast in moral terms as funding "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.[1] This implies the need for "differences in resource allocation based on legitimate differences between individuals" (e.g. Underwood (1995)). The argument is other times cast in efficiency terms, as under-achievement from disadvantaged students leads to poorer labour force quality and lower economic growth (Hanushek and Woessman, 2012; Hanushek and Kimko, 2000).

Major examples of policies proposed and evaluated for addressing disadvantaged students include school finance reform in the United States, where primarily local financing of schools through property taxes has led to court challenges regarding insufficient funding of schools in lower income districts (Card and Payne, 2002; Jackson, Johnson and Persico, 2014). Other examples include the introduction of school choice/vouchers (Hsieh and Urquiola, 2006; Cullen, Jacob, Levitt, 2006), special education funding for students with physical or learning disabilities (Hanushek, Kain and Rivkin, 2002), and at university level, affirmative action in the selection or support of students by ethnicity, sex, income, and other factors (Hinrichs, 2012).

Yet when seeking to improve the educational outcomes of disadvantaged students, an important question for policy makers is *which* measurable dimensions of disadvantage to target for

[1] Empirically, many studies have found that the cost of educating disadvantaged students is higher (see for example Downes and Pogues, 1994; Reschovsky and Imazeki, 2001). Ladd and Fiske (2001) propose causal explanations why.

greatest effect. Test scores or graduation rates may vary on average between students based on their disabilities, range of schools available, or by their parents' income, education, ethnicity/race, marital status, neighbourhood amenities, and so on. In some jurisdictions, policy makers may have access to high quality data on the specific students/families enrolled in each school, but only for a limited range of socio-economic factors (Rivkin, Hanushek and Kain, 2005). This paper contributes to the literature by focussing on New Zealand, where policy makers have access to a much broader range of socio-economic characteristics for the immediate census neighbourhoods of the children enrolled in each school.

We exploit the structure and available data from the New Zealand national school funding system to address the relative effectiveness of targeting funding across five measures of socio-economic disadvantage on raising high school qualification achievement rates. The five measures of disadvantage are low household income, lack of educational qualifications, employment in low skill occupations, household crowding, and the proportion receiving welfare. To control for unobserved school-level characteristics that affect achievement rates, we use school fixed effects regressions to evaluate whether some disadvantage factors are more effective than others in raising school achievement rates. To control for the endogeneity of greater school funding flowing to schools with students from disadvantaged neighbourhoods, we control for the same relative measures of disadvantage that feed into the funding formula. Secondarily, we also test whether other measurable factors such as family structure, immigrant status, health or ethnicity co-vary with achievement rates once the current five factors are controlled for.

We find that the marginal effectiveness of targeting extra funding to schools serving students from neighbourhoods with a relatively high proportion in "low skill occupations" is comparatively high, while the effectiveness of targeting schools serving students from neighbourhoods with a relatively high proportion "receiving welfare" is comparatively low. This may suggest that, from a starting point of equally weighting disadvantage factors, government funding

via schools is being more effective in raising achievement rates by targeting children from low skill occupation households than children from households receiving welfare. Finally, in addition to the five disadvantage factors used, we find that single parent status and rural/urban status co-vary significantly with achievement rates, though we lack evidence regarding whether targeting funding according to these factors would be effective in raising achievement rates. Given that a major grounds for receiving welfare in New Zealand is single parent status, and single parent status retained additional significant covariance with lack of achievement, we speculate that government funding may be showing greater effect when targeting low skill occupation households than households on welfare because of greater available parental time and support of childrens' education in two parent households. Finally, neighbourhood crime and mortality rates did not significantly covary with achievement, but this is possibly because the data was available at a higher level of aggregation. Hence, it might be worth focussing on these variables in the future if better data were available. For other countries, our findings suggest that allocating state or national "disadvantage funding" to schools serving the children of families disproportionately in low skilled occupations might be a promising avenue for raising student outcomes. It also suggests attention should be given to evaluating the efficacy of central funding targeted to schools serving the children of rural or single parent families in raising student outcomes.

The remainder of the paper is structured as follows. In Section 2 we consider how school funding operates in New Zealand and is adjusted for disadvantage – the "decile" funding system. In Section 3 we present our empirical estimation strategy, while in Section 4 we present our results. Section 5 concludes the paper with a discussion of our findings.

2. EDUCATION FUNDING IN NEW ZEALAND AND A THEORY OF OPTIMAL FUNDING

Among the 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.[2]

The same 2009 PISA results showed, however, that reading performance differed more between those of different socio-economic backgrounds in New Zealand 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). Disparities exist also by ethnicity. For example, the proportion of high school leavers identifying as Asian who achieved at least "National Certificate of Educational Achievement (NCEA) Level 2" qualifications in 2012 was 87%, compared to 79.6% for Europeans, 64.8% for Pacific, and 54.6% for Maori (Ministry of Education 2013).[3] The country's Ministry of Education has identified the country's unequal achievement distribution as "the greatest challenge facing the schooling sector" (Ministry of Education 2011a).

Of course, the issue of whether increasing funding of schools will raise student achievement in general, or for disadvantaged students in particular, is notoriously contentious in the international education literature (see, for example, the Coleman Report (1966), Hanushek (1986), Hedges, Greenwald and Laine (1994), Kruger (1999), Nye, Konstantopoulos and Larry (2004), and Konstantopolous and Borman (2011)). Relevant here, Konstantopolous and Borman (2011) revisit the question of funding and outcomes using the Coleman Report's data, and find that "schools play meaningful roles in distributing equality or inequality of educational outcomes to females, minorities, and the disadvantaged." Similarly Nye, Konstantopoulos and Larry (2004), using

[2] 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.

[3] Note that students can leave high school in New Zealand with differing levels of qualification: NCEA Level One, Two, or Three. The Ministry of Education judges 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" (Ministry of Education 2011b, p. 41).

experimental data from Project STAR find that teacher aide effects are bigger for schools with lower socioeconomic status (SES).[4] An advantage of the New Zealand funding structure is that we too will be able to test whether additional government funding channelled through schools raises achievement rates.

So how is funding currently adjusted in New Zealand to mitigate the effect of students' socio-economic status on their educational outcomes? Introduced in the 1990's, the main programme designed for this purpose has been the "decile" funding system.[5] 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. Schools in turn use this money for things such as smaller class sizes, extra counsellors, specialist literacy or numeracy teachers, teacher peer-mentoring, or pastoral assistance such as breakfast clubs or behavioural specialists. Decile funding represented an average of 13.4% of school operational funding from government between 2004-2007, and 12.6% between 2008-2011.[6]

Approximately one year after the release of new census data, the Ministry matches the home addresses of the students of each public and public - integrated school to their corresponding census "meshblocks."[7] (A "meshblock" is the smallest boundary unit of the New Zealand census, typically consisting of 100-200 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

[4] Project STAR was an experiment in which 11,600 Tennessee kindergarten students and teachers were randomly assigned to one of three types of classes beginning in the 1985-86 school year: small classes (13-17 students) and regular-size classes (22-25 students) with or without a teacher's aide.
[5] More formally, three categories of government operational funding for schools are adjusted by decile: the main Targeted Funding for Educational Achievement, Special Education Grants, and for year 9-14 students, Career Information Grants. Outside operational funding, decile rankings also affect a Priority Teacher Supply Allowance, Resource Teachers of Learning and Behaviours, and grounds for funding social workers in schools.
[6] Source: Ministry of Education http://www.educationcounts.govt.nz/statistics/schooling/resourcing/47696 .
[7] 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.

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.[8]

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 welfare:** 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**: 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 distribution of household members before dividing by the number of bedrooms, and sets a threshold ratio above which households are deemed 'crowded'.[9]

For each of the five variables separately, the Ministry then ranks each school's meshblock weighted average values relative to that of all public and public-integrated schools in New Zealand. A school

[8] 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.

[9] For both crowding measures, household size to room ratios are calculated at individual household levels before being aggregated up to meshblock, and then school catchment levels. The equivalized crowding assumes couples or two children under 10 may share a bedroom, while older children require their own room.

serving primarily disadvantaged students might, for example, be in the 80th percentile for low household income, 90th percentile for adults with no education qualifications, 70th percentage for households on welfare, 75th percentile for working adults having low skilled occupations, and 85th percentile for household crowding. The Ministry then sums each school's five percentiles 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.

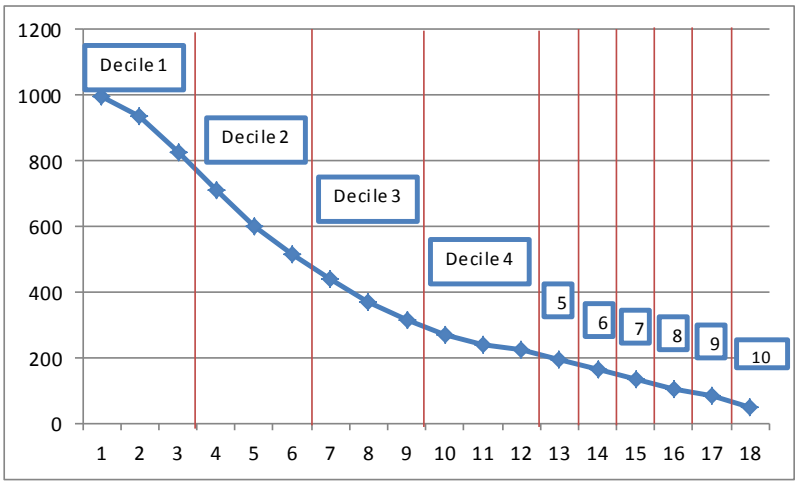
Finally, the Ministry ranks schools by their overall ses score. Schools with the highest ten percent of score values (i.e. schools serving the most disadvantaged students) are assigned decile 1, schools with the next ten percent are assigned decile 2, and so on. As illustrated in Figure 1, funding per student changes more progressively between the lowest four deciles, and so 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 public or public-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.[10]

The Ministry's current method of adjusting funding to each school based on their relative socio-economic status can be well-motivated by simple economic theory, provided one assumes that a) more school funding can improve student achievement rates, and b) more school funding can (imperfectly) substitute for various dimensions of students' socio-economic disadvantage. Suppose

[10] Individual schools can appeal their funding step any year if they believe the demographics of their students are not being accurately reflected. Between 2007 and 2012, for example, an average of 43 schools out of 2500 appealed annually, with 48% of these appeals resulting in a changed funding step (http://www.parliament.nz/en-nz/pb/business/qwa/QWA_08890_2013/8890-2013-chris-hipkins-to-the-minister-of-education).

that there are N schools. Each school *i*'s production of students achieving NCEA Level 2 or better, Q_i, can be modelled as a function of 1) the socio-economic status of its students, 2) the money the



Source: New Zealand Ministry of Education http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/SchoolOperations/Resourcing/ResourcingHandbook/Chapter1/Appendices/Appendix1OperationalFundingRates.aspx

Figure 1: Per Student Funding Received by Schools from the Three Components of Operational Funding that are Adjusted by Decile, for Year 9-14 Students, in 2014 NZ$.

school receives from the Ministry of Education, and 3) the effectiveness of each school's teachers, Board of Trustees, facilities 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 students' neighbourhoods, and q_i stands for the quality of school *i*'s teachers/trustees. α, β, γ and θ refer to the relative importance of government funding, socio-economic factors 1 and 2, and internal school quality, to the school's production of graduates with NCEA level 2 qualifications. The choice of Cobb Douglas production assumes that increases in f_i can to a moderate extent compensate for decreases in s_{1i}, s_{2i} and q_i for student achievement.

The Ministry of Education, reflecting the views of government and society, cares about the qualification achievement rates 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 of achievement rates across schools, not wanting disparities to be too large. This trade-off between a high average and low variance can be represented by a social welfare function of the form

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

The specific trade off the Ministry is willing to make between a high average and limited variance is given by ρ. If the Ministry cared only about average achievement, it would set ρ=1. If it cared only about eliminating disparity in achievement, it would set ρ to negative infinity. The Ministry's 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, ($\sum_{i=1}^{N} f_i \le B$), and subject to each school's education 'production' function.

$$\underset{\{f_1,\ldots,f_N\}}{Max} \left(\sum_{i=1}^{N} Q_i^{\rho}\right)^{\frac{1}{\rho}}$$

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

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

If we partition school i from the remaining j = 1,….,N-1 schools, then optimal funding for school i can be expressed as

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

That is, the Ministry will optimally set the funding for school *i* as a function of the overall socio-economic status of its catchment and teacher/trustee quality relative to that of other schools. Equation (4) says that if the Ministry cares enough about reducing disparity in school outcomes to set ρ to a negative value, then school *i*'s funding should increase if its catchment has a low socio-economic status relative to other schools.

In reality, however, it is not enough for the Ministry to identify the socio-economic characteristics that vary with school achievement rates. It is also necessary to establish whether these socio-economic factors can be successfully offset by directing funds directly to schools serving such students. To appreciate the distinction, suppose it could be demonstrated that students from low income households were less likely to achieve school qualifications. If increasing government funding of the schools serving students from low income families made no difference to their achievement, then those increased funds may be being spent to no effect. It might be preferable to support these low income students through other means than funnelling additional money to the schools that serve them, such as alterations to the tax system for the students' parents. But among those disadvantage factors for which school funding can compensate, the Ministry needs to establish in which dimensions added funding is most effective (the relative values of β and γ.) It is to these empirical questions that we now turn.

3. EMPIRICAL ESTIMATION STRATEGY

Any attempt to evaluate the return to increased education funds across different measures of disadvantage must take the following constraints into account:

a. There is a funding formula already present that is affecting school achievement rates. There is almost certainly endogeneity between achievement rates and the funds schools receive, because it is precisely schools serving relatively disadvantaged students that receive greater

funding per student. This endogeneity must be addressed by accounting for the relative socio-economic status of the students that schools serve when they receive 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 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 government, almost certainly affect that school's achievement rates.
d. The New Zealand Ministry funds students at a higher level in their upper high school years (years 11-13, or potentially years 11-15 for students taking longer to achieve a qualification).
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 public-integrated schools than for public schools, with higher tuition rates for parents making up the difference. (Fully private schools receive very limited funds from the Ministry, and 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 students leaving each high school achieving NCEA Level 2 qualifications or better. We follow individual school's leaver qualification achievement rates (LQAR's) in 2007 and 2011, asking to what extent variation in this can be explained by real average funds per student the school received from 2004-2007, and 2008-2011, which in turn were based on census results in 2001, and 2006. We control for the current five factors (in relative, percentile form) to address the endogeneity that more money goes to schools serving more relatively disadvantaged students. Of central importance, we add interaction terms between government funding per student at each school, and each of the five deprivation factors of the students/neighbourhoods served by each school. These interaction terms indicate whether the

effectiveness of government funds per student in raising LQAR's is especially high or low for each of the five factors. If we find, for example, that one deprivation factor greatly heightens the effectiveness of government funding on LQAR's, while others leave it unchanged or reduced, we will take this as evidence that the Ministry of Education should increase the weight on the first factor, and decrease the weight on the other factors. In augmented models, we also add additional neighbourhood factors not currently in the funding formula to our regressions. To the extent these additional factors (in relative percentile form, though also tried in absolute form) can further explain variation in schools' LQAR's, we take this as suggestive evidence that these factors too should be considered for targeted funding. We say only 'considered', because we have no evidence whether increasing the funding of schools serving students with those factors would raise achievement rates. More formally, we regress

$$LQAR_{i,t} = \beta_0 + \beta_1 AveGovFundsPerSt_{i,\bar{t}} + \beta_2 AveOthFundsPerSt_{i,\bar{t}} + \beta_3 \%Students11-15_{i,\bar{t}} + D_1 Integrate_{i,t}$$
$$+\beta_4 LowHHIncome_{i,t-6} + \beta_5 LowSkillOccup_{i,t-6} + \beta_6 HHCrowding_{i,t-6} + \beta_7 LowEduc_{i,t-6} + \beta_8 OnWelfare_{i,t-6}$$
$$+\beta_9 LowHHIncome_{i,t-6} * Gov'tFunds_{i,\bar{t}} + \beta_{10} LowSkillOccup_{i,t-6} * Gov'tFunds_{i,\bar{t}}$$
$$+\beta_{11} HHCrowding_{i,t-6} * Gov'tFunds_{i,\bar{t}} + \beta_{12} LowEduc_{i,t-6} * Gov'tFunds_{i,\bar{t}}$$
$$+\beta_{13} OnWelfare_{i,t-6} * Gov'tFunds_{i,\bar{t}} + \beta_{14} OtherNeighVar_{i,t-6} + \alpha_i + u_{i,t} \quad (5)$$

where i = 1,…,N schools, t = 2007 or 2011, and $\bar{t}$ = (2004 + 2005 + 2006 + 2007)/4 or (2008 + 2009 + 2010 + 2011)/4. The fixed effect term α_i in equation (5) controls for time-invariant unobserved school characteristics that are affecting LQAR's. Of prime interest here is whether the interaction coefficients β_9, β_{10}, β_{11}, β_{12} or β_{13} differ significantly from each other, and whether any other school catchment variables β_{14} are significant in explaining additional variation in school LQAR's. Other neighbourhood-based variables we investigate by theme are:

a. Crime and Health

- 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 ratio of deaths to expected deaths given national levels and the area units' age and sex distribution while Version 2 is the age- and sex- standardized mortality rate.

b. Rural vs. urban

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

- 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 year+ in schools' meshblocks who are 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' religious affiliations "Christian", "No-", "Other Religion"

It is important to note that many of these observable factors are likely proxies for unobserved individual level characteristics that influence students' success at school. While it might be politically undesirable for the Ministry to include any of the above additional factors in revisions to the funding formula, a correct estimate of the marginal effects of each of the current five factors ($\beta_9 \ldots \beta_{13}$) on the effectiveness of Ministry spending requires that other relevant effects be considered in (5) to minimize omitted variable bias. For augmented models that include these other factors, we will initially include all 21 simultaneously, and remove them sequentially ("from general to specific") starting with those furthest from having a statistically significant correlation.

Finally, challenges arise because several aspects of the funding formula 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, a simple ratio of "household size/number of bedrooms" in 2001 was replaced with an equivalised crowding index in 2006. Third, low skill occupations were defined using the NZSCO99 occupation classification system in 2001, but with a more sophisticated ways of measuring skill using both the NZSCO99 and ANZSCO systems in 2006. Given that our fixed effects strategy requires us to follow schools using the most consistent measures possible, we have done as follows: 1) for crowding, Statistics New Zealand kindly 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.

4. RESULTS

We begin with descriptive statistics. Recall that in all cases, our unit of observation is each public or public-integrated school containing students in years 11-15. In Figure 2, we illustrate the extent to which the five current measures of relative disadvantage used in the decile funding formula remain negatively correlated with NCEA Level 2 or higher achievement rates under the current system. Negative correlations are apparent for each measure, with the exception of household crowding.[11] More comprehensively, Table 1 describes all variables tried in our regressions over both 2007 and 2011 waves pooled, using a common sample of public and public-integrated 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 government) 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. If the five factors were perfectly or near-perfectly correlated, there would be no benefit to using five factors rather than one in the formula. In our estimation, our ability to estimate separate marginal effects on LQAR's of funding according to each factor would also 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

[11] We find a lack of correlation between equivalised household crowding and achievement rates both in 2007 based on the 2001 census, and in 2011 based on the 2006 census. We also find surprisingly high variation over time in each school's crowding measure in Appendix 1. This could suggest either that the equivalised crowding measure is not correlated with achievement rates in the first place and so should not be in the funding formula, or that the current funding formula exactly offsets the negative impact of equivalised crowding on achievement rates.

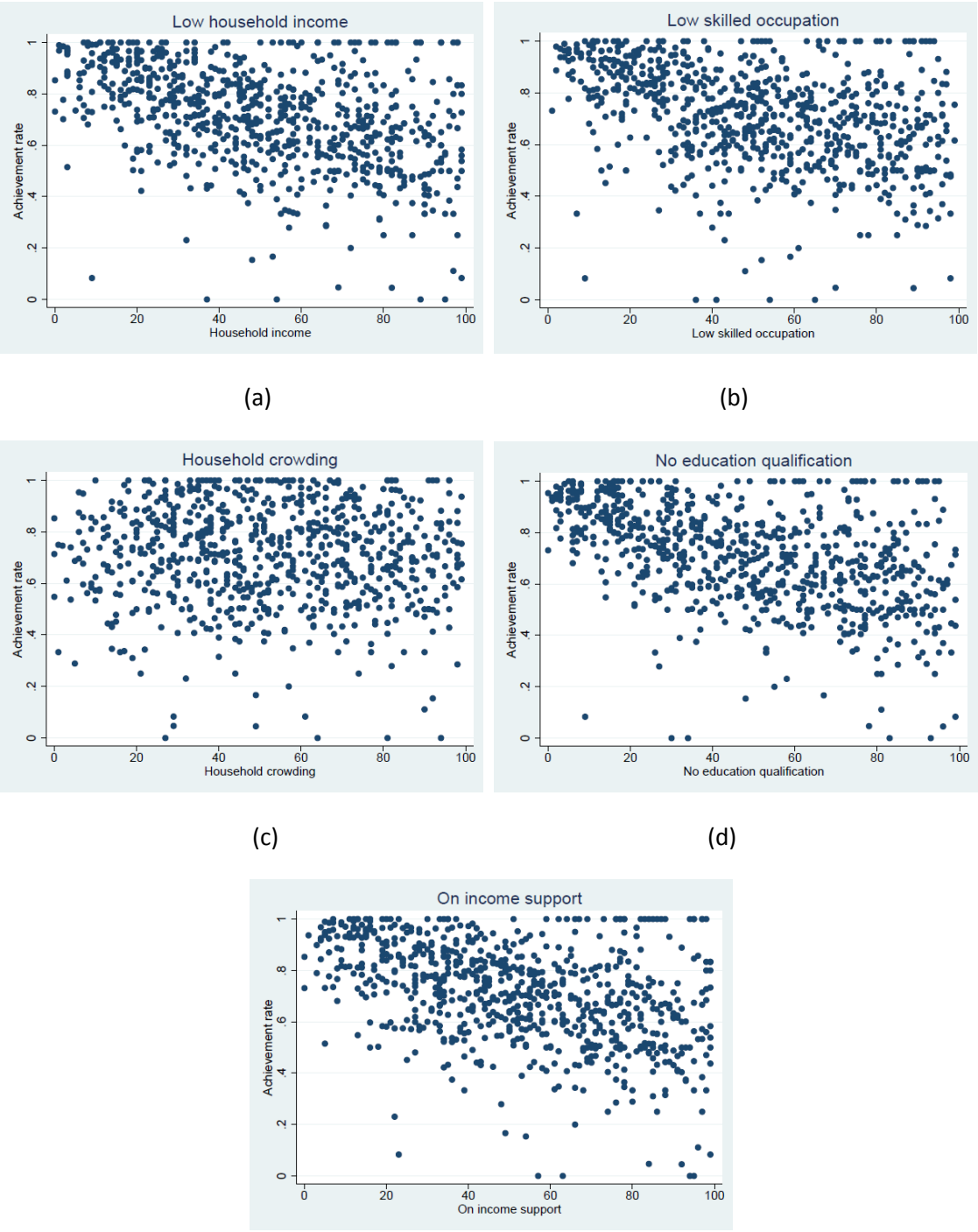


Figure 2: Scatterplots of the Qualification Achievement vs the Five Deprivation Factors

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	0.7070	0.1903	0.0000	1.0000
Ave Real Gov't Funds Per Student last 4 years ($100's)	810	77.73	26.15	38.27	222.82
Ave Real Other Funds Per Student last 4 years ($100's)	810	1242.51	752.36	1.38	52.50
Ave Proportion of Roll Yrs. 11-15 last 4 years	825	0.4178	0.1754	0.0000	1.0000
Dummy - School is Integrated?	840	0.2202	0.4147	0	1
Low Household Income (Percentile)	808	51.816	26.277	0.000	99.000
Low Skill Occupation (Percentile)	808	52.708	25.766	1.000	99.000
Household Crowding (Percentile)	808	52.816	25.103	0.000	99.000
No Educ Qualif. Adults (Percentile)	808	50.196	27.599	0.000	99.000
On Welfare (Percentile)	808	53.170	26.111	0.000	99.000
Crime Offences Per 10000 (Percentile)	808	51.467	25.926	0.000	99.000
Ratio deaths/expected Mortality (Percentile)	808	51.533	25.985	0.000	99.000
Age-standardized Mortality Rt (Percentile)	808	51.531	25.989	0.000	99.000
Rural or Secondary Urban (Percentile)	808	49.636	26.929	0.000	85.000
Rural (Percentile)	808	50.728	27.946	0.000	88.000
Yrs Since Arrival in NZ (Percentile)	807	50.897	25.713	0.000	99.000
Not Same Res. 5 Yrs Ago (Percentile)	808	49.780	24.420	0.000	99.000
Share not born in NZ (Percentile)	808	50.189	27.051	0.000	99.000
Share not own home (Percentile)	808	50.672	24.231	0.000	99.000
Share children in fam w 1 parent (Percentile)	808	50.828	24.261	0.000	99.000
Share not partnered (Percentile)	808	50.076	24.551	0.000	99.000
Share not married (Percentile)	808	50.382	24.945	0.000	99.000
Share of partnered not married (Percentile)	808	50.972	25.739	0.000	99.000
Share unemployed (Percentile)	808	52.394	24.887	0.000	99.000
Share not in labour force (Percentile)	808	51.266	25.047	0.000	99.000
Share unem or not in LF (Percentile)	808	51.363	25.358	0.000	99.000
Share ethnic affiliation Maori (Percentile)	808	51.472	27.440	0.000	99.000
Share ethnic affiliation Pacific (Percentile)	808	52.890	26.027	0.000	99.000
Share ethnic aff Maori or Pacific (Percentile)	808	51.804	26.153	0.000	98.000
Share can't speak English (Percentile)	808	52.782	25.547	0.000	99.000
Share Christian Affiliation (Percentile)	808	48.720	24.750	0.000	99.000
Share No Rel Affiliation (Percentile)	808	49.835	25.615	0.000	99.000
Share Other Rel Affiliation (Percentile)	808	52.516	25.840	0.000	99.000

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	0.7106	0.1913	0.0000	1.0000
Ave Real Gov't Funds Per Student last 4 years ($100's)	751	76.91	25.06	38.27	222.82
Ave Real Other Funds Per Student last 4 years ($100's)	751	12.70	7.61	1.60	52.50
Ave Proportion of Roll Yrs. 11-15 last 4 years	751	0.4379	0.1543	0.0000	0.8926
Dummy - School is Integrated?	751	0.2224	0.4161	0	1
Low Household Income (Percentile)	751	50.466	25.961	0.000	99.000
Low Skill Occupation (Percentile)	751	51.679	25.663	1.000	99.000
Household Crowding (Percentile)	751	52.501	24.906	0.000	99.000
No Educ Qualif. Adults (Percentile)	751	48.671	27.149	0.000	99.000
On Welfare (Percentile)	751	51.779	25.771	0.000	99.000
Rural or Secondary Urban (Percentile)	751	49.846	26.476	0.000	85.000
Share not own home (Percentile)	751	50.599	23.989	0.000	99.000
Share not partnered (Percentile)	751	49.912	24.226	0.000	99.000

calculated) are moderately high, but not extremely so. Over all public and integrated schools using a 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 welfare.[12] Not quite as fortunately for our estimation, pairwise correlations between the five factors over only those public and integrated 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 welfare, is 0.915. Other correlations are reported in Appendix 2.[13] To test whether this degree of correlation is affecting the stability of our coefficient estimates for the five socio-economic factors, we used two approaches. First, we ran baseline regressions of (5) without interaction terms, where we omitted one deprivation factor at a time. Reassuringly, we found that the coefficients on the remaining deprivation factors remained stable, as did their levels of statistical significance. Second, using the same baseline regression of (5) without interactions, we calculated the variance inflation factor (VIF)

[12] The next highest correlations are between percentile of households receiving welfare 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).

[13] For our restricted sample of non-private schools containing year 11-15 students, the next highest correlations are between percentile receiving welfare and no education qualification (0.862), percentile low income and no education qualification (0.841), and percentile low skill occupation and no education qualification (0.814).

for each explanatory variable (Greene 2003). The VIF is a measure of the increase in variance of a coefficient on a variable due to correlation with other explanatory variables. VIF values in excess of 10 are often taken to indicate substantial multicollinearity. None of the VIF values in our panel regression came close to this, with none exceeding 4.6.

Some other preliminaries concern whether we have sufficient variation in school and school catchment outcomes over time to use fixed effects, and whether we should use robust standard errors. In contrast to pooled cross section, fixed effects regressions that follow schools over time as in (5) have the considerable advantage that they control for *unobserved* school quality characteristics that are affecting each school's LQAR's. However, fixed effects will only be able to identify the effects of observed school or neighbourhood characteristics on LQAR's if the former are varying sufficiently over time. In Appendix I, we provide scatterplots showing variation in our key variables over time. These scatterplots show considerable dispersion from the 45 degree line, indicating a reasonable degree of variation over time.[14] Nonetheless, for every specification to follow, we also present analogous pooled cross section regressions in Appendices 3 and 4, though recognizing they will suffer from considerable omitted variable bias. With regard to robust standard errors, we compare results using regular standard errors (that assume homoscedasticity) with those from using robust standard errors (that assume heteroscedasticity 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.

With preliminary checks done, we move to our regression results. Recall that the legitimacy of the Cobb-Douglas approach to modelling school production presumed that government spending

[14] The scatterplot for real government funds per student averaged over the previous four years shows several outlier schools reporting funding in excess of $17,500 per student. We therefore repeat the analysis to come in Table 4 without these outliers. Our results concerning the effect of key variables (government funds, optimal weighting of the five factors, and other significant neighbourhood factors), are not affected by this exclusion.

via schools raises school LQAR rates. We thus begin by checking if this is the case in New Zealand under the decile funding formula. Our results are presented in Table 3. We address the endogeneity of poor achievement rates 'causing' higher funding per student under the current system by controlling for the five factors use to determine decile funding. Using the full sample in model 1, we see that on average a $100 increase in real government funding per student in each of the four years prior to a student leaving school would increase the proportion of leavers achieving NCEA Level Two or better by 0.39 percentage points (at sample mean, from 71.06 to 71.45 percent). So indeed, government spending per student is associated with higher achievement rates in New Zealand. In model 2, we repeat this exercise examining only those schools in the bottom four deciles/12 funding steps, to see if this association persists among disadvantaged students. The estimated effect of spending per student remains stable, at .38 percentage points.

With regard to other variables, variation in non-government sourced funds per student surprisingly does not have a significant effect on LQAR's in model 1 or 2. This may reflect the limited scale of non-government funds received by schools relative to government funds, the costs associated with raising those funds, or perhaps the higher needs as well as revenues associated with schools taking in more international students. Consistent with the Ministry of Education providing more funding per student for students in years 11-15, (and also possibly with 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 in their rolls also have a 1.26 percentage point higher LQAR's on average (from 71.06 percent to 72.32 percent at sample mean).[15] Among the five control factors, the significant negative coefficient on "low income" in models 1 and 2 show that low household income remains negatively associated with school LQAR's in New Zealand under the current funding system. Note that this says nothing about whether targeting more money to schools serving low income students would raise achievement rates. To address this question, we introduce

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

Table 3: Effectiveness of Government Spending on School LQAR's of "NCEA Level 2 or Higher" School Fixed Effects Regressions

Variable	Model 1 Full Sample	Model 2 Lowest 4 Deciles
Ave Real Gov't Funds Per Student last 4 Years ($100's)	0.00387***	0.00375***
	[0.00105]	[0.00132]
Ave Real Other Funds Per Student last 4 years ($100's)	-0.00168	0.000694
	[0.00182]	[0.00277]
Ave Proportion of Roll Yrs. 11-15 last 4 years	1.259***	0.322
	[0.392]	[0.562]
Low Household Income (Percentile)	-0.00241**	-0.00401*
	[0.00106]	[0.00224]
Low Skill Occupation (Percentile)	0.000372	0.00163
	[0.00106]	[0.00188]
Household Crowding (Percentile)	0.000152	0.00150**
	[0.000346]	[0.000615]
No Education Qualification (Percentile)	0.00274	0.00318
	[0.00194]	[0.00331]
On Welfare (Percentile)	-0.000272	-0.00223
	[0.00152]	[0.00311]
Constant	-0.142	0.177
	[0.145]	[0.302]
N (observations)	751	306
N (schools)	409	181
R^2 (within)	0.299	0.319

Robust standard errors in brackets. Run on Stata 12.0
*** p<0.01, ** p<0.05, * p<0.1

interaction terms to examine whether each factor currently raises or depresses the effectiveness of government spending through schools to raise LQAR's.

Model 1 in Table 4 presents our baseline model (for all deciles of schools) with each socio-economic factor interacted with government spending per student. The inclusion of these interaction terms complicates slightly the calculation of the overall marginal effect of government funding on LQAR's from Table 3. This becomes the sum of the main effect of government spending,

Table 4: Effectiveness of Ministry Spending By Dimension on School LQAR's of "NCEA Level 2 or Higher"
School Fixed Effects Regressions

Variables	Model 1 Baseline	Model 2 Baseline + 3 Factors	Model 3 Baseline + Crime,Health
Ave Real Gov't Funds Per Student last 4 Years ($100's)	0.00398*	0.00509***	0.00378*
	[0.00220]	[0.00195]	[0.00218]
Ave Real Other Funds Per Student last 4 years ($100's)	-0.00192	-0.00252	-0.00216
	[0.00177]	[0.00176]	[0.00183]
Ave Proportion of Roll Yrs. 11-15 last 4 years	1.115***	1.096***	1.120***
	[0.381]	[0.376]	[0.381]
Low Household Income (Percentile)	-0.00605	-0.00524	-0.00588
	[0.00448]	[0.00389]	[0.00441]
Low Skill Occupation (Percentile)	-0.00332	-0.00364*	-0.00346
	[0.00215]	[0.00204]	[0.00211]
Household Crowding (Percentile)	0.000375	0.00072	0.000296
	[0.00150]	[0.00144]	[0.00152]
No Education Qualification (Percentile)	-0.000169	0.0000472	0.000102
	[0.00475]	[0.00434]	[0.00478]
On Welfare (Percentile)	0.00845*	0.00805*	0.00809
	[0.00502]	[0.00432]	[0.00500]
Low HH Income* Gov't Funds Per Student	0.0000404	0.0000310	0.0000375
	[0.0000517]	0.0000442	[0.0000509]
Low Skill Occup*Gov't Funds Per Student	0.0000453*	0.0000457*	0.0000452*
	[0.0000258]	0.0000241	[0.0000255]
HH Crowding*Gov't Funds Per Student	-0.00000111	-0.00000649	-0.000000516
	[0.0000205]	0.0000197	[0.0000207]
No Educ Qualification*Gov't Funds Per Student	0.0000252	0.0000233	0.0000241
	[0.0000553]	0.0000504	[0.0000553]
On Welfare*Gov't Funds Per Student	-0.000103*	-0.0000995**	-0.0000964*
	[0.0000563]	0.0000499	[0.0000556]
Share of Adults not partnered (Percentile)		-0.00210***	
		[0.000501]	
Share Rural or Secondary Urban (Percentile)		-0.00128***	
		[0.000466]	
Share not own home (Percentile)		0.00152***	
		[0.000541]	
Rate of overall crime per 10000 (Percentile)			-0.0000392
			[0.000382]
Mortality Rate - deaths/expected deaths (Percentile)			-0.000451
			[0.000395]
Constant	-0.0504	-0.00635	-0.013
	[0.172]	[0.162]	[0.171]
N (Observations)	751	751	751
N (Schools)	409	409	409
R^2 (within)	0.319	0.375	0.322

Robust standard errors in brackets. Run on Stata 11.0.
*** p<0.01, ** p<0.05, * p<0.1

summed with the coefficients on each of the five interaction terms, where each of the latter is multiplied by the sample mean value of the particular factor, taken from Table 2.[16] This sum is 0.004195, meaning that on average a $100 increase in real government funding per student in each of the four years prior to a student leaving school is estimated to increase the proportion of leavers achieving NCEA Level Two or better by 0.42 percentage points (at sample mean, from 71.06 to 71.48 percent). This is fairly similar to the 0.39 and 0.38 estimates from Table 1 model 1 without interaction terms.

We turn now to the key issue of whether, under the current funding system, some deprivation factors increase or decrease the effectiveness of government decile funding per student on LQAR's. If so, this provides evidence that the overall average effectiveness of government spending per student on raising LQAR's could be increased if the weight on factors that increased effectiveness were raised, while the weight on factors that decreased effectiveness were lowered. The positive significant interaction between government funds and low skill occupation in Model (1) reveals that a one percentile increase in the share of school catchment with low skill occupations raises the effectiveness of an extra $100 in government spending per student on raising LQAR's by 0.0045 percentage points, relative to the overall marginal effect of government spending of 0.4195 percentage points. In contrast, a one percentile increase in the share with low household incomes, or in crowded housing, or with no education qualifications, would have no significant influence on the effectiveness of government spending at the margin. Of course, if the relative weight on one factor (low skill occupation) should increase, this would imply that the relative weight on at least one other factor should decrease. Consistent with this, Model (1) shows that a one percentile increase in the share on welfare *decreases* the effectiveness of an extra $100 in government spending per student on raising LQAR's by 0.0103 percentage points, relative to an overall marginal effect of

[16] For a $100 increase, .004195 = 0.00398+(0.0000404*50.46605)+(0.0000453*51.67909)+(-0.00000111*52.50067)+(0.0000252*48.67111)+(-0.000103*51.77896). Similarly, the complete residual effect of a marginal increase in one of the five socio-economic deprivation factors on LQAR's would be given by the coefficient on that factor, summed to the coefficient on the relevant interaction term, with the latter multiplied by the sample mean value of government spending per student.

0.4195. Model (1) thus indicates that the current funding formula, which weights the relative percentiles of the five factors equally, would increase the overall effectiveness of spending per student on raising achievement rates if it increased the weight on low skill occupation, and decrease the weight on share receiving welfare.

Why might funds targeted at schools serving children of low skill workers raise achievement rates more effectively than funds targeted at schools serving children of households receiving welfare? We cannot offer firm conclusions, but only tentative explanations. First, because funding is based on the characteristics of the immediate neighbourhoods of school children, rather than the characteristics of the childrens' immediate households, it is possible that neighbourhoods with high proportions of welfare recipients have other characteristics that may hinder the effectiveness of better funded schools in reaching their disadvantaged children. Such children may have higher absenteeism or transience between schools, than children of the low skilled working parents. Second, a major component of welfare in New Zealand is the Domestic Purposes Benefit for single mothers. Thus, children from households receiving welfare are also more likely to live with a single parent. Dual parent households, even those with parents in low skill occupations, may be better able to support and reinforce school-funded initiatives to raise academic achievement of disadvantaged children. Our findings below reinforce this possible explanation.

To pursue the secondary objective of this research, we also tested whether any of the 21 additional neighbourhood variables listed in Section 3 had additional explanatory power regarding school LQAR's.[17] Our method was to initially add all 21 variables to Model (1), and then remove them one at a time by the criteria of being furthest from statistical significance (a "general to specific reduction"). The additional neighbourhood variables that were significant at the 10% level or better were retained in our augmented model (2) of Table 4. It is worth noting that other approaches, such as adding the additional variables one at a time, and retaining those significant at 10% or better, led

[17] Of 23 variables, we excluded one of the two mortality measures as it was almost perfectly correlated with the other, as well as one of the three broad religious affiliation categories ("other").

to an identical list of variables to retain. Since two of the "surviving" variables related to urban/rural status and were highly correlated, we retained the one with the higher level of significance. The three remaining factors that retained residual explanatory power regarding LQAR's in the presence of the current funding regime were 1) the relative proportion of adults in schools' children-filtered meshblocks 'not partnered', 2) the relative proportion "not main urban" (i.e. that were rural or secondary urban), and 3) the relative proportion who did not own their own home.[18] [19] Interestingly, two variables that did not have residual explanatory power regarding LQAR's once other deprivation factors were controlled for were the proportion in schools' meshblocks reporting a Maori or Pacific ethnic affiliation, despite the simple descriptive statistics mentioned earlier.

In our results for augmented model (2), government funds per student continues to raise LQAR's by a roughly similar magnitude as before (0.4657 percentage points, or from 71.06 percent to 71.53 percent at sample mean), as does the proportion of roll in years 11-15. Also as in model (1), low skill continues to increase the effectiveness of government spending per student on raising LQAR's, while percentile on welfare decreases it, with almost identical magnitudes as before. But model (2) also shows that a one percentile increase in the proportion of non-partnered adults in the schools' "children-filtered" meshblocks decreases LQAR's by 0.21 percentage points (or from 71.06 to 70.85 percent at sample mean). Similarly, a one percentile increase in the proportion of the schools' meshblocks classified as rural/secondary urban decreases LQARs by 0.13 percentage points (from 71.06 to 70.93 percent). Lastly, we surprisingly find low home-ownership rates to be significantly associated with *higher* LQARs; a one percentile increase in the proportion of the schools' meshblocks households who did not own their own homes increased LQAR's by 0.15

[18] Several measures of family structure 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 "not partnered" outperformed the other two measures in the "general to specific" elimination process.

[19] For robustness, we also tried entering these three variables in absolute value form rather than relative percentile form. Results for other coefficients remained stable, and the three factors retained the same signs and statistical significance.

percentage points (from 71.06 to 71.21 percent). We emphasize that finding a neighbourhood factor is associated with lower LQAR's does not guarantee that adding funding to schools serving students with those factors will raise LQAR's. Nonetheless, the results of Model (2) suggest that, in addition to the five factors already accounted for, other relevant dimensions of disadvantage that might be considered in New Zealand and in other countries include:

1) the single parent status of schools' catchment meshblocks, in the form of the relative proportion of households containing school-aged children where the adults are "not partnered". This census variable slightly outperformed similar family structure measures such as percentage of children in single parent families, or the share of adults whose legal marital status was "not married", i.e. single, divorced, separated, or widowed (lowering achievement rates by 0.21 percentage points from 71.06 to 70.85 percent at sample mean).

2) the "rural + secondary urban" status of schools' catchment meshblocks rather than "main urban" status, (lowering achievement rates by 0.13 percentage points from 71.06 to 70.93 percent at sample mean)

3) the proportion of households that are owner-occupied in schools' catchment meshblocks (lowering achievement rates by 0.15 percentage points from 71.06 to 70.91 percent at sample mean).

The negative direction of effect for (relative) home-ownership rates on qualification achievement rates was unexpected. Further investigation suggests this result is driven primarily by rural/secondary urban areas. First, we tried introducing an interaction term between non-home ownership and rural/secondary urban status. This made the main effect of non home-ownership lose significance, but the interaction with rural/secondary urban was positive and significant. Thus, non-home ownership has no covariance with achievement rates in main urban areas, but starts to be positively related to achievement for schools with more rural/secondary urban catchments. This

finding was corroborated when we dropped the interaction, but instead split our regression of model (2) in Table 4 between schools located in New Zealand's major urban centres (Auckland, Wellington and Christchurch) vs. schools located everywhere else. Lack of home ownership did not significantly co-vary with achievement in the major centres, but was positively associated with achievement outside them. Our speculation is that, in a fixed-effects context, rural/secondary urban areas that are growing economically see increased in-migration and people renting, and that the new students in schools there do better when compared to other rural regions that do not experience economic growth and rising migration and renting.

Conversely, other demographic factors often thought to be associated with disadvantage failed to provide additional explanatory power for achievement rates. For example, the Ministry's decision from 2005 onward to remove ethnicity from the decile formula looks well-supported, despite the apparent disparities in LQARs by simple ethnic grouping.

As mentioned, we also collected non-census sourced data on total recorded offences per 10,000 people from the New Zealand Police at police station level in 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. Promisingly, both measures had low correlations with the current five factors, as shown in Appendix 2. Yet as shown in model (3) of Table 4, neither variable's residual effect on LQAR's is statistically significant. This could be because they truly have no residual covariance with LQAR's not already captured by existing measures of disadvantage, or because both 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, the mortality rate was much closer to having a discernible negative effect on LQAR's, being not far off from significance at the 10% level despite the aggregated loss of information. Given that neighbourhood mortality and crime rates have the potential to influence

children's schooling and given the fact that they are less correlated with traditionally used disadvantage measures, they seem promising to investigate further in cases where better data allows.

5. CONCLUSION

Much of the education finance literature is concerned with evaluating policies that seek to lessen the effect of economic or social disparities outside schools on the disparity of student outcomes within them. Major policy proposals are justified (or court-mandated) in part for the beneficial effects they will have on disadvantaged students, such as school finance reform, school choice, affirmative action, and special needs funding. Less attention has been paid to the fact that "disadvantage" can be measured by various partially correlated characteristics of students or their families, such as income, education, ethnicity, and so on. To use scarce public funds via schools to raise the educational outcomes of disadvantaged students, it helps to know which dimensions of disadvantage can be most effectively addressed by funding schools. The structure of funding for socio-economic disadvantage in New Zealand, via the decile funding system, loans itself to a rare investigation of this issue.

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 comparison to wealthier OECD countries. Yet concerns persist about the relatively strong effect of socio-economic status on student outcomes. These concerns are addressed in large part through New Zealand's "decile" funding system, which adjusts per-student funding per school according to five socio-economic deprivation factors, each weighted equally.

We have used school fixed effects to estimate whether the "return" to spending on different deprivation factors varies under a regime where they are currently equally weighted. We take

evidence that one factor elevates the effectiveness of government spending, while a second factor decreases it, to imply that the weight on the first factor should be increased relative to the second. Secondarily, we have tested whether additional disadvantage factors have residual explanatory power regarding school achievement rates, though without evidence of whether targeting school funding via these factors would raise achievement.

Using this approach, we have found that the relative proportion of adults in schools' children's immediate neighbourhoods employed in low skill occupations raises the effectiveness of government spending on raising achievement rates (LQAR's), while the relative proportion on welfare reduces it. From our model (2) in Table 3, a one percentile increase in a school's catchment's percentile for low skill occupation would raise the effectiveness of a $100 real increase in government spending per student on LQAR's by 0.0046 percentage points. To place that in perspective, the overall marginal effect of government spending per student is 0.4657 percentage points. Conversely, a similar increase in a school's catchment's percentile on welfare would lower the effectiveness of government spending by 0.0100 percentage points. This suggests that government funding for disadvantage in New Zealand would be more effective in raising qualification achievement rates if the current weighting on low skill occupations was raised, while the weighting on receiving welfare was lowered.

In our investigation of whether additional factors co-vary with achievement rates, we considered 21 related to family structure, labour force status, ethnicity, residential stability, health, crime, and others. 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, nor crime or adjusted mortality rates as a proxy for health, though the latter had suggestive effects. In the positive, we found that relative family instability, and rural or secondary urban status had residual negative explanatory power for schools' qualification achievement rates. We also found that, in rural or secondary urban areas in particular, an increase in the relative proportion renting

their homes was associated with higher achievement rates, possibly due to localised economic growth and in-migration.

For each of these additional factors, no money has here-to-fore been targeted via the decile funding formula, and so we cannot evaluate whether doing so would be effective in raising achievement rates. These factors would, however, be promising first candidates to consider. More fundamentally, however, our study finds that public money spent via schools is more effective in offsetting some legitimate measures of disadvantages than others. Future research might fruitfully investigate further which dimensions can be targeted most effectively to improve outcomes for disadvantaged students.

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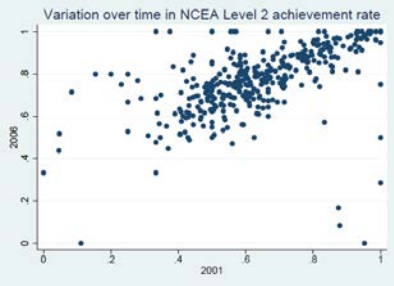
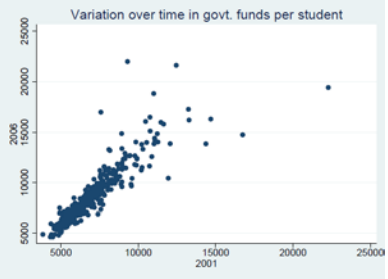
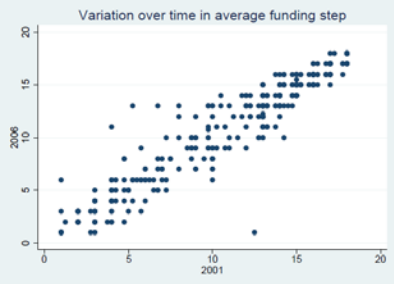
Appendix 1: Within-School Variation Over Time in Key Variables



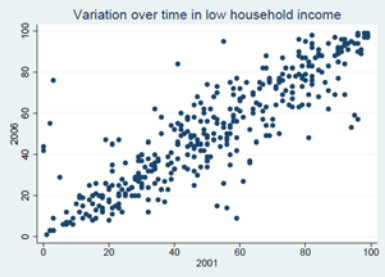
(a) NCEA Level 2 or Higher
2008 vs 2011



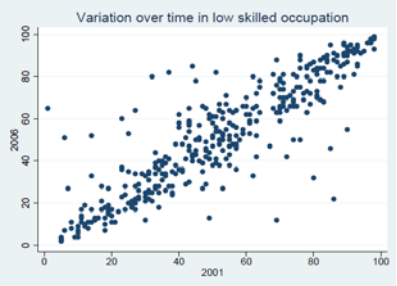
(b) Real Averaged Gov't Funds Per Student
(2004-2007) vs (2008-2011)



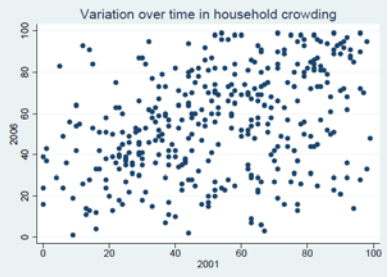
(c) Averaged Funding Step
(2004-2007) vs. (2008-2011)



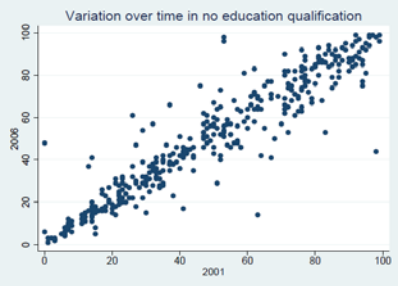
(d) Low Income Percentile
2001 vs 2006



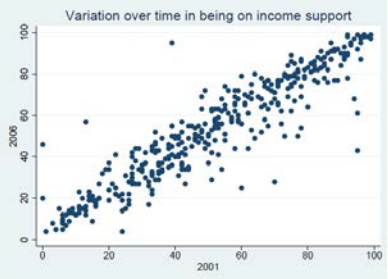
(e) Low Skill Occupation Percentile
2001 vs 2006



(f) Household Crowding Percentile
2001 vs 2006



(g) No Education Qualification
Percentile 2001 vs 2006



(h) Receiving Welfare Percentile
2001 vs 2006

Appendix 2: Degrees of Correlation Between Existing Five Deprivation Factors and Other Candidate Factors

	Low Income	Low Skill	Crowding	No Educ Qualif.	On Welfare	Not Partnered	Rural or Secondary	Not Own Home	Crime	Mortality
Low Income	1.000									
Low Skill	0.646	1.000								
Crowding	0.230	0.199	1.000							
No Educ Qualif.	0.841	0.814	0.232	1.000						
On Welfare	0.915	0.711	0.301	0.862	1.000					
Not Partnered	0.017	-0.075	0.145	0.017	0.018	1.000				
Rural or Secondary	-0.048	-0.045	-0.041	-0.051	0.016	-0.410	1.000			
Not Own Home	0.116	0.015	0.190	0.114	0.111	0.545	-0.140	1.000		
Crime	0.082	-0.007	0.119	0.057	0.083				1.000	
Mortality	0.086	-0.047	-0.038	0.108	0.089				0.294	1.000

Run on Stata 12.0.

Appendix 3: Effectiveness of Government Spending on School LQAR's of "NCEA Level 2 or Higher" Pooled Cross Section Regressions

Variable	Model 1 Full Sample	Model 2 Lowest 4 Deciles
Ave Real Gov't Funds Per Student last 4 Years ($100's)	0.00165***	0.00212***
	[0.000551]	[0.000544]
Ave Real Other Funds Per Student last 4 years ($100's)	0.00111	-0.000368
	[0.000715]	[0.0000143]
Ave Proportion of Roll Yrs. 11-15 last 4 years	0.0366	-0.220**
	[0.0617]	[0.0864]
Integrated rather than State School?	0.103***	0.0820**
	[0.0161]	[0.0405]
Low Household Income (Percentile)	-0.0003	-0.000873
	[0.000696]	[0.00118]
Low Skill Occupation (Percentile)	0.000127	0.00140*
	[0.000472]	[0.000720]
Household Crowding (Percentile)	0.000644**	0.00118**
	[0.000257]	[0.000465]
No Education Qualification (Percentile)	-0.00284***	-0.00413***
	[0.000694]	[0.000962]
On Welfare (Percentile)	-0.000847	-0.000917
	[0.000746]	[0.00107]
Constant	0.688***	0.786***
	[0.0442]	[0.0916]
N (observations)	751	306
R^2	0.314	0.190

Robust standard errors in brackets. Run on Stata 12.0
*** p<0.01, ** p<0.05, * p<0.1

Appendix 4: Effectiveness of Ministry Spending By Dimension on School LQAR's of "NCEA Level 2 or Higher"
Pooled Cross Section Regressions

Variables	Model 1 Baseline	Model 2 Baseline + 3 Factors	Model 3 Baseline + Crime,Health
Ave Real Gov't Funds Per Student last 4 Years ($100's)	0.0000198	0.000179	0.00004
	[0.0000135]	[0.00132]	[0.00135]
Ave Real Other Funds Per Student last 4 years ($100's)	0.000931	0.000989	0.000952
	[0.000714]	[0.000715]	[0.000720]
Ave Proportion of Roll Yrs. 11-15 last 4 years	0.0331	0.0377	0.036
	[0.0622]	[0.0615]	[0.0623]
Integrated rather than State School?	0.101***	0.103***	0.103***
	[0.0159]	[0.0158]	[0.0157]
Low Household Income (Percentile)	-0.00394	-0.00384	-0.0039
	[0.00329]	[0.00321]	[0.00330]
Low Skill Occupation (Percentile)	-0.00109	-0.00101	-0.00134
	[0.00115]	[0.00114]	[0.00115]
Household Crowding (Percentile)	0.000531	0.000384	0.000494
	[0.00119]	[0.00117]	[0.00119]
No Education Qualification (Percentile)	-0.00354*	-0.00352*	-0.00344
	[0.00211]	[0.00209]	[0.00213]
On Welfare (Percentile)	0.00258	0.0026	0.00272
	[0.00419]	[0.00405]	[0.00421]
Low HH Income* Gov't Funds Per Student	0.0000444	0.0000411	0.0000436
	[0.0000433]	[0.0000423]	[0.0000435]
Low Skill Occup*Gov't Funds Per Student	0.0000174	0.000015	0.0000186
	[0.0000124]	[0.0000122]	[0.0000123]
HH Crowding*Gov't Funds Per Student	0.000000887	0.00000223	0.00000125
	[0.0000164]	[0.0000160]	[0.0000164]
No Educ Qualification*Gov't Funds Per Student	0.00000702	0.00000694	0.00000753
	[0.0000252]	[0.0000248]	[0.0000253]
On Welfare*Gov't Funds Per Student	-0.0000404	-0.0000385	-0.0000417
	[0.0000531]	[0.0000513]	[0.0000535]
Share of Adults not partnered (Percentile)		-0.000919**	
		[0.000371]	
Share Rural or Secondary Urban (Percentile)		-0.00022	
		[0.000287]	
Share not own home (Percentile)		0.000851**	
		[0.000336]	
Rate of overall crime per 10000 (Percentile)			-0.000116
			[0.000235]
Mortality Rate - deaths/expected deaths (Percentile)			-0.000251
			[0.000262]
Constant	0.807***	0.812***	0.823***
	[0.0943]	[0.0959]	[0.0938]
N (Observations)	751	751	751
R^2	0.323	0.333	0.325

Robust standard errors in brackets. Run on Stata 12.0.
*** p<0.01, ** p<0.05, * p<0.1

Appendix 5: Variable Definitions

Variable Label	Definition
LQAR NCEA2 or Higher	The number of school leavers achieving an 'attain' code of 4.5 or lower in 2007 or 2011, divided by all recorded school leavers. 4.5 refers to students leaving school with the qualification "Year 12: Cambridge International Exams, International Baccalaureate, Accelerated Christian Education, or other Overseas Awards". The attain code 4 is "NCEA Level 2 or other Level 2 NQF highest_attainment." Source: provided directly by the New Zealand Ministry of Education, from their "paper" rather than ENROL-based data base.
Ave Real Gov't Funds Per Student	The total government-sourced funds received by each school for 2004-2011, reported directly from the New Zealand Ministry of Education, adjusted for inflation by the consumer price index (2004=100). This was divided by the total student roll (the sum of roll by year by school) reported for each school in those years, sourced from the Ministry of Education. Real funding per student is averaged over 2004-2007, and over 2008-2011.
Ave Real Other Funds Per Student	The total non-government-sourced funds received by each school for 2004-2011, reported directly from the New Zealand Ministry of Education, adjusted for inflation by the consumer price index (2004=100). This was divided by the total student roll (the sum of roll by year by school) reported for each school in those years, sourced from the Ministry of Education. Real funding per student is averaged over 2004-2007, and over 2008-2011.
Ave Proportion in Years 11-15	The roll of students in years 11-15 for each school for 2004-2011, divided by the school's total roll, available publicly from the New Zealand Ministry of Education. Proportion averaged over 2004-2007, and over 2008-2011.
School Integrated	Takes on the value '1' if the authority classification of the school is 'state-integrated', rather than 'state-non integrated' or 'private fully regulated'. Source: Ministry of Education.
Low Household Income	For both the 2001 and 2006 censuses, the proportion of households containing school-aged (5-17) children in meshblocks with equivalent income (adjusted for the number of adults and children in the household, and the age of the children), in the lowest 20 percent nationally. Households with a member who is unemployed are usually not included in this group nor are households supported on a benefit. Source: Statistics New Zealand provided this for the Ministry of Education in 2001 and 2006, and made it available also to us.
Low Skill Occupation	For both the 2001 and 2006 censuses, the proportion of those working (aged 15 or older) in the two lowest skill occupation classifications according to the NZSCO99 Level 1 v1 classification system. These were series 8 "Plant and Machine Operators and Assemblers" and series 9 "Elementary Occupations". A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand provided this for the Ministry of Education in 2001, and provided us with a customised replication for 2006 to keep the classification system consistent.

Appendix 5: Variable Definitions (Cont'd)

Variable Label	Definition
Household Crowding	For both the 2001 and 2006 censuses, an equivalised crowding index. This index roughly divides the number of household members by the number of bedrooms, but with adjustments that assume couples or children under 10 may share a bedroom. It then calculates the proportion of households deemed crowded over all households in a meshblock. Unlike other factors, this is calculated at household rather than meshblock level, before being averaged over the meshblocks containing the children attending each school. It is then converted to a percentile ranking. Source: Statistics New Zealand provided this for the Ministry of Education in 2006, and provided us with a customised replication for 2001 to keep the measure consistent.
No Education Qualification	For both the 2001 and 2006 censuses, the proportion of adults from households containing school-aged (5-17) children in meshblocks who have no education qualifications (i.e. not completing high school to at least a Level 1 Certificate). A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand provided this for the Ministry of Education.
On Welfare	For both the 2001 and 2006 censuses, the proportion of households containing school-aged children that also contained at least one adult receiving a non-pension government benefit, e.g. the Domestic Purposes Benefit, the Invalid's Benefit, Community Wage – Job Seeker or Community Wage – Sickness Benefit. A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand provided this for the Ministry of Education.
Share of Adults Not Partnered	For both the 2001 and 2006 censuses, the proportion of adults in households containing school-aged children who were "not partnered" (i.e. neither married nor living common-law). A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand customised order.
Share Rural/Secondary Urban	For both the 2001 and 2006 censuses, the proportion of meshblocks containing a school's students that was classified by location as 'rural', 'minor urban' (1000-9,999), or 'secondary urban' (10,000-29,999) rather than 'main urban' (30,000 plus). A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand customised order.
Share Not Own Home	For the 2001 census, the proportion of households containing school aged children that were owned or partly owned by the usual residents. For the 2006 census, this definition of ownership was combined with one newly available on the census of "dwelling held in a family trust by usual residents". A student-weighted meshblock average is created for each school, which is then converted to a percentile ranking. Source: Statistics New Zealand customised order.

Appendix 5: Variable Definitions (Cont'd)

Variable Label	Definition
Rate of Overall Crime	For 2001 and 2006, the total number of recorded offences of all kinds, per 10,000 usually resident population, from the 282 Police Station Boundaries in New Zealand. These were mapped to 2006 census meshblock boundaries using a concordance provided by Statistics New Zealand. A student-weighted meshblock average is then created for each school, which is then converted to a percentile ranking. Source: New Zealand Police customised request.
Mortality Rate	For 2001 and 2006, the number of deaths divided by the expected number of deaths given the distribution of population by age and sex distribution in each census area unit. Expected mortality rates calculated by age- and sex- adjusted mortality rates at the national level. These were mapped to meshblock boundaries for 2001 and 2006. A student-weighted meshblock average is then created for each school, which is then converted to a percentile ranking. Source: New Zealand Ministry of Health.