How Principals Affect Schools*

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Abstract

We construct estimates of the idiosyncratic effects of principals on student achievement in public schools employing a unique administrative panel data set from the Australian state of Victoria. We do so using turnover of principals across schools to isolate the effect of principals from the effect of schools themselves. Using annual detailed staff surveys, we identify several potential mechanisms through which effective principals improve student outcomes. These mechanisms include principal encouragement of: goal congruence, teacher interactions and teacher professional development.

Keywords: student achievement, school principals, value-added

JEL codes: I21

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1 Introduction

The focus of the Economics literature on school effectiveness has ranged considerably since the late 1960s. Initially the focus was on resource-based inputs such as class size, education spending and teacher education, yet the effectiveness of altering such inputs was often found to be limited. More recently, the focus has fallen on school accountability, school choice (e.g. vouchers), autonomy (including charter and academy schools) and the idiosyncratic effect of individual teachers. Most studies of individual teacher effects find that teachers are an important input into student learning,[1] yet observable teacher characteristics explain little of this effect.

In the Education literature, while teachers are recognised as having significant effects on student learning, school principals have long been considered equally important (Leithwood et al., 2004; Leithwood and Jantzi, 2005; Seashore et al., 2010). This literature highlights the importance of instructional leadership, a key aspect of principals' jobs which involves building, managing and developing the teaching team. School leadership is also increasingly at the centre of recent education policies regarding "turnaround schools", where low-performing schools are restructured.

We have two main objectives in this study. To begin, we construct estimates of the idiosyncratic effect of school principals on student achievement in grades 3 and 5 using longitudinal administrative student test score data from public primary (elementary) schools in the Australian state of Victoria. When constructing our estimates, we employ two specific estimation methods that isolate the effect of principals from the effect of schools themselves by focusing on principal changes within schools only (principal turnover): the variance decomposition approach of Coelli and Green (2012), and directly estimating principal fixed effects while allowing for school fixed effects.[2] The first method provides a direct test of principal effectiveness, while the second method provides

[1] Examples include the early influential studies of Rockoff (2004) and Rivkin et al. (2005), to more recent additions such as Chetty et al. (2014).

[2] One key point of difference between Education and most Economics studies of principal effectiveness is the focus within Economics on identification of principal effectiveness by isolating principal effects from potentially unobserved but fixed effects of schools. Such identification generally relies on changes of principals across schools.

an important input into our second main objective.

Our second main objective is to attempt to identify specific pathways or mechanisms by which individual school principals may affect the schools they lead and ultimately affect student achievement. The effective practices of school leaders, and leaders more generally, is only beginning to be understood. This study is an early attempt to "lift the veil" and attempt to isolate specific practices that are effective in raising employee (teacher), and ultimately student, performance.

The school and student data we employ is well-suited to pursuing this second objective. The Victorian Department of Education has conducted annual surveys of both staff and parents for many years. These surveys measure a range of factors potentially influenced by school principals. We then attempt to identify the specific changes in school factors are also related to improved student achievement. We focus on the precise timing of changes in school factors and student achievement to ensure as far as possible that school principals are the likely driving mechanism. The staff survey data includes information on staff morale, staff interaction, supportive leadership, professional development and goal congruence. These teacher reports help us understand how leadership affects the employees (teachers) ultimately responsible for raising student achievement.

Our work provides several contributions to the literature on whether and how school leaders affect student achievement. Obtaining credible objective evidence on the individual effect of school principals on student achievement has been a focus within Economics in the past five to ten years. The evidence to date is based primarily on a handful of North American studies, including: Branch et al. (2012, 2013); Coelli and Green (2012); Grissom et al (2015); Dhuey and Smith (2014, 2017); and Laing et al (2017). This literature generally finds principals have a significant effect on student achievement as measured by standardised test scores. The estimated effects in some of these studies are almost as large as the effects of individual school teachers. Our estimates will provide robustness to the effects found in the North American studies.

In cross-country comparisons, Hanushek et al. (2011) and the OECD (2013) report that the decision-making powers vested in principals differs considerably across and within countries. Both studies conclude that principal autonomy is mostly associated with better student outcomes under certain conditions. These conditions include a combination of

devolved responsibilities, the schools' capacity to assume these responsibilities, and the extent of accountability in the schooling system. Our study will provide evidence on the effectiveness of school principals in a jurisdiction (the Australian state of Victoria) with above average principal autonomy (OECD, 2013).

A small handful of recent studies attempt to uncover the mechanisms by which principals affect schools. Branch et al. (2013), Bohlmark et al. (2016) and Dhuey and Smith (2017) focus mostly on potential pathways measured using the observable characteristics of each school's teaching workforce, such as experience, individual effectiveness, turnover and certification. Our data (specifically the staff surveys) allow us to investigate a wider set of school factors that are not solely related to changes in the teacher workforce.

A closely related pair of recent studies investigate school management practices using detailed surveys of school principals: Bloom et al. (2015) and Di Liberto et al. (2015). Such surveys may have advantages in terms of understanding the practices of principals rather that teacher perceptions of school conditions and leadership. Teacher reports, however, have the advantage of isolating school conditions that are "felt on the ground" rather than potentially being purely aspirational on the part of responding principals. Laing et al. (2016) use teacher survey information to identify the leadership practices of school principals. Dobbie and Fryer (2013) use teacher, principal and student surveys in their analysis of effective charter schools. Importantly, we observe changes over time within schools in student and leadership outcomes, rather than relying on cross-sectional variation alone.

Previewing the results, we find principals in Victoria have significant effects on student achievement that are comparable in size to those estimated in the North American studies. A one standard deviation improvement in principal effectiveness is related to 0.09 to 0.16 of a standard deviation improvement in student achievement. School principals also have significant effects on a range of school factors associated with teaching, learning and school management, as revealed in the teacher surveys. The factors found to be closely related to principal effectiveness include improved sense of goal congruence among teachers, professional interaction amongst staff, and increasing staff professional development opportunities. The parent survey data includes information on general satisfaction and environment, quality of teaching, "customer" responsiveness, student reporting and

academic rigour. What is most interesting is that we find significant variation in these parental perceptions across principals, but no evidence that such parental perceptions are related to principal effectiveness.

This paper is organised as follows. The student achievement and survey data we employ are detailed in Section 2, along with a description of the Victorian public school environment and details of the school principal movements we employ in identification. The strategies we employ to estimate principal effectiveness are described in Section 3. Our main estimates are provided in Section 4. A discussion of the results, their relationship with existing studies, and potential policy implications, is presented in Section 5. Concluding comments are provided in Section 6.

2 Environment and Data Description

2.1 Victorian public school system

In this analysis, we employ administrative and survey data for government (public) schools from the state of Victoria - Australia's second most populous state. Our main estimates focus on primary (elementary) schools. Two-thirds of Victorian primary school students attend government schools, 22% are enrolled in Catholic schools and the remainder attend independent schools (also private non-profit schools, often religious-based). Non-government schools, particularly independent schools, have traditionally enjoyed greater autonomy than most government schools (Productivity Commission, 2012). In the Australian setting, both Catholic and independent schools are funded in part by the government, but at lower per-student amounts than government schools. These schools also charge fees, ranging from moderate amounts less than $1,000 per year in many, but up to $20,000 and higher in more prestigious schools.

Individual school councils govern public schools in Victoria. At least one-third of council members must be elected parents, while Education Department representatives including the principal and other teachers can comprise no more than one-third of members. One of the main tasks of the school council is to appoint the school principal. Public school principals in Victoria are generally employed on five-year contracts. Con-

tracts can be renewed by council for a second five-year period, after which positions must be advertised. There are no restrictions, however, on the council renewing principal appointments after ten years, if the school council decides the current principal dominates other applicants responding to the advertisement.

In Victoria, the school principal is responsible for developing and implementing a budget to manage school resources, which are primarily received from the Victorian government, but also includes some locally raised funds. Principals are responsible for hiring and allocating staff, are expected to identify excess and under-performing staff, and are responsible for managing such staff in accordance with government policy (Productivity Commission, 2012). Although several education systems have increased the decision-making responsibility and accountability of school principals, the autonomy of Victorian government school principals is high in national and international comparisons. Information collected as part of the 2012 Programme for International Student Assessment (PISA) revealed that Victorian government schools have above-average autonomy among OECD countries regarding responsibility for curricular and instructional decisions, as well as in managing financial and material resources and personnel (OECD, 2013).

2.2 Information on school principals

To reliably estimate the effect of school principals on schools and student outcomes, it is essential to isolate the effect of the principal from the effect of the underlying characteristics of the schools they run. Recent studies within Economics have employed estimation techniques that remove any observed or unobserved time invariant characteristics of schools. Identification of principal effects then relies on changes in principals leading schools over time. The estimated effect of principals on school outcomes is then the difference in outcomes between principals leading the same school.

We constructed annual information on all principals leading Victorian public schools over the period from 1997 to 2011, using a quarterly database of Victorian public school administrative records. In some cases, more than one principal was recorded as leading a specific school at different quarterly intervals within a school year (same as the calendar year in Australia). To allocate just one principal to a school in a specific year, we chose

the principal who had led the school for at least half the year, with the outgoing principal chosen in case of ties.

We constructed full employment histories within the Victorian public school system for these principals using Human Resource (HR) records. These records include information dating as far back as 1950. All HR-related status changes were captured, including changes in job classification, contract initiation, contract renewal, transfers and working hours.

Summary statistics for Victorian school principals are provided in Table 1. Of these principals, 47% are female, with a growing female proportion over time (left-hand panel of Figure 1). On average, these principals had nearly 24 years of experience in the Victorian public education sector prior to their first principal appointment. The average age at first appointment is 44, with 63% aged between 40 and 49. Movements between schools prior to becoming principals was common: The median principal worked at 6 different Victorian public schools prior to becoming a principal. Less than 5% remained at the same school since starting their careers, while 18% had worked at more than 9 schools. After being appointed as a principal, 52% served at one school only up to 2011, while 25% served at two schools and 11% at three schools. This observed distribution, however, is potentially a function of the specific period covered (some observed principal careers are right censored). The median number of schools served as principal among principals observed until retirement was 2.

When we construct our estimates of principal effectiveness below, we isolate the effect of principals on student achievement from the effect of schools using changes in principals leading schools. In the right-hand panel of Figure 1, the percentage of schools each year with a new principal appears to be on a slight upward trend over the period, apart from a notable decline in 2011. In a typical year, 15% of schools have a new principal starting. Only 22% of schools had the same principal over the entire 1997-2011 period, while 37% experienced one change in principal, 28% two changes and 11% three changes. The frequency of principal turnover is similar to jurisdictions where explicit principal rotation policies exist such as BC, Canada (Coelli and Green, 2012).

The prior positions of most incoming principals could be identified in the HR data, with summary statistics provided in Table 2. On average, 55% of incoming principals

were external appointments, with approximately half of those having served as principals in other schools, while the remainder were in teaching or administrative positions. Two-thirds of this external group that were promoted to principal upon appointment served as assistant principals in their previous school, while the remainder were in teaching positions. On average, 30% of new principal appointments are internal promotions, but this percentage fell over the period. Approximately 4% of new principal commencements observed were former principals at the same school. This group includes those who left for another school after serving as principal but then return, and those who return to the school after extended leave.[3]

To use within school variation in leadership to estimate the causal effect of principals, principal changes must be unrelated to within-school changes in school characteristics beyond the control of the principal. It does not require principal turnover to be unrelated to fixed characteristics of schools, as we remove fixed school effects in the estimators we employ. However, it is useful to understand whether principal changes are related to school and principal characteristics. In Table 3, we provide estimates of models where the dependent variable is an indicator for whether a change of principal occurs in a school in a specific year. Each column presents a separate set of estimated coefficients, where the set of explanatory variables differs from column to column. These estimates are average marginal effects constructed from Probit model estimation.[4]

The estimates in the first two columns of Table 3 suggest principal turnover is marginally lower in more advantaged schools (higher parental Socio-Economic Status or SES) and in larger schools. Turnover is higher in secondary and combined schools than in primary schools, with little difference in turnover between non-metropolitan (regional) schools compared to schools in metropolitan areas. Regarding principal characteristics (based on the remaining or exiting principal), there is little evidence of turnover differences by gender, but consistent evidence of higher turnover among older principals (likely retirement). Finally, turnover is more likely among principals with longer tenure (linear turnover term

[3]We could not trace the Victorian government school working history of 11% of new principals. These may be individuals hired from outside the system, including principals and teachers from private schools, other states or other countries.

[4]Estimates from linear probability models were similar.

including in column 1), however the relationship is not linear throughout (indicators for each year of tenure in column 2). Turnover is lower in the second and third years of tenure relative to the first year (the base category).[5]

In columns 3 and 4 of Table 3, we include average school achievement in grade 5 reading and mathematics exams as additional covariates, and focus on primary and combined schools.[6] Average school achievement in reading is essentially unrelated to principal turnover, but there is lower turnover in schools with higher mathematics achievement. By including measures of achievement, and excluding secondary schools, there is now a larger negative relationship between turnover and school size, a smaller negative relationship with parental SES (which is strongly correlated with achievement), and a larger positive relationship with principal tenure.

By only using within school variation in principals during estimation, we are potentially constructing lower bound estimates of the overall variation in principal effectiveness in the schooling system. Some schools may be able to attract more able principals than others due to their underlying characteristics; for example, schools based in wealthy suburbs of large cities. In other schooling jurisdictions, non-random sorting of principals across schools has been observed. For instance, principals leading schools with a high proportion of low-income, low-achieving and non-White students have less experience, less education and have attended less selective colleges prior to entering the workforce (Loeb et al., 2010).

While information on the education backgrounds of principals is not captured in our data, we can look at potential sorting across schools by principal experience. Relationships between principal experience and various school characteristics are presented in Table 4. While there is some evidence that principals at schools with the lowest level of achievement and with students from less-advantaged backgrounds have less experience, the relationships are neither strong nor monotonic. There are stronger relationships between principal experience and the remaining four school characteristics in Table 4.

[5]Estimates of turnover by years of tenure revealed slight spikes after 5 and 10 years, as expected given the five-year contracts used when employing Victorian government school principals over the period.

[6]Our estimates below also focus only on primary and combined schools, as we employ grade 3 and grade 5 test scores as our measures of student achievement.

Smaller schools, primary schools, schools located in remote areas and schools with lower proportions of students from non-English speaking backgrounds (NESB) tend to have less experienced principals. Note, however, that school size is strongly related to these other characteristics. School size is lower among primary and remote schools, while it is higher among schools with a high proportion of NESB students.[7] Principals generally gravitate to larger schools over their careers as principal salaries are higher in larger schools.[8]

2.3 Student achievement data

Our main measures of student achievement are individual scores on state-wide assessments of literacy and numeracy in Grades 3 and 5 (primary school) from 1997 to 2007 in Victoria.[9] Testing took place in the first half of August each year. These assessments were scored against the state's Curriculum and Standards Framework (CSF),[10] which described what students should know and be able to do in eight key areas of learning at each schooling stage. The average student was expected to improve their level of achievement by about one CSF level over a two-year period.

Our main estimates of principal effectiveness are based on value added models of student achievement in two domains: reading and mathematics.[11] We focus on scores for those students who were assessed in both grades 3 and 5, and who can be matched over time. In total, 264,826 students could be matched over this period. This matching was

[7]NESB students are more likely in metropolitan schools, which are larger.

[8]Approximately two-thirds of all principal switches we observe in our estimation sample are principals moving to larger schools.

[9]The student assessment program in Victoria was known as the Learning and Assessment Project (LAP) up until 1999, then as the Achievement Improvement Monitor (AIM) program up until 2007. Australia-wide testing under the National Assessment Program - Literacy and Numeracy (NAPLAN) replaced all such state-based tests in 2008.

[10]The Curriculum and Standards Framework (CSF) was replaced by the Victorian Essential Learning Standards (VELS) in 2006.

[11]Scores on tests of numbers and reading were also available. Scores for the numbers domain were highly correlated with mathematics scores at the individual student level. Scores for the writing domain were based on both a centrally set and marked component and a teacher set and marked component. Having a teacher assessed component in this domain made it less amenable to the type of analysis we undertake.

undertaken using student name, grade and school only, as no birth-date information was available. Approximately 72% of all students were matched.[12] The student-level data we have includes information on school attended, gender, non-English speaking background (NESB), and Aboriginal or Torres Strait Islander (ATSI) origin.

Summary statistics for the students we employ in our analysis are presented in Table 5, along with statistics for all students who undertook the same tests during the same period. On average, 15% of students had a language background other than English (Victoria is home to many recent migrants to Australia) while approximately 1% were of ATSI origin. Consistent with the scoring of tests against CSF levels, grade 5 average scores are approximately 1 point higher than those observed at the grade 3 level. The matched sample of students were less likely to be NESB or ATSI and had slightly higher test scores than all students.

2.4 Staff and parent surveys

The main contribution of this analysis is the ability to explore some of the potential mechanisms by which principals can influence schools and student achievement. We undertake this exploration by analysing changes in a range of school-level factors which principals can directly or indirectly influence. These school factors are measured using annual surveys completed by school staff (in June each year) and by parents of enrolled students. All school staff were invited to complete the questionnaires, while a 20% random sample of parents were sent the questionnaire for completion. We only have information on response rates for recent years, which exceeded 70% for both the staff and parent surveys.

Summary statistics for the school factors we employ in our investigation are provided in Table 6. Staff responses to individual survey questions were combined to produce measures on each school factor using a 100-point scale. We have information on the first four factors over the whole period from 1997 to 2007, and from 1998 to 2007 on Professional Growth. The summary statistics in Table 6 are provided for the last year in

[12] If names were not unique within school and grade, no match was formed. Matches were only formed if the two tests were taken two years apart, thus students who repeated grades would not be matched and thus not included in the estimates.

our investigation: 2007. The specific questions that were combined to construct each of these factors are listed in Appendix Table A1.[13]

The Parent Opinion Surveys (conducted in late July each year) sought parental perceptions of the school, staff and the extent of their own interactions with their children's school. Responses to individual questions were collected on a 6 or 7 point scale (depending on year), and were subsequently combined to produce an overall score for each factor on a 6 or 7 point scale.[14] The specific parental questions that form each of these factors are listed in Appendix Table A2. We have information on the first two factors over the whole period from 1997 to 2007, and information on the remaining four parental factors from 1997 to 2003.

While the absolute levels of these composite responses by factor may be difficult to interpret directly, what is clear in Table 6 is that there is significant variation across schools in these measures. We employ variation over time within schools in these composite scores to isolate the influence of individual principals on these school factors. We also investigate whether our measures of principal effectiveness identified using student test score gains are related to simultaneous changes in these school factors.

3 Empirical Strategy

Our first main objective is to construct measures of the idiosyncratic effect of individual school principals on student test scores in Victorian government primary schools. The key statistic we construct is the variance of principal effectiveness in terms of their ability to improve student test performance. Non-zero variation in measured principal effectiveness implies both variation in the effectiveness of principals, and that principals can affect student outcomes.

We construct our measures using two estimation techniques that both remove a fixed effect of schools. Firstly, we employ the variance decomposition technique of Coelli and Green (2012), which in turn is based on the technique employed by Rivkin et al. (2005)

[13]We do not have access to individual staff responses to specific questions.

[14]As with the staff survey, we have been provided with the average school scores for each factor only, not individual parent responses to each question.

to estimate teacher effectiveness.[15] Secondly, we construct estimates of each individual principal's effectiveness using standard "education production function" regressions that include individual principal and school indicators. We then construct estimates of the variance of the estimated coefficients on the principal indicators after appropriate shrinkage to allow for measurement error (see Coelli and Green, 2012: Dhuey and Smith, 2014, 2017; Bohlmark et al., 2016).

Both techniques assume that principals have a time-invariant effect on the schools that they lead. We allow these effects to differ across each school a principal leads, as principals may have different effects on different schools.[16] Note that only variation over time within schools in principal leadership is exploited by both techniques. These estimators thus potentially provide lower bound estimates of the actual dispersion in principal effectiveness, as average principal ability may differ considerably across schools.

3.1 Variance decomposition method

Construction of the variance decomposition estimator is as follows. Average student achievement $\bar{A}_{st}$ in school s in academic year t is defined as a linear and additive function of a fixed school effect (γ_s), the effect of the specific principal leading school s at time t (θ_{st}), average student ability in school s and time t ($\bar{\delta}_{st}$), and a random error term (u_{st}), which is assumed independent of the other three components[17]:

$$\bar{A}_{st} = \gamma_s + \theta_{st} + \bar{\delta}_{st} + u_{st} \tag{1}$$

Constructing deviations from the within school over time mean removes the fixed school effect (γ_s). Squaring both sides then yields:

$$(\bar{A}_{st} - \bar{A}_s)^2 = (\theta_{st} - \bar{\theta}_s)^2 + (\bar{\delta}_{st} - \bar{\delta}_s)^2 + 2(\theta_{st}\bar{\delta}_{st} + \bar{\theta}_s\bar{\delta}_s - \theta_{st}\bar{\delta}_s - \bar{\theta}_s\bar{\delta}_{st}) + (u_{st} - \bar{u}_s)^2 + \nu_s \tag{2}$$

where ν_s denotes all the cross product terms of the random error deviations ($u_{st} - \bar{u}_s$) with ($\theta_{st} - \bar{\theta}_s$) and ($\bar{\delta}_{st} - \bar{\delta}_s$). In expectation, ν_s will equal zero, due to the assumed independence of u_{st}.

[15] Branch et al. (2012) and Liang et al. (2016) also employ a different variant of this technique when measuring principal effectiveness.

[16] Some prior studies constrain principals to have the same fixed effect in each school that they lead.

[17] This error term is also assumed to be drawn from the same distribution across schools.

Equation 2 thus relates over time variation in average student performance within a school to variation in principal effectiveness within the school, variation in average student cohort ability over time within the school, twice the co-variation of principal effectiveness with average student ability, and within school variation in the random error u_{st}. Taking expectations of Equation 2 yields:

$$\sigma^2_{\bar{A}_s} = \sigma^2_{\theta_s} + \sigma^2_{\bar{\delta}_s} + 2 \cdot \sigma_{\theta_s \bar{\delta}_s} + \sigma^2_u \tag{3}$$

where the within-school variance in student outcomes $\sigma^2_{\bar{A}_s}$ is a linear function of a term representing the within-school variance in principal effectiveness $\sigma^2_{\theta_s}$, the variance of average student ability within a school $\sigma^2_{\bar{\delta}_s}$, twice the covariance of average student ability and principal effectiveness $\sigma_{\theta_s \bar{\delta}_s}$, and the variance in the random error term σ^2_u.

Following Coelli and Green (2012), we invoke three assumptions to identify the underlying variation in principal effectiveness. The main additional assumption is that the within-school covariance of average student ability and principal effectiveness is zero ($\sigma_{\theta_s \bar{\delta}_s} = 0$). This assumption does not require that average student ability is the same in all schools. It just requires that shocks to average student ability do not occur simultaneously with any principal change within a school. This assumption thus rules out more able students moving to a school that at the same time has a principal change, or principals being replaced in schools where student ability is declining or rising. Ruling out student sorting across public schools appears reasonable since school enrollment in the public school sector is generally determined by local geographic catchment areas in Victoria.[18] In addition, individual school boards choose the principal to hire in their school. The Victorian government did not allocate principals to schools based on any strategic objectives.

This assumption also requires that temporary shocks to measured student performance in a school cannot be the instigator of a principal change. For example, sharp and sudden declines in student performance due to some random event should not lead to principals being replaced. Mean reversion of measured student performance after such

[18]While it is possible that some parents may respond to negative events at their local government school by enrolling their child in a Catholic or independent school, such enrollment decisions are usually taken well in advance and often for pastoral care reasons.

random events would then create a mechanical relationship between principal changes and changes in student performance unrelated to principal effectiveness. In our setting, such principal changes are unlikely to occur for two main reasons. First, principals are hired on five-year contracts, making it difficult for school boards to fire a principal in response to a sudden drop in performance. Second, the standardised test scores employed in this analysis were not used as part of any public accountability mechanism during the years we study.[19] In addition, while year-to-year changes in school average standardised test scores were on average negative in the year prior to a principal change in our data, the effects were small and not statistically significantly different from zero.[20]

The second additional assumption we invoke is that each principal p is drawn randomly with fixed effectiveness θ_p from a pool with common variance denoted by σ_p^2. We are primarily interested in constructing an estimate of σ_p^2, this common variance in underlying principal effectiveness. This common variance assumption does not preclude schools attracting principals with different average effectiveness. Schools in better locations may be able to attract principal applicants with higher abilities than other schools. By removing school fixed effects, we are removing this potential source of variation in principal effectiveness.

The third additional assumption is that students are drawn randomly from a distribution with common variance across schools. This assumption does not rule out schools attracting students of different average ability. Schools in more affluent locations are likely to attract students from more advantaged backgrounds. Again, by removing school fixed effects, the effects of potential variation in average student ability on our estimates is removed. This assumption assures that the within school variation in average student ability $\sigma^2_{\bar{\delta}_s}$ will simply be proportional to the inverse of the average number of students in the school sitting each test. There will be higher variation in average student ability over time in smaller schools.

[19]School average performance on more recent versions of these standardised tests have been made publicly available since 2010 across Australia via the My School website (see Coelli et al., 2018), but our analysis in this paper stops in 2007.

[20]Interestingly, year-to-year changes in grade 5 and value-added mathematics scores were on average negative in the year of principal change, suggesting a disruptive effect of school leadership change. No such effect was found for reading scores.

The main intuition underlying this estimator is as follows. Variation over time in average student achievement in a school will be higher in schools where school leadership changes, other things being held constant. If a school is led by the same principal over a specific time period, the variation in principal effectiveness $\sigma^2_{\theta_s}$ within that school will be zero. If more than one principal leads the school, this variation will be positive. Using the assumption that each principal's underlying effectiveness θ_p is drawn randomly and independently from a distribution with variance σ^2_p (i.e. $E[\theta_p \theta_k] = 0 \; \forall \; p \neq k$), the within school variance in principal effectiveness for any school s can be constructed as follows:

$$\sigma^2_{\theta_s} = \frac{1}{T}\sum_{t=1}^{T}(\theta_{st} - \bar{\theta}_s)^2 = \sigma^2_p \left[\frac{1}{T}\sum_{p=1}^{P_s} q_p \left[1 + \frac{1}{T^2}\sum_{k=1}^{P_s} q_k^2 - \frac{2}{T} q_p\right]\right] \tag{4}$$

where the school is observed in our data for T years, where P_s individual principals serve at the school during that period, and where each principal serves for a spell of q_p years ($\sum_{p=1}^{P_s} q_p = T$). This derivation is explained in more detail in the Appendix of Coelli and Green (2012).

The variance of principal effectiveness within a school $\sigma^2_{\theta_s}$ is thus the underlying variance of principal effectiveness σ^2_p (our main object of interest) multiplied by a deterministic term measuring the amount of turnover of school principals within school s over the time period T. This principal turnover term will equal zero if one principal leads the school over T. It increases with the number of principals leading the school during the period, with the precise value also a function of how many years each principal leads the school.

We estimate the object of interest σ^2_p using a simple regression equation at the school level. We regress the variance in mean student outcomes across cohorts in each school $\sigma^2_{\bar{A}_s}$ [21] on the turnover term defined in Equation 4, the inverse of the average number of students in the school sitting the test n_s to control for variation in average student quality $\sigma^2_{\bar{\delta}_s}$,[22] and a constant term to absorb σ^2_u.

$$\sigma^2_{\bar{A}_s} = \beta_0 + \beta_1 \cdot \text{Turnover}_s + \beta_2 \cdot 1/n_s + \varepsilon_s \tag{5}$$

[21] In the estimates below, we remove the effect of a number of observable characteristics of students on achievement prior to constructing $\sigma^2_{\bar{A}_s}$.

[22] The correct control - which we employ below - is an adjusted measure of the inverse of cohort size that reflects the limited time horizon of our data. The correct control equals $1/n_s - 1/(n_s \cdot T)$, where n_s is the average size of the cohort sitting the test in each school.

The estimated coefficient on the turnover term β_1 is our estimate of σ_p^2. The main advantage of this estimation method over our second method is that it provides a direct test of whether our estimate of underlying principal effectiveness variation σ_p^2 is statistically different from zero. It thus provides a specific test of whether it can be claimed that principals affect student outcomes. It must be noted, however, that finding a positive estimate for σ_p^2 requires both that principals can significantly affect student outcomes, and that there is significant variation in principal effectiveness within the principal pool. Small or insignificant estimates of σ_p^2 may not in itself imply that principals have no effect on student outcomes. It may imply that there is little variation in principal effectiveness within schools (all are equally good at their jobs).

3.2 Fixed effects regression method

Our second method for estimating σ_p^2 begins by estimating a value-added model of student achievement as follows:

$$A_{ist} = \alpha_1 A_{ist-2} + \alpha_2 \mathbf{X_{ist}} + \alpha_3 \mathbf{Z_{st}} + \gamma_s + \theta_{st} + \tau_t + u_{ist} \tag{6}$$

where A_{ist-2} is prior achievement of student i (noting the two year gap in testing in Victoria), $\mathbf{X_{ist}}$ is a vector of student demographic characteristics, $\mathbf{Z_{st}}$ is a vector of time-varying school characteristics, γ_s are school fixed effects, θ_{st} are principal indicators, τ_t are year fixed effects and u_{ist} is an idiosyncratic error term.

By including school fixed effects, we are again using turnover of principals in schools to isolate the effect of principals on student achievement from the potentially unobserved effect of schools themselves. We use the estimated coefficients on the principal indicators to construct a measure of the variance in principal effectiveness. Of the three assumptions we invoked above for identification of the variance decomposition method, the first two are also implied here.[23]

One potential source of bias in our estimates is if principals choose schools based on time-varying qualities of schools. For example, if certain principals tend to apply for jobs in schools where student ability is on an upward trend, this may bias our estimates

[23]The third assumption of common variance of student quality across schools can be weakened here without affecting consistency.

of the effect principals on achievement. By controlling for the individual student and time-varying school characteristics that we have, we are minimising the potential bias from such principal sorting. As a robustness exercise, we also constructed estimates that also allowed for school-specific time trends in achievement. While this exercise is pushing the variation available in our data quite hard, it is of some comfort to note that our estimates of the variance in principal effectiveness were no smaller (the estimates were actually generally larger) than our main estimates that we report below.

As noted in Coelli and Green (2012), bias in estimates of the variance of principal effects using either method could arise from non-random exit of principals from the principal workforce. If only the most effective and/or least effective principals choose to quit the principal workforce, this would bias up estimates of the variance of principal effectiveness based on turnover of principals within schools. Our analysis of the main reasons why principals exit the system entirely in Victoria, however, found that exit is most often associated with retirement.

As cautioned by Kane and Staiger (2002), estimates of the variance of principal effectiveness constructed using unadjusted coefficients on the principal indicators are subject to sampling error bias. Random year to year variation in test day conditions and in student ability are the main sources of such bias. The variance of these estimated coefficients will overstate the true variance in principal effectiveness. To account for this bias, we follow the previous literature by employing an Empirical Bayes shrinkage technique. Using an appropriate shrinkage technique is also important when we estimate relationships between our measures of principal effectiveness and our measures of the effect of school principals on school factors. Estimation of such relationships using measures subject to sampling error bias will yield attenuated estimates. By using appropriate shrinkage techniques, such attenuation is avoided.

We use the following specific shrinkage technique, similar to the technique employed by Branch et al. (2012). The adjusted (shrunk) principal effect $\hat{\theta}_p^*$ for principal p is constructed as follows:

$$\hat{\theta}_p^* = \left(\frac{V_T}{V_p + V_T}\right) \hat{\theta}_p + \left(\frac{V_p}{V_p + V_T}\right) \bar{\theta} \tag{7}$$

where $\hat{\theta}_p$ is the coefficient on the fixed effect for principal p from estimation of Equation 6, V_p is the estimated variance for that principal effect estimate, $\bar{\theta}$ is the overall mean of

all the estimated principal effects, and V_T is the estimate of the overall variance of the "true" principal effects. This shrinkage formula essentially pulls those estimates where the variance of the estimate V_p is large (an imprecise estimate, perhaps due to only a small number of students sitting the test) towards the overall mean $\bar{\theta}$.

To construct V_T, we begin by assuming that we observe a noisy estimate $\hat{\theta}_p$ comprised of the true effect θ_p^* plus a random disturbance ϵ_p. If the true effect and the random disturbance are independent, the variance of the true principal effect can be calculated as V_T=V_E $-$ V_ϵ, where V_E is the variance of the "noisy" principal effects $\hat{\theta}_p$, and V_ϵ is the variance of ϵ_p. We estimate V_ϵ using the average of the variances of the estimated principal fixed effects V_p.

The main advantage of this second method over the variance decomposition method is that it provides measures of the relative effectiveness of each principal compared to the other principals that led the same school over the estimation period. We use these measures of relative principal effectiveness to identify potential mechanisms by which principals affect student outcomes. To do so, we construct measures of the effect of principals on the various school factors that are measured in the parent and staff surveys. We construct these measures in a comparable manner to how we construct our measures of principal effectiveness. We estimate regression models as follows:

$$Y_{st} = \gamma_s + \theta_{st} + \tau_t + u_{st} \tag{8}$$

where the Y_{st} are the school factors described above.

The coefficients on the principal indicators from these regressions will then be compared to the estimates of individual principal effectiveness to ascertain which specific school factor changes coincide with improvements in principal effectiveness. These comparisons will be made using the appropriately shrunk measures to remove attenuation bias.

4 Results

We first provide our estimates of overall principal effectiveness using both methods described above. We then explore the potential pathways by which principals may be

affecting schools.

4.1 Principal effects - variance decomposition method

Estimates of the variance of principal effectiveness calculated using the variance decomposition method are presented in Table 7. All individual student scores were first normalised to have mean zero and standard deviation one within each testing domain, grade level and testing year. They were also adjusted for the effect of individual student, school and peer characteristics. This adjustment was undertaken by regressing the normalised scores at the individual student level on individual student characteristics (gender, NESB and ATSI indicators, plus interactions of gender with NESB and ATSI), school characteristics (socio-economic status of students based on post-code characteristics of where they live, proportion of students in the school from an NESB background, indicators for whether the school is located in a regional or remote area), and average student peer characteristics (proportions of other students in the same school, grade level and year that are female, NESB and ATSI). The adjusted scores at the individual student level are simply the residuals from these regressions. We also present estimates where grade 3 scores are also included in the grade 5 adjustment regressions. This adjustment aids comparisons to the estimates we construct using the fixed effects regression method.[24]

The coefficient estimates from these first stage individual student regressions for reading and mathematics are presented in Appendix Table A3. Overall, these estimates are in line with expectations. Female students achieve higher reading scores than their male counterparts, while the opposite is true in mathematics. Students from a non-English speaking background (NESB) achieve lower scores in reading in both grades 3 and 5 and in mathematics in grade 3, but achieve higher scores in mathematics in grade 5. Indigenous students (ATSI) had lower achievement in both testing domains and both grades. Regarding school level characteristics, the average socio-economic status of parents and the proportion of non-English speaking students at the school were also associated with higher achievement. Somewhat surprisingly, schools located in regional areas performed

[24]Estimates of principal effectiveness using unadjusted test scores were also constructed. Estimates were larger and more likely to be statistically significant using the unadjusted scores. These estimates are available upon request.

better than those located in major cities, while those located in remote areas performed above city schools but below regional schools. Keep in mind, however, that these location effects were estimated after already controlling for parental SES, which is much lower in regional and remote schools. Regarding the influence of peer characteristics, the gender of class peers was unrelated to achievement, the NESB status of peers was positively related to achievement, while ATSI status was negatively related.

The results presented in Table 7 are the estimated coefficients on the principal turnover term from estimation of Equation 5 at the school level. These coefficients are our estimates of σ_p^2, the underlying variation in principal effectiveness. In all cases, these estimates are positive, and are statistically significantly different from zero in half of the estimates. This implies that school principals can have significant effects on student achievement in Victorian government primary schools, and that there is significant heterogeneity in the effectiveness of these school principals.[25] Note that the value-added versions at the bottom of Table 7 are not always smaller than the grade 5 estimates that do not include prior grade 3 scores when constructing the adjusted scores. Whether to include prior test scores when estimating principal effectiveness is open to some debate (see for example Clark et al., 2009). When constructing teacher effectiveness estimates, controlling for prior test scores seems clear. However, principals may lead a school for several years. They may thus have also affected the prior test scores of students. Effective principals may not necessarily yield high value added if they had boosted prior test scores considerably.

To interpret the size of these estimated effects, we take the square root of the coefficients to yield estimates of the standard deviation of principal effectiveness. These standard deviations range from 0.088 to 0.164, depending on grade level and domain. This implies that having a principal that is one standard deviation higher in the distribution of the principal pool is associated with test scores that are higher by 0.088-0.164 standard deviations. Transforming these back into terms of years of student learning, these effects equate to 0.14-0.22 years.[26] These estimates are large and at the upper end

[25]These estimates were constructed using information on schools with at least two students sitting the test in each year, grade and domain. In addition, only schools with a continuous run of 4 years or more of information were included.

[26]This transformation relies on the test scoring regime being used at that time in Victoria, where an increase in raw scores of one is equivalent to 2 years of learning for the average student.

of estimates in the literature.

4.2 Principal effects - fixed effects regression method

Estimates of the standard deviation of principal effectiveness calculated using the fixed effects regression method (Equation 6) are presented in Table 8. In all cases, the estimates are sizable, even after using the Empirical Bayes shrinkage method to deal with measurement error. Note that allowing for measurement error reduces the estimates by approximately one half, highlighting the importance of employing this procedure. Note also that the shrunk standard deviation estimates are quite comparable in size to those constructed using the variance decomposition method (Table 7).

Coefficient estimates on the other variables (apart from the principal and school fixed effects) included in the value added model (VAM) regressions used to construct the standard deviation results at the bottom of Table 8 are presented in Appendix Table A4.[27] The effects of individual characteristics on achievement are similar to those reported in Appendix Table A3 (gender, NESB, ATSI, grade 3 test scores). The estimated effects of the school characteristics (parental SES and NESB proportion) are much reduced in these estimates that also include school fixed effects. These school characteristics have much less variation within schools than across schools. The estimated effects of the student peer characteristics also differ, but to a lesser extent. There remains some variation in these characteristics across grades and years within schools.

In these models, we are also able to include indicators of how long each principal has been leading the school (tenure indicators). This allows us to ascertain whether principals take time to improve the schools that they are brought in to lead. Coefficient estimates on these tenure indicators (not reported) suggest that achievement does improve by 0.02-0.03 of a standard deviation over the first two years of tenure, then barely increased after that, and the increase even dissipates beyond approximately 8 years.

[27] Only schools that had a change in principal during the observed period are included in these estimates, as principal fixed effects are only identifiable in such schools.

4.3 Principal effectiveness mechanisms

We begin this part of the analysis by estimating the extent to which individual principals influence the school factors measured in the staff and parent surveys. We do so by employing the two estimation techniques described above. We use each school factor as the dependent variable in turn.[28] All factors were first normalised to have mean zero and standard deviation one. Our estimated effects of principals on these factors are presented in Table 9. Note that we are again controlling for school fixed effects, so these estimates pick up changes within schools in these factors as principal leadership changes.

The estimates in Table 9 imply that principals have substantial effects on staff and parent perceptions of many school factors. Tests of whether the variance of principal effects equals zero are strongly rejected in all cases. Somewhat comfortingly, the two estimation methods again yield estimates that are similar in size. We can interpret these estimates as follows. Having a principal that is one standard deviation higher in the distribution of principals in terms of affecting school morale raises school morale by 0.469-0.494 of a standard deviation in the cross-school morale distribution. Equivalently, the estimates suggest that approximately 22% of the cross-school variance in school morale is attributable to school principals. Among the school factors measured using staff perceptions, principals appear to have the most impact on supportive leadership. This makes intuitive sense, and gives us some confidence that we are measuring the underlying effect of principals on these school factors. Among the school factors measured using parent perceptions, principals appear to have the least effect on quality of teaching, again making intuitive sense.

While the results presented in Table 9 highlight the influence that principals can have on important school factors associated with teaching, learning and school management, we now turn to the larger question of determining which specific factors are associated with improved student outcomes. We do so by simply regressing each principal's fixed effect on achievement on the same principal's fixed effect on each of these school factors, after both fixed effects have been appropriately shrunk. The results from these simple regressions are presented in Table 10, where we focus on principal effectiveness in terms

[28] We do not adjust these factors for student or school characteristics here.

of value-added student achievement from grade 3 to 5.

Among the school factors measured by staff perceptions (top half of Table 10), only supportive leadership is not significantly and positively related to student achievement growth for at least one testing domain. Having a principal that staff members can communicate with and who understands their concerns is not related to improved student achievement. Of the four factors that are related to effective principals, they are more closely related to effectiveness in improving mathematics achievement than in improving reading. The strongest relationships are with goal congruence and professional growth. Effective principals appear to be leaders that improve these two specific school factors. We can interpret these estimates as follows. Having a principal that is one standard deviation higher in terms of promoting professional growth is associated with a principal that has raised value added math achievement by 0.0447 of a standard deviation (0.06 of a year of learning).[29]

The factors measured in the parental surveys were not positively related to principal effectiveness. Some estimates are even negative. Parental perceptions of schools do not appear to be related to the effectiveness of school principals in terms of raising student test scores. This is a very interesting finding. It suggests that those principals that are effective in terms of raising student performance on standardized tests are not necessarily also those that are effective in raising parental perceptions of the quality of the school, its teachers and its "customer service". This may suggest that the skills of principals regarding these two dimensions of their job are not necessarily related. It may also suggest that principal effort in raising one of these outcomes (student performance or parental perceptions) may be at the expense of raising the other.

Note that over this period, student test scores were not used for any public accountability exercise. Parents were not able to easily compare student performances across schools. This changed in 2010 with the introduction of the My School web-site in Australia, but this occurred after the period we employ during estimation.

[29]Results using grade 5 achievement without controlling for grade 3 scores were very similar. Results using grade 3 achievement revealed essentially no significant relationships between principal effectiveness and the school factors, apart from goal congruence with reading achievement. These results are available upon request.

5 Discussion and Policy Implications

The estimates presented above reveal an important and large effect of individual principals on student achievement. These effects are sizable when compared to international estimates of teacher effectiveness. Rockoff (2004) finds that individual teachers have an unadjusted effect of approximately 0.21 of a standard deviation in annual reading growth and 0.29 in mathematics growth. Aaronson et al. (2007) find an effect of 0.13 of a standard deviation of teacher effects on math scores in Chicago. Other sizeable effects were found by Ballou et al. (2004), Rivkin et al. (2005), Gordon et al. (2006) and Lavy (2009). In a review of the evidence on teacher effectiveness, Hanushek and Rivkin (2010) find an average effect of 0.11 of a standard deviation in reading and 0.15 in mathematics. In Australia, Leigh (2010) finds an average teacher effect of 0.1 of a standard deviation on literacy and numeracy achievement using data from Queensland.

Compared to other studies of principal effectiveness, our estimates are comparable or larger, with one notable exception. Our results are larger than effects estimated by Branch et al. (2012) using data from Texas (approximately 0.1 of a standard deviation, or 0.1sd), by Grissom et al. (2015) using data from the Miami-Dade school district in Florida,[30] and by Laing et al. (2016) using Chicago Public School system data (approximately 0.03sd in their preferred specification). Our estimates are similar in size to those reported by Dhuey and Smith (2017) using data from North Carolina (0.12sd in reading, 0.17sd in mathematics), but smaller than the notably large estimates reported in Dhuey and Smith (2014) for British Columbia (0.29sd-0.41sd).

In related studies, Coelli and Green (2012) found that principals may take several years to have their full effect on schools. Given our relatively long time period for estimation (relative to these previous studies), we may see principals in schools for more years, and thus are potentially able to get closer to estimating their "full" effect. Another potential source of difference in the size of estimates from previous studies, as noted above, is the relatively high level of autonomy afforded to Victorian government school principals.

As noted above, Economics research on the factors associated with principal effective-

[30]These authors highlight the modeling complexities and stringent data requirements for estimating principal effects. Their estimates using models that are consistent with other research in the field (using within-school variation only) produced estimates of 0.04sd in math and 0.02sd in reading.

ness are relatively rare, with many studies constrained to investigating pathways related to changes in the teaching workforce. Branch et al. (2012, 2013) find that less effective teachers are more likely to leave schools run by effective principals in Texas. Bohlmark et al. (2016) investigate the relationship in Sweden between principal effectiveness and observable characteristics of the school's teachers. The authors find some significant relationships between principal effectiveness with teacher wage dispersion, the proportion of female teachers and the proportion of certified teachers, but with little consistency. Dhuey and Smith (2017) found little in terms of consistent relationships in North Carolina between principal effectiveness and teacher workforce characteristics including: experience, education, certification, licensing or turnover.

Both Brewer (1993) and Dhuey and Smith (2014) find no relationship between principal experience and effectiveness. In contrast, Eberts and Stone (1988) and Clark et al. (2009) find principal experience is positively related to effectiveness. Miller (2013) finds that achievement declines in the first two years of a new principal's tenure, then rises over the next 3 years. While we do not attempt to estimate the effect of principal experience on student outcomes in our research, our findings regarding principal tenure effects are at odds with Miller, as we find average improvements in achievement early in a principal's tenure that then dissipate in later years.

In related findings, Branch et al. (2012) find the variation of the effectiveness of principals to be larger in high-poverty schools. Beteille et al. (2013), using data from the Miami-Dade school district in Florida, find that principal turnover itself is detrimental for both student performance and teacher turnover, particularly for high poverty schools, low-achieving schools, and schools with many inexperienced teachers. Miller (2013) also found achievement declines immediately prior to a principal change. Corcoran et al. (2012) find that principals trained in the New York City Aspiring Principals Program have positive effects on student outcomes. Clark et al. (2009), however, find mixed evidence on the effect of principal development programs on student achievement.

We have found that principals have a significant effect on a range of factors related to teaching and professional collaboration. Our estimates imply that principals who effectively raise student achievement are those who enhance their teaching staff's sense of goal congruence as well as their level of professional interaction and professional growth.

School morale also improved, but there is the possibility that this increase is a result of improving student achievement rather than the cause.

While we do not have individual responses to the questions asked of staff that make up these specific factors, these questions (listed in Appendix Table A1) may provide some insights into what effective principals are doing. Principals may be able to enhance staff's sense of goal congruence by establishing a set of clearly-stated objectives and goals, explaining their meaning to staff, and encouraging staff to commit themselves to achieving those objectives and goals. Principals can encourage healthy professional interaction by providing specified times and places for such collaboration, allocating mentors to junior staff, and setting up simple ways for staff to communicate with each other. Principals can encourage professional growth by including professional development opportunities in regular staff reviews, and providing staff with time and resources to undertake professional development activities.

Our findings are consistent with qualitative findings in the Education literature which emphasize the importance of instructional leadership. As Hattie (2009) points out, this refers to principals who focus on more than just administrative leadership. Effective principals are actively involved in developing the school's learning environment by setting clear teaching objectives as well as high expectations for teachers and students (Hallinger and Heck 1998). This was also observed by Seashore et al. (2010) who concluded that school leaders who influence teachers' motivation and working conditions have the greatest impact on student achievement.

Regarding studies within economics, our findings are generally in alignment with Bloom et al. (2015), who found that measures of management quality based on principal surveys are positively related to school outcomes in the cross-section.

The empirical evidence on pathways uncovered here and supported by previous studies in the Education literature can assist policy-makers in identifying effective principals or those in need of further support without the need to wait for repeated measures of student achievement over an extended period. Moreover, the quantitative evidence linking effective leaders to certain practices can be used to develop capacity amongst current and future principals. The design of professional development programs for both existing principals and senior staff identified as potential future leaders can benefit from these

findings. Leaders who create a stimulating and collaborative professional environment, with a shared school vision and goals, are those who can best raise student achievement.

6 Conclusion

Our investigation has revealed that school principals have significant effects on student outcomes in Victorian primary schools. This provides further evidence on the importance of leadership in affecting student outcomes. Investigating the role of school principals in raising student achievement is as important as the current focus on the role of teachers, since a high-quality principal can affect outcomes among all students in a school.

Our analysis has also highlighted some potential pathways through which principals may impact student achievement, partially lifting the veil to reveal some of the key mechanisms. As might be expected, the more effective pathways involved principals influencing their teaching staff, rather than via influencing parental perceptions of the school. Our results suggest that the most effective principals establish a coherent set of goals for the school's workforce, to encourage professional interaction among staff, and to promote the professional development of staff. More work is required, however, to fully understand the specific strategies effective principals employ to improve these school factors that are most closely related to improved student achievement.

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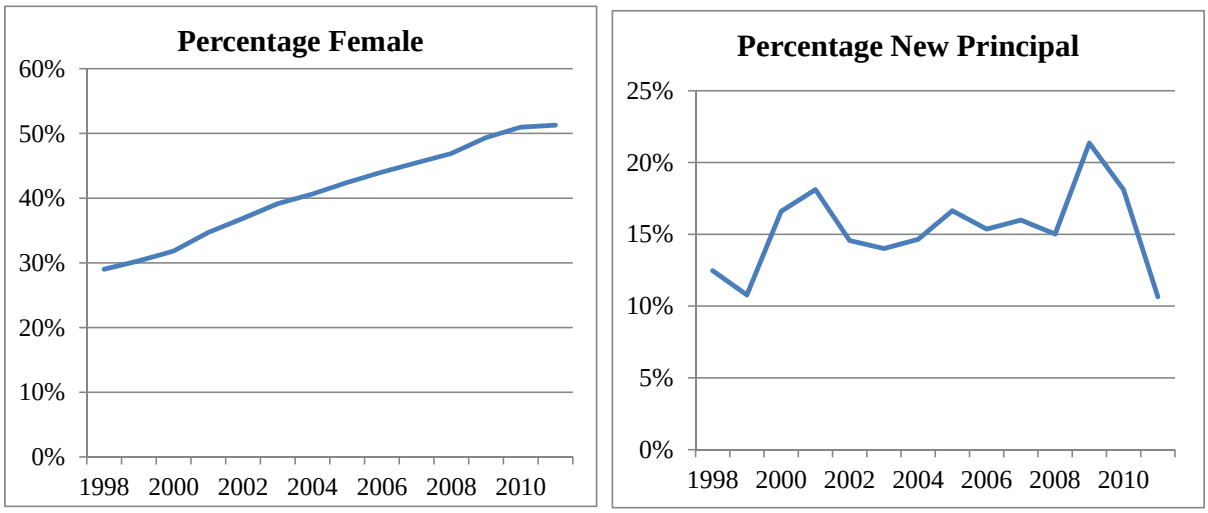
Table 1: **Characteristics of Victorian government school principals**

Characteristic	Mean	Median	Proportion
Female			0.472
Experience at first principal appointment	23.7	25.0	
10 years or less			0.068
11-15 years			0.087
16-20 years			0.136
21-25 years			0.267
26-30 years			0.268
31-34 years			0.120
35 years plus			0.054
Age at first principal appointment	44.0	44.0	
Under 35			0.054
35-39			0.151
40-44			0.330
45-49			0.298
50-54			0.139
55+			0.029
Schools worked at prior to first principal appointment	6.5	6.0	
0-1			0.044
2-3			0.140
4-5			0.241
6-7			0.232
8-9			0.165
10-11			0.101
12-13			0.047
14 plus			0.031
Schools worked at as a principal	2.0	2.0	
1			0.524
2			0.251
3			0.114
4			0.055
5			0.024
6 plus			0.032

Notes: Descriptive statistics for full sample of 4,665 principals who served in Victorian Government schools between 1997 and 2011, from Victorian DET data.

Figure 1: **Trends in principal characteristics**



Notes: From DET data, all Victorian government school principals over the 1998 to 2011 period.

Table 2: **Prior positions of entering principals**

Prior position	average	trend
Principal, other school	27%	some increase
Staff, other school	28%	increase
Staff, same school	30%	decline
Principal, same school	4%	–
Unknown	11%	–

Notes: From DET data, all Victorian government school principals over the 1998 to 2011 period.

Table 3: **Probability of a change in principal - model estimates**

	(1)	(2)	(3)	(4)
SES decile	-0.00164*	-0.00171*	-0.00151	-0.00153
	(0.000996)	(0.000991)	(0.00128)	(0.00128)
Size (000s)	-0.0245**	-0.0255**	-0.100***	-0.0975***
	(0.0101)	(0.0101)	(0.0197)	(0.0196)
Non-metropolitan	-0.0276	-0.0318	-0.00301	-0.00734
	(0.0783)	(0.0804)	(0.0604)	(0.0586)
Secondary	0.0338***	0.0340***		
	(0.00834)	(0.00834)		
Combined	0.0512***	0.0521***	0.0611***	0.0605***
	(0.0134)	(0.0136)	(0.0161)	(0.0163)
Female	-0.00943	-0.00910	-0.00283	-0.00261
	(0.00613)	(0.00615)	(0.00718)	(0.00720)
Age	0.00400***	0.00392***	0.00444***	0.00448***
	(0.000626)	(0.000629)	(0.000731)	(0.000738)
Tenure	0.00480***		0.00765***	
	(0.000788)		(0.000988)	
2nd year		-0.0304***		0.0160
		(0.00915)		(0.0109)
3rd year		-0.0178*		0.0213*
		(0.00996)		(0.0114)
4th year		0.00236		0.0441***
		(0.00988)		(0.0116)
5th year		0.0298***		0.0640***
		(0.0114)		(0.0127)
6th year		0.0258**		0.0630***
		(0.0118)		(0.0137)
7th year		0.0161		0.0553***
		(0.0127)		(0.0145)
8th year		0.0143		0.0567***
		(0.0135)		(0.0162)
9th year		0.0312**		0.0675***
		(0.0152)		(0.0186)
Grade 5 Reading			0.0102	0.00951
			(0.0137)	(0.0137)
Grade 5 Mathematics			-0.0440***	-0.0440***
			(0.0141)	(0.0141)
N	18,138	18,138	11,967	11,967

Notes: Average marginal effects from Probit model estimation. Only schools offering grade five (primary and combined) are included in last two columns. Time and region indicators were also included. Tenure indicator effects beyond 9 years are not reported for brevity. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 4: **Principals' experience and school characteristics**

Experience (years)	0-3	4-7	8-11	12-15	16+	Total
Average Student Achievement						
1st quartile	0.18	0.37	0.31	0.11	0.03	1.00
2nd quartile	0.16	0.35	0.33	0.13	0.04	1.00
3rd quartile	0.15	0.34	0.34	0.14	0.04	1.00
4th quartile	0.20	0.32	0.30	0.13	0.04	1.00
Parental Socio-Economic Status						
1st quartile	0.15	0.32	0.30	0.16	0.07	1.00
2nd quartile	0.17	0.31	0.29	0.16	0.06	1.00
3rd quartile	0.17	0.30	0.30	0.18	0.07	1.00
4th quartile	0.11	0.26	0.33	0.21	0.08	1.00
School Size						
1st quartile	0.40	0.33	0.19	0.08	0.01	1.00
2nd quartile	0.13	0.37	0.31	0.14	0.04	1.00
3rd quartile	0.06	0.30	0.37	0.20	0.08	1.00
4th quartile	0.03	0.20	0.35	0.29	0.14	1.00
Proportion NESB Students						
1st quartile	0.27	0.31	0.25	0.12	0.04	1.00
2nd quartile	0.16	0.33	0.30	0.16	0.05	1.00
3rd quartile	0.11	0.28	0.33	0.20	0.08	1.00
4th quartile	0.06	0.27	0.34	0.22	0.11	1.00
School type						
Primary	0.17	0.31	0.30	0.16	0.05	1.00
Secondary	0.05	0.22	0.33	0.26	0.14	1.00
Combined	0.13	0.27	0.31	0.21	0.08	1.00
School location						
Metropolitan	0.07	0.28	0.34	0.22	0.10	1.00
Provincial	0.09	0.32	0.35	0.19	0.05	1.00
Remote/Very Remote	0.27	0.32	0.25	0.13	0.03	1.00

Notes: Proportions for full sample of 4,665 principals who served in Victorian Government schools between 1997 and 2011. NESB - Non-English Speaking Background.

Table 5: **Summary statistics - students**

	Matched students		All Students	
Variable	Mean	Std Dev	Mean	Std Dev
Female	0.492		0.488	
Non-English Speaking Background	0.147		0.185	
Aboriginal or Torres Strait Islander	0.009		0.012	
Achievement - grade 3				
Reading	2.349	0.767	2.308	0.782
Writing	2.419	0.663	2.374	0.685
Numeracy	2.340	0.696	2.304	0.711
Mathematics	2.280	0.638	2.245	0.652
Achievement - grade 5				
Reading	3.203	0.781	3.161	0.789
Writing	3.200	0.759	3.152	0.769
Numeracy	3.193	0.745	3.154	0.749
Mathematics	3.145	0.668	3.106	0.675
Number of students	264,826		366,293	

Notes: Descriptive statistics for matched students who sat AIM tests in grades 3 and 5 between 1997 and 2007, and for all students observed in the same years.

Table 6: **Summary statistics - school surveys**

	Mean	Std Dev	Min	Max
Staff survey				
School morale	74.55	13.46	25.00	100
Supportive leadership	76.52	13.21	19.29	100
Goal congruence	78.50	10.84	42.08	100
Professional interaction	78.86	10.01	22.45	100
Professional growth	72.45	11.31	26.82	100
Parent survey				
General satisfaction	5.78	0.46	4.11	7
Quality of teaching	5.63	0.41	4.21	7
Academic rigour	5.06	0.34	2.94	6
General environment	5.17	0.37	2.78	6
Customer service	5.21	0.37	3.00	6
Reporting	5.17	0.32	3.05	6

Notes: Staff surveys - 1,576 (primary) schools in 2007. Parent surveys, first two items - 1,586 schools in 2007. Parent surveys, remaining four items - 1,589 schools in 2003 (last year available).

Table 7: **Estimates of principal effectiveness - Variance Decomposition method**

	reading	mathematics
Grade 3		
Variance	0.0183	0.0247
(s.e.)	(0.0128)	(0.0167)
Standard Deviation	0.135	0.157
Grade 5		
Variance	0.0215**	0.0229*
(s.e.)	(0.0108)	(0.0137)
Standard Deviation	0.147	0.151
Value added 3-5		
Variance	0.00775	0.0270*
(s.e.)	(0.0104)	(0.0151)
Standard Deviation	0.0880	0.164

Notes: 1,100 schools approximately. The exact numbers differed slightly due to some schools not having information on all scores where at least two students sat the test over a run of at least four years. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 8: **Estimates of principal effectiveness - fixed effects regression method**

	reading	mathematics
Grade 3		
Raw standard devn.	0.291	0.310
Shrunk SD	0.144	0.172
Grade 5		
Raw standard devn.	0.259	0.308
Shrunk SD	0.098	0.162
Value added 3-5		
Raw standard devn.	0.229	0.302
Shrunk SD	0.105	0.191

Notes: Grade 3 - 1780 principals (approx.), grade 5 and VAM - 1875 principals (approx.). The "Shrunk" standard deviation measures were constructed using the Empirical Bayes method detailed in Equation 7.

Table 9: **Principal effects on school factors**

	Variance Decomposition Method			Fixed Effects Method	
Factor	Variance	s.e.	SD	Raw SD	Shrunk SD
Staff survey					
School morale	0.220***	(0.0421)	0.469	0.623	0.494
Supportive leadership	0.334***	(0.0569)	0.578	0.701	0.568
Goal congruence	0.168***	(0.0336)	0.410	0.578	0.452
Professional interaction	0.244***	(0.0586)	0.494	0.665	0.519
Professional growth	0.145***	(0.0442)	0.381	0.642	0.514
Parent survey					
General satisfaction	0.167***	(0.0550)	0.409	0.609	0.455
Quality of teaching	0.157***	(0.0299)	0.397	0.498	0.373
Academic rigour	0.296***	(0.0526)	0.544	0.607	0.403
General environment	0.162***	(0.0592)	0.402	0.584	0.394
Customer responsiveness	0.262***	(0.0644)	0.512	0.630	0.462
Reporting	0.325***	(0.0923)	0.570	0.612	0.406

Notes: Sample sizes differ slightly across school factors, as not all were available over all years.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table 10: **Estimation of pathways of principal effectiveness**

	Reading	Mathematics
Staff survey factors		
School Morale	0.0104*	0.0244***
	(0.00532)	(0.00927)
Supportive leadership	0.00291	0.00391
	(0.00463)	(0.00807)
Goal congruence	0.0160***	0.0416***
	(0.00581)	(0.0101)
Professional interaction	0.00417	0.0236***
	(0.00507)	(0.00881)
Professional growth	0.0213***	0.0447***
	(0.00519)	(0.00910)
Parent survey factors		
Quality of teaching	0.00252	0.00991
	(0.00702)	(0.0121)
General satisfaction	0.00390	0.00624
	(0.00575)	(0.00991)
Academic rigour	0.000120	-0.00639
	(0.00790)	(0.0151)
Customer responsiveness	-0.0106	-0.0332**
	(0.00688)	(0.0131)
Reporting	-0.0100	-0.0243
	(0.00783)	(0.0149)
General environment	-0.00743	-0.0212
	(0.00809)	(0.0154)

Notes: Value-added models of achievement used to identify effective principals. These estimates are simply the coefficient on the school factor from regressing the principal effects on achievement on the corresponding principal effects on each school factor, separately.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Appendix

Table A1: **Staff survey individual questions**

School morale

1. There is a good team spirit in this school.
2. There is a lot of energy in this school.
3. The morale in this school is high.
4. Staff go about their work with enthusiasm.
5. Staff take pride in this school.

Supportive leadership

1. Staff are able to approach the school's leaders to discuss concerns and grievances.
2. The school's leaders don't really know the problems faced by staff (reversed).
3. There is support from the leaders in this school.
4. There is good communication between staff and the leaders in this school.
5. The leaders in this school can be relied upon when things get tough.

Goal congruence

1. The staff are committed to the school's goals and values.
2. The goals of this school are not easily understood (reversed).
3. The school has a clearly stated set of objectives and goals.
4. My personal goals are in agreement with the goals of this school.

Professional interaction

1. I feel accepted by other staff in this school.
2. I have the opportunity to be involved in cooperative work with other members of staff.
3. There is good communication between groups in this school.
4. Staff in this school can rely on their colleagues for support and assistance when needed.
5. Staff frequently discuss and share teaching methods and strategies with each other.
6. There is good communication between staff in this school.
7. I receive support from my colleagues.

Professional growth

1. I am encouraged to pursue further professional development.
2. Others in this school take an active interest in my career development and professional growth.
3. The professional development planning in this school takes into account my individual needs and interests.
4. There are opportunities in this school for developing new skills.
5. It is not difficult to gain access to in-service courses.

Notes: The precise wording of questions may have changed slightly from year to year.

Table A2: **Parent survey individual questions**

General satisfaction

1. Overall, I am satisfied with the education of my/our child.

Quality of teaching

1. Teachers at this school motivate my child to want to learn.
2. My child's teachers are committed and enthusiastic in their approach to teaching.
3. Teachers at this school provide a stimulating and challenging environment for my/our child.
4. My child receives high quality teaching.
5. My child's teachers care if my child is not doing as well as he/she can.

Academic rigour

1. This school is meeting the academic needs of my child.
2. This school has high academic standards.
3. This school has realistic educational expectations of my/our child.
4. This school is meeting the social needs of my/our child.
5. This school provides sufficient challenge for my/our child in other areas (eg. sport/music etc).

General environment

1. The student management policy at this school is fair and reasonable.
2. This school is caring.
3. This school has high standards of student behaviour.
4. This school has a safe and secure environment.

Customer responsiveness

1. The school takes the concerns I have seriously.
2. This school is managed well.
3. I believe there is effective educational leadership within the school.
4. I am given the opportunity to be involved in the school's educational activities.

Student reporting

1. My child's school reports are informative in that they indicate achievement level.
2. My child's school reports are comprehensive.
3. The staff at this school are approachable (by parents).
4. This school provides helpful information about my/our child's progress.

Notes: The precise wording of questions may have changed slightly from year to year.

Table A3: **First stage adjustment equations for Variance Decomposition method**

	Grade 3		Grade 5		Grade 5 value added	
	Reading	Math	Reading	Math	Reading	Math
Female	0.232***	-0.117***	0.188***	-0.123***	0.0409***	-0.0483***
	(0.00417)	(0.00422)	(0.00415)	(0.00417)	(0.00327)	(0.00327)
NESB	-0.128***	-0.0352***	-0.0863***	0.0914***	-0.00238	0.112***
	(0.00840)	(0.00848)	(0.00834)	(0.00838)	(0.00653)	(0.00654)
ATSI	-0.470***	-0.510***	-0.475***	-0.552***	-0.173***	-0.236***
	(0.0299)	(0.0302)	(0.0298)	(0.0299)	(0.0237)	(0.0236)
Female * NESB	-0.0264**	0.0157	-0.0134	-0.00884	0.00193	-0.0159*
	(0.0108)	(0.0109)	(0.0107)	(0.0108)	(0.00840)	(0.00842)
Female * ATSI	0.00446	0.0396	-0.0289	0.0856**	-0.0216	0.0718**
	(0.0415)	(0.0420)	(0.0413)	(0.0414)	(0.0328)	(0.0328)
Parental SES for school	0.00750***	0.00674***	0.00870***	0.00841***	0.00370***	0.00392***
	(8.13e-05)	(8.22e-05)	(7.91e-05)	(7.94e-05)	(6.31e-05)	(6.30e-05)
School NESB proportion	-0.0819***	-0.0568*	0.0458	0.135***	0.0879***	0.155***
	(0.0305)	(0.0308)	(0.0292)	(0.0293)	(0.0229)	(0.0229)
Regional location	0.0841***	0.0272***	0.0744***	0.0266***	0.0276***	0.0123**
	(0.00755)	(0.00763)	(0.00746)	(0.00748)	(0.00585)	(0.00585)
Remote location	0.0480***	0.0715***	0.0529***	0.0452***	0.0346***	0.00974**
	(0.00540)	(0.00546)	(0.00528)	(0.00530)	(0.00414)	(0.00415)
Female peer proportion	-0.0125	0.0102	-0.0203	0.0168	-0.0117	-0.000277
	(0.0178)	(0.0180)	(0.0178)	(0.0178)	(0.0139)	(0.0139)
ATSI peer proportion	-0.0131	-0.249***	-0.0348	-0.212***	-0.0670	-0.115**
	(0.0698)	(0.0703)	(0.0695)	(0.0696)	(0.0546)	(0.0544)
NESB peer proportion	0.187***	0.194***	0.191***	0.175***	0.0686***	0.0557***
	(0.0241)	(0.0244)	(0.0237)	(0.0238)	(0.0186)	(0.0186)
Grade 3 score, same subject					0.638***	0.636***
					(0.00155)	(0.00154)
Observations	254,419	255,109	254,883	255,551	245,479	246,798
R-squared	0.065	0.043	0.072	0.062	0.451	0.446

Notes: These regressions also include year indicators. NESB: Non-English speaking background. ATSI: Aboriginal and/or Torres Straight Islander. Parental SES is measured in percentiles of distribution across schools. Peer measures are proportions of other students in the same school sitting the same test. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table A4: **Value-Added models of achievement including fixed effects**

	Year 3		Year 5		Year 5 value added	
Testing Domain	Reading	Math	Reading	Math	Reading	Math
Year 3 score, same subject					0.6347***	0.6316***
					(0.0018)	(0.0019)
Female	0.2396***	-0.1155***	0.191***	-0.1207***	0.0407***	-0.045***
	(0.0051)	(0.0050)	(0.0050)	(0.0049)	(0.0040)	(0.0038)
NESB	-0.1303***	-0.0365***	-0.0918***	0.086***	-0.0086	0.1086***
	(0.0108)	(0.0113)	(0.0105)	(0.0113)	(0.0083)	(0.0084)
ATSI	-0.4667***	-0.5035***	-0.502***	-0.5454***	-0.2117***	-0.2306***
	(0.0367)	(0.0361)	(0.0311)	(0.0319)	(0.0283)	(0.0272)
Female * NESB	-0.032**	0.0127	-0.01	0.0006	0.0043	-0.0073
	(0.0136)	(0.0144)	(0.0133)	(0.0143)	(0.0106)	(0.0108)
Female * ATSI	-0.0063	0.0443	-0.0045	0.0728*	0.0287	0.0583
	(0.0506)	(0.0498)	(0.0434)	(0.0431)	(0.0389)	(0.0379)
Parental SES for school	-0.4681***	-0.3245**	-0.058	-0.09	0.0406	-0.0101
	(0.1457)	(0.1524)	(0.1389)	(0.1439)	(0.1111)	(0.1126)
School NESB proportion	-0.0002	0.0000	-0.001***	-0.0002	0.0000	0.0007***
	(0.0004)	(0.0004)	(0.0004)	(0.0003)	(0.0003)	(0.0003)
Female peer proportion	0.0213	0.0286	0.01	-0.0097	0.0292	0.0109
	(0.0262)	(0.0262)	(0.0254)	(0.0250)	(0.0201)	(0.0199)
ATSI peer proportion	-0.2247*	-0.1654	0.0702	-0.1835	0.1485	-0.1374
	(0.1358)	(0.1345)	(0.1306)	(0.1272)	(0.1019)	(0.1012)
NESB peer proportion	0.0998**	0.052	0.1155***	0.1468***	0.0633**	0.1431***
	(0.0391)	(0.0398)	(0.0381)	(0.0393)	(0.0302)	(0.0303)
Observations	163236	163780	168199	168779	161878	162922
R-squared	0.1181	0.1127	0.1238	0.1375	0.4799	0.4935

Notes: These regressions also include year, school and principal indicators. NESB: Non-English speaking background. ATSI: Aboriginal and/or Torres Straight Islander. Parental SES is measured in percentiles of distribution across schools. Peer measures are proportions of other students in the same school sitting the same test. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.