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Principal leadership changes in South Africa: Investigating their consequences for school performance

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ABSTRACT

A rising number of school leadership changes have been occurring in South African schools as a large proportion of incumbent principals near retirement age. While this presents opportunities to replace weaker school principals with better performing ones, these changes may also destabilise school environments and impede on learning. This paper explores how these principal change events affect school performance in the context of South Africa using a unique administrative dataset constructed by linking payroll data on the population of public school principals to national data on schools and matriculation examination outcomes. Exploiting the panel structure of the data, a school fixed effects strategy suggests that principal changes are indeed detrimental to school performance especially when leadership changes are due to principals exiting the public education system. These results are robust to using an alternative estimation strategy proposed by Heckman, Ichimura and Todd (1997) which combines propensity score matching with a difference-in-difference estimation strategy. The paper also considers two mechanisms through which school leadership changes may impact on school performance, namely through rising promotion rates and teacher turnover.

Keywords: Principals, school leadership, principal turnover, teacher turnover, school performance
JEL codes: J63, I29, J45

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1. Introduction

The South African public education system is experiencing a substantial and rising number of school principal replacements due to the aging profile of incumbent principals. In a system of over 24 000 public schools, roughly 7 000 principals would have to be hired between 2012 and 2017 just to replace retiring principals (Wills, 2015b). The rising age profile of school principals presents an imminent opportunity for improving the leadership trajectories of schools. However, these principal retirements also pose significant challenges for education planners. Provincial administrations will not only have to expend resources recruiting a substantial number of principal replacements, but there may be other knock-on effects of school leadership changes on the school system.

Although there is an increasing consensus that principals matter for school performance (Branch, Hanushek and Rivkin, 2012; Coelli and Green, 2012; Grissom, Kalogrides and Loeb, 2012), a growing body of literature explores whether the event of a principal leadership change, or typically referred to as 'principal turnover', may initially create instability in school environments mitigating the intended gains expected from principal replacements (Beteille, Kalogrides and Loeb, 2012; Miller, 2013). In this regard, Beteille *et al* (2012) argue that it is unclear whether these leadership changes are likely to have beneficial or detrimental effects on school outcomes. This paper explores how principal leadership changes affect school performance in the short to medium term in the developing country context of South Africa using unique administrative panel dataset of national education payroll data linked to national data on schools.

The paper proceeds with a review of the international literature on the impacts of principal turnover on the school environment. The estimation sample of schools with grade 12 students is then described, followed by a discussion of the identification strategies used to detect the impacts of principal turnover on school performance. A key theme that emerges in the discussion is the challenge of disentangling the impacts of a turnover event on learning outcomes from various sources of endogeneity that may influence both a principal's decision to move out of a school and learning outcomes. In exploiting the panel structure of the administrative dataset, a school fixed effects strategy is initially used to control for unobserved heterogeneity at the school level that may confound estimates of principal turnover. The results suggest that leadership instability may be detrimental to school outcomes, particularly where the leadership change is initiated through a principal exiting the public education system. However, even after conditioning on permanent school characteristics the assumption that principal departures are as good as random may not hold (Miller, 2013). In response, an alternative estimation strategy following the work of Heckman, Ichimura and Todd (1997) is used which combines propensity score matching with difference-in-difference estimation (PSM-DiD) to test the robustness of the fixed effects results. This robustness check provides some support for the conclusions of the fixed effects model.

In exploring potential mechanisms by which principal leadership changes affect student achievement, the final part of the paper identifies how teacher turnover responds to principal leadership changes. There is suggestive evidence is that teacher turnover rises in response to principal leadership changes, at least in the primary school sample. However, rising teacher turnover does not explain the decline in matriculation examination outcomes related to a principal change in secondary schools.

2. Background literature on principal turnover effects

Principals play a pivotal role in school functioning, upholding the operational management of schools, coordinating teachers, disciplining and motivating students while providing instructional leadership. A growing evidence-base using valued-added models provides convincing evidence that school principals matter for school effectiveness and student outcomes (Branch, Hanushek and Rivkin, 2012; Chiang, Lipscomb and Gill, 2012; Grissom, Kalogrides and Loeb, 2012; Coelli and Green, 2012). Grissom *et al* (2012), in reviewing these studies of principal effectiveness in the United States and Canada, note educationally significant impacts on student performance ranging between 0.05 to 0.16 standard deviations. This research implies that changes in leadership can be beneficial when lower quality principals are replaced with better ones. As succinctly stated by Leithwood et al (2004) in a review of case studies on school leadership and how it influences student learning in the education administration literature,

> *Indeed, there are virtually no documented instances of troubled schools being turned around without an intervention by a powerful leader. Many other factors may contribute to such turnarounds, but leadership is the catalyst* (Leithwood et al., 2004: 7).

Despite considerable consensus that principals matter for school performance by both education scholars and economists, a growing literature explores whether principal turnover may actually create instability in school environments, mitigating the intended gains expected from principal replacements (Miller, 2013; Beteille, Kalogrides and Loeb, 2012; Weinstein et al., 2009). Prior to these studies, organisational stability has been identified as an important aspect of well-functioning education systems and schools (Hallinger and Heck, 1996).[2] At a systems level, research has identified that sustained leadership, either in the form of longer tenure or smooth leadership transitions, is a key characteristic of education systems that have experienced sustained learning improvements. The purpose and vision underlying an education system's pedagogy and improvement is argued as being sustained through seamless leadership transitions (Mourshed, Chijioke and Barber,

[2] Instability in education policy, curriculum and in key education leadership positions has been identified as a threat to school functioning in the South African context. While it does not mention instability at the school level, the 2013 NEEDU report highlights how frequent changes in leadership positions are a threat to provincial and district level administration and effectiveness (Taylor, 2014).

2010). At the school level, studies on organisational instability in the form of teacher turnover have suggested that frequent changes in teachers can undermine efforts to implement a school's instructional program. In reference to teacher turnover, Ronfeldt *et al* (2011: 2) note that

> *Turnover may impact student achievement beyond the relative effectiveness of those who stay as compared to those who leave. When teachers leave schools, for example, previously held relationships and collaborations are lost, and new ones form.*

Similarly, principal turnover may negatively affect student achievement as it destabilises the school environment. Citing Miskel and Cosgrove (1985), Hart (1991: 451) identifies that a leadership succession is a disruptive event that alters lines of communication, realigns relationships of power within the school, affects decision-making processes and generally disturbs the equilibrium of normal activities. Practically, it may lower employee commitment and morale as teachers may struggle to adjust to the new leaders' ideas and systems. Furthermore, institutional knowledge is potentially removed from the environment as the outgoing principal leaves, and the incoming principal may adjust slowly to the new role and 'social organisation' of the school (ibid, 1991). Ultimately, this can impact on student achievement as school functionality is disrupted or the school's composition is altered. Beteille *et al* (2012: 915) observe that principal turnover negatively affects student achievement because better teachers tend to leave schools when the principal leaves. These better teachers are not immediately replaced where a lack of experience on the part of the new principal or other institutional dynamics constrain principals from hiring effective replacement teachers or providing new teacher hires with the support they need to be effective.

In other organisational contexts, such as private sector firms, positive effects of managerial replacements are commonly observed. Managerial exits are often driven by shareholders replacing poor performing managers with those more suited for the job (Denis and Denis, 1995). By contrast, in the principal labour market the majority of principal exits are likely to be voluntary. These transitions are less likely to mean that outgoing leaders are replaced with those that are more effective (Branch, Hanushek and Rivkin, 2012). This is especially the case in South Africa where less than one in a 1000 principals are dismissed per year and the majority of principal leadership changes are due to principal retirements (Wills, 2015a).

However, even where lower quality principals are replaced with better ones, school performance may initially decline and only improve with time. Substantial changes and disruptions to 'business as usual' may have to take place before improvements can be realised. Furthermore, research indicates that it may take several years for new school leaders to have their full effect on student learning as identified by Coelli and Green (2012) in British Columbia, Canada. In addition to an adjustment period associated with a leadership succession, delayed leadership impacts may also be attributed to principals having largely indirect effects on learning. Unlike teachers, principals are often not directly engaged with classroom instruction but impact on learning indirectly through three overarching mechanisms: establishing purposes and goals, through people, and through the organisational culture (Leithwood et al., 2004; Hallinger and Heck, 1996). The economics literature is less clear on these mechanisms, but selecting and hiring better teachers while firing under-performers is considered important (Branch, Hanushek and Rivkin, 2012), as well as effective administration and organisational management (Grissom and Loeb, 2011). Yet it takes time to attract and hire better teachers, especially in systems such as South Africa where poor-performing teachers are very difficult to dismiss and school leaders are not directly responsible for the hiring and firing of teachers. Moreover, adopting new policies and procedures may be slow processes requiring buy-in from School Governing Board (SGB) members, staff and school-based union members.

Empirical studies of principal turnover effects on learning, all of which are located across different districts and states in the United States, provide evidence for both negative (Beteille, Kalogrides and Loeb, 2012; Weinstein et al., 2009) as well as positive effects (Miller, 2013). While the mixed evidence may be attributed to actual heterogeneous principal turnover effects across states and samples analysed, it is also entirely plausible that estimations have been compromised by various sources of confounding factors that must be controlled for in isolating the impact of a principal turnover event. Principal departures from a school may be non-random. For example, the decision to move out of a school may be correlated with the unobserved conditions at the school or student ability, which in turn may be correlated with school outcomes. School and student fixed effects models are typically used to deal with these unobserved sources of endogeneity.

Miller (2013) notes, however, that even after conditioning on permanent school characteristics, fixed effects strategies may be inadequate in dealing with non-random principal departures. She also highlights that declines in school and student performance in years preceding a principal departure may compromise the validity of difference-in-difference and fixed effects estimates. In illustrating this problem, Miller (2013) adopts a method by Jacobson, LaLonde, and Sullivan (1993) to measure how schools perform relative to their usual performance before, during, and after a principal change. In her North Carolina sample, school performance declines in years preceding the principal leadership departure. It continues to decline up until the first two years after the leadership change but then rebounds in the third year. School performance only reaches its level prior to the change from the start of the fifth year of the new principal. Application of the estimation procedure by Jacobson et al (1993), however, is data intensive and is not suited to the short panel dataset available to the author.[3]

[3] Jacobson et al's (1993) method requires panel datasets linking schools to comparable measures of school performance over many periods and to information on school principals over the same period that identifies their years of tenure in each school that they serve. Neither is available to the author.

As an alternative strategy, I use propensity score matching with difference-in-difference (PSM-DiD) in addressing remaining bias in the estimations.

Another related complication in estimating principal turnover effects is that decisions to move out of a school may be correlated with the existing ability or preferences of the principal, which may also affect school outcomes (Miller, 2013).[4] It is argued, however, that whether one wants to control for principal ability in estimations depends on the research question at hand. If the researcher is concerned about identifying the *net* impact on learning of leadership changes facing South African schools in general, then it is likely not necessary to isolate out the impact of the leadership change event from the ability of incoming and outgoing principals. However, if policy-makers were monitoring the effectiveness of current recruitment and selection policies, they may want to know whether the quality of new principal replacements has been satisfactory. In this case, it would be necessary to separate out the impact of the leadership change event from principal ability. This is a data-intensive exercise currently not possible with available datasets on schooling in South Africa.[5] The research that follows is only able to address the first research question, identifying what the *net* impact of principal leadership changes is likely to be on the school environment. What is likely to be more important in answering this research question is establishing the duration over which impact is measured. Depending on the length of time elapsed between when a principal leaves and when impact is measured, estimates will vary notably (Miller, 2013). Within the constraints of the data available, only short-term impacts within a 0 to 24 month period following the leadership change are considered in this study. *A priori*, these impacts are expected to be negative as any anticipated gains of principal replacements are unlikely to have yet been realised in schools in the short-term.

[4] The negative effects of a principal turnover event may be overestimated where the ability of the outgoing principal exceeds that of the incoming principal. Alternatively, it may be underestimated where there is a net increase in principal effectiveness through the leadership change.

[5] Controlling for the confounding effects of principal quality on turnover decisions requires either an instrumental variable (IV) that is correlated with turnover but uncorrelated with the student performance or a valid 'value-added' measure of principal effectiveness. Due to data constraints, finding a suitable IV is problematic and identifying value-added measures of principal effectiveness is virtually impossible with currently available data in South Africa. This requires sophisticated modelling with large-scale panel datasets that follow students, teachers and principals over time and contain standardised test scores that are both horizontally and vertically comparable to obtain value-added estimates of principals (Grissom, Kalogrides and Loeb, 2012). While considerable data progress has been made in educational research in South Africa in recent years, we are many years away from having data as extensive as this to model the effects of both teacher and principal quality on student outcomes in this way. Even if students and teachers could be tracked across time and across the schooling system, which is becoming increasingly probable with new data systems such as 'Lurits' which stands for "Learner Unit Record Tracking System", we do not have strictly standardised test scores against which to track individual student progress in the majority of provinces. The school level panel dataset constructed for this study moves one step forward, allowing one to track the movement of principals and teachers into, out of and across schools.

3. Data

To investigate the impact of school leadership changes on school outcomes, the primary dataset used in this study is a panel of schools and their principals, constructed by matching South African payroll data on all public sector educators (referred to as Persal data) to administrative data collected on schools including the Annual Survey of Schools (ASS) data, Snap[6] survey data as well as the EMIS master list of schools. Payroll data of individuals working in the public education sector was made available to the author for the months September 2004, October 2008, October 2010 and November 2012.[7]

Connecting the administrative datasets is a challenging task. EMIS and payroll data are managed and collated by two distinct national departments and the different datasets were never designed to be used for analyses over time or for linking them together. Furthermore, systems for identifying schools are not common across the two datasets. Payroll-school links are largely possible by matching across two codes in payroll that point to school establishments. In this study the matched national dataset was limited to those schools with grade 12s in each of three years (2008, 2010 and 2012) that can be matched to school performance data as expressed through the matriculation examination results.[8]

The final constructed dataset includes variables identifying the characteristics of principals and the schools they lead. School characteristics include, *inter alia*; enrolment numbers, school location, the racial composition of the school, teacher numbers and a proxy for school poverty level as measured by the DBE's official quintile ranking.[9]

The dataset also includes information on principal credentials, including traditional qualifications and total experience. In the education payroll data, qualifications of educators are identified using the

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[6] Snap data contains information on enrolments and teacher numbers in South African schools. It has recently been made publically available to researchers through the DataFirst Portal.

[7] Access to Persal data was obtained through the Department of Basic Education in order to assess the degree to which different datasets could be merged with a view to monitoring the movement of staff across schools over time. Access to other non-public datasets were obtained through participation in a research project conducted by The Presidency and titled Programme to Support Pro-poor Policy Development (PSPPD). Assistance from Dr Martin Gustafsson at the Department of Basic Education in understanding the data is acknowledged.

[8] Again, the author drew on a school level matriculation examination series dataset constructed by Martin Gustafsson in modelling the impact of South Africa's 2005 provincial boundary changes on school performance (Gustafsson and Taylor, 2013).

[9] The DBE classifies schools into 'wealth' quintiles where the infrastructural development of schools' surrounding areas proxies for the wealth of the enrolled students. Identified as the poorest schools, quintile one to three schools are non-fee paying while quintile four and five schools receive much smaller state funding allocations but are left to determine the amount of school fees charged in consultation with parents. Although quintile rankings provide an imperfect measure of poverty, student performance profiles using official school quintile rankings roughly follow profiles where school poverty is more accurately quantified through asset-based measures of student poverty (Spaull, 2013).

Relative Educational Qualifications Value (REQV) system which is a value ranking on a scale of 10 to 17. The determination of the REQV ranking is based primarily on the number of recognised full-time professional or academic years of study at an approved university, technikon or college of education while taking into account the level of school education attained (RSA DoE, 2003). Higher rankings are assigned to more advanced qualifications with implications for promotions, the status of contracts and salary levels.[10] In the payroll data, 'years of service' is the only available measure of experience. This is not the same as total work experience in the education sector as individuals may have moved in and out of public education. Nevertheless, it provides a close proxy for total experience in the teaching profession. The payroll data available to the author is very thin in terms of other experience variables. Years served as a principal or a principal's tenure in a school is not directly identifiable.

Four key school performance measures are used in estimating principal turnover effects as expressed in Table 1. The first three measures are indicators of school performance in the National Senior Certificate (NSC) or otherwise known as the matriculation examination. Until recently, the matriculation examination in South Africa has been the only national measure of school performance where "much behaviour has understandably been oriented towards grade 12 indicators, in particular 'pass rates', the percentage of students successfully obtaining the certificate or surpassing minimum thresholds in individual subjects" (Gustafsson and Taylor, 2013: 3). Prior to 2008, students typically wrote a minimum of six subjects as part of the grade 12 senior certificate. This changed to seven subjects given a fundamental change in the curriculum system between 2007 and 2008 which saw the removal of the distinction between higher and standard grade examination papers and the introduction of compulsory mathematical literacy for non-mainstream mathematics takers. Coinciding with the year 2008 when the National Senior Certificate (NSC) examination first replaced the Senior Certificate system, the dataset used in the analyses is limited to three of the four available 'waves' of the constructed panel.[11]

The first measure of grade 12 performance used is the much talked about percentage pass rate in the NSC, which is a key measure of school success in South Africa. However, where students choose

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[10] A REQV 10 level, for example, is associated with having at most a Grade 12 academic qualification and no teachers' qualification. At the other end, a REQV level 17 is equivalent to having Grade 12 plus seven years relevant training, which includes at least a recognised master's degree. The minimum requirement for entry into a permanent teaching post is REQV 13 – a grade 12 qualification plus three years of relevant training, which is typically a three year teaching diploma. The PAMs identify the minimum qualification criteria for a permanent entry level teacher appointment as a REQV 13 (RSA DoE, 2003). In practice, however, this has increased to a REQV 14 level. This implies that teachers should possess a four year bachelor degree in teaching or a three year degree in another subject area and one additional year specialising in education.

[11] Excluding the 2004 data-year is also prompted by the lower levels of successful matching of Persal to EMIS data in 2004 compared to later years.

between a plethora of subjects, it may be argued that overall pass rates in the NSC are not directly comparable across schools if students in some schools on average take easier subjects than in others. For this reason, the second and third performance measures are limited to focus on improvements in one subject area, mathematics. This follows Gustafsson and Taylor (2013) who solely focus on mathematics performance in estimating provincial boundary change impacts on school performance. The average mathematics score out of one hundred obtained by students is a key indicator of improvements with respect to the quality of mathematics teaching and learning. Additionally, the percentage of mathematics takers who pass this examination is also included as measure of performance. As noted above, there are two streams of mathematics offered at the FET phase[12] – mathematics and mathematical literacy which attempts to introduce students to mathematical concepts with everyday practical applications. Only mathematics outcomes are considered here.

Additionally, the promotion rate of students from grade 10 to grade 12 is used as a non-examination based school outcome. The promotion rate is expressed as the ratio of grade 12 enrolments in school i in year t to grade 10 enrolments in school i in year $t-2$ as recorded in the Snap data. In the absence of school switching by pupils, this measure provides a proxy for dropout and repetition which is prevalent in the FET phase.[13] In this dataset, the average promotion rate was roughly 57 percent over the three waves of data.

A maximum of 4 518 schools are available for the estimations over three 'waves' of data. This represents 77 percent of the total number of 5 865 public ordinary schools that were identified as having grade 12 enrolment in 2008, 2010 and 2012 in the Snap data. Of a total number of 5 865 public ordinary schools with grade 12 students, a remaining 23 percent of schools could not be linked to a principal in at least one of the three years in question and are excluded from the estimations. Principal vacancies in some years could account for non-matching. Unfortunately, it is not possible to confirm whether the cause of non-matching is that the principal position is vacant or whether this reflects a problem in linking identifiers across datasets. It is acknowledged that these unmatched schools may be substantively different from those that are linked to a principal in all three waves. This may present sample selection concerns for the estimations that follow.

[12] In this context, FET refers to "Further Education and Training" and is the name given to curriculum implemented at the level of grades 10 to 12.

[13] It may be argued that promotion rates are also amenable to national, provincial and local pressures around the criteria to use when promoting students into Grade 12 from Grade 11 which may change from year to year (Gustafsson and Taylor, 2013). In gaming matriculation results, school principals may artificially raise school performance by holding back weaker students in the grade 10 and 11 years. Towards the end of 2013, a new regulation was gazetted that a student can only fail once in the FET phase (RSA DBE, 2012). While this regulation would reduce the legitimacy of this promotion rate as a measure of school performance, the national regulation would not yet have applied to the cohort of students considered in this dataset.

Table 1: School performance measures

	Mean	Standard deviation	P10	P95	N (school-years)
% who pass mathematics	47.85	28.66	14.29	97.50	12 819
Average mathematics %	31.27	13.45	18.32	54.03	12 819
% who achieve the NSC	63.45	24.27	40.37	98.48	13 458
Grade 10 to12 promotion rate	56.75	24.28	28.02	96.90	13 514

Source: Persal-EMIS matched dataset, connected to matriculation examination data. **Notes:** Calculations are based on sample sizes used in the OLS estimations in Table 2. P10 = school performance at the 10^{th} percentile, P95 = school performance at the 95^{th} percentile.

In the appendix, Table A.1 compares the descriptive statistics of schools depending on whether they are connected to a principal in all three waves. It confirms that there are significant differences in the observable characteristics of across these two groups. Schools that are not connected to a principal in all three waves are smaller (both in terms of student enrolment and student numbers), are more likely to be located in rural areas, have lower matriculation pass rates in the NSC and have a larger majority of black students. Moreover, principal turnover is less common in schools that could be linked to a principal in all three waves when compared to principal turnover rates calculated using principals as the unit of analysis. For example, in the grade 12 sample dataset connected to principal in all three waves, principal turnover between 2008 and 2010 was eight percent. However, 15 percent of principals in schools offering grade 12 in 2008 moved out of their schools between 2008 and 2010. In the analyses that follow the sensitivity of the results to the exclusion of schools that are not matched to a principal in each year is considered.

4. A school fixed effects estimation approach

Method explained

Fixed effects estimation strategies are typically used to isolate the principal turnover effect from unobserved school and student characteristics that influence not only a principal's decision to leave a school but school outcomes. The logic of the approach is that the fixed effects absorb these time-invariant differences in school and student factors that confound estimates. As a starting point, a school fixed effects strategy is initially used; then the validity of the estimation results is evaluated in light of the identifying assumptions of the strategy. In the following regression framework, school performance is expressed as a function of school and principal characteristics and the characteristics of a school's student body.

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \beta_2 D_{it} + \pi_i + \pi_t + \varepsilon_{it}$$

Here Y_{it} is the measure of performance of school i in year t, and X_{it} is a vector of time-variant school and principal characteristics. D_{it} is the 'treatment' indicator which takes on a value of one at time t if the school experiences a principal turnover event between year t' and t where $t' < t$. The term π_i reflects school-specific fixed effects and ε_{it} is an idiosyncratic error term which is assumed to be serially uncorrelated over time. Year fixed effects as reflected in π_t are also included. The parameter of interest, β_2, measures the within-school effect of a principal leadership change event. Each school serves as its own control group where school performance outcomes following a principal leadership change are compared to performance outcomes in years in which there is no change.

The school fixed effects identification strategy assumes that principal turnover is as good as random, conditional on time-invariant school characteristics. The only source of confoundedness should be fixed over time. However, the likelihood of a leadership change may be affected by time-varying school and student factors that also influence grade 12 performance measures. For example, if principals have preferences for posts in schools with wealthier rather than poorer students, declines in the socio-economic composition of students at their school or falling levels of school resourcing may induce principals to leave their schools.

In response, proxies for time-varying school changes are included in the model. Teacher-to-pupil ratios are used to capture changes in school resourcing. The motivation for this is that higher levels of funding through the collection of school fees (or other donations) enable schools to hire School Governing Body (SGB) paid teachers in addition to their state assigned quota. Student socio-economic composition is proxied by the proportion of all students enrolled at the school that are racially identified as black in Annual Survey of Schools data. Due to historical apartheid legacies, race has been closely tied to socio-economic status where black students have typically come from poorer backgrounds than other race groups.

A noted limitation of the data is that it does not follow students longitudinally to control for individual student fixed effects. In this regard, the identification strategy requires that principals did not move in response to sudden changes in the quality of students and that there is no student sorting in response to principal turnover (Coelli and Green, 2012). Considering the first of two complications, analysis of teacher movements in South Africa by Gustafsson (2016) suggests that school quality, as measured by matric performance, is associated with teachers' choices about schools. Where the principal labour market tracks the teacher labour market (Clotfelter et al., 2007), principals' decisions to move schools may also be informed by relative differences in the 'quality' of students across schools. However, Gustafsson (2016) finds teachers' decisions to move is based on relatively outdated information on schools' performance rather than recent performance data. This potentially alleviates concerns that decisions to leave a school are made on the basis of sudden changes in the quality of students. Regarding the second complication, it is unclear to what extent student sorting may respond to principal changes at the FET phase. The choice of public school in South Africa is regulated by legislation. Geographic catchment policies technically limit an individual's choice of school to a geographic area; but these rules are not strictly adhered to and catchment areas are often poorly defined. Researchers have documented how students are attending schools outside of their geographical areas to access better quality education (de Kadt, 2011); and at the FET phase there is evidence that students are attending schools that are not the nearest school to which they live (Cosser and du Toit, 2002). Yet little is known about how much students are actually switching schools during, specifically, their last three years of school. If better students leave schools in response to a principal change, this will overestimate the negative effects of a principal change event on school outcomes. Without data that follows students over time, it is not possible to evaluate to what extent this is a problem for the estimations that follow.

Model specifications and heterogeneous effects

With respect to model specifications, two fixed effects regressions are run for each of the four outcome measures considered. Ordinary least squares (OLS) estimates, controlling for a host of principal and school characteristics, are also reported as benchmark estimates.

The regression specifications vary in their inclusion of time-varying school and principal characteristics. In the first fixed effects specifications, only year and school fixed effects are included. The second specification extends the number of controls to include time-varying school characteristics namely; school enrolment, teacher-to-pupil ratios (expressed as the number of teachers per hundred students) and the percentage of students who are black. In the third specification, principals' educational qualifications and proxies for their previous experience in public school management are also included. In the estimations, principal qualifications are based on their Relative Educational Qualifications Value (REQV) recorded in payroll which range from 10 to 17. Indicators for previous management experience are generated using the principals' previous position in 2004. This position could be a school management post as a principal, deputy or head of department, or alternatively a non-management position as a teacher or simply not being in the public education system at all. The international literature notes that it is important to control for experience in measuring principal turnover effects. As identified by Clark, Martorell and Rockoff (2009), if there are positive returns to principal experience with respect to student learning, any effect of a principal change on school performance may in part be attributable to the lower levels of experience of the incoming principal. Descriptive statistics of the control variables used are provided in the appendix, Table A.2.

Initially, estimations are run on the full sample of schools offering grade 12 that could be linked to principal and outcome variables. Estimations are then limited to a sub-sample of poorer schools (quintile one to three schools). A common thread emerging from studies on principal turnover is that marginalised schools are especially at risk of the negative consequences of principal leadership changes. A higher incidence of principal turnover in these schools aggravates existing inequalities in the distribution of quality leaders where poorer and weaker performing schools also struggle more to attract good principals (Beteille et al, 2012; Loeb, Kalogrides and Horng, 2010; Gates et al., 2006). Contrary to the U.S. literature, there is no clear evidence that poorer schools in South Africa are unequally exposed to principal leadership changes. The sheer number of leadership changes taking place in these schools, however, presents a potential concern for stability. Furthermore, poorer and weaker performing schools may have fewer institutional systems in place or managerial resources to maintain levels of school functionality during a transitional period in school management and leadership. It is also possible that in poorer schools, political disruptions associated with promotion post appointments may result in more destabilising consequences for school functionality. A report by South Africa's independent body tasked with evaluating the provision of education highlights the irregularities associated with the appointment of personnel into promotion posts and associated conflicts where actual appointments do not meet the demands of unions, the recommendations of politicised School Governing Bodies or traditional authorities (Taylor, 2014). These concerns are likely to be more prevalent in the poorer part of the school system which is unequally exposed to the rent-extracting influence of organised interest groups (Wills, 2014).

It follows that the analysis investigates whether principal turnover impacts are larger when the estimation sample is limited to poorer schools that are also characterised by lower levels of school performance. Poorer schools are identified as non-fee paying quintiles one to three schools as per the official quintile classification status provided by the Department of Basic Education.[14]

Results

The results of the school fixed effects estimations of matriculation examination outcomes are reported in Table 2 for the grade 12 school sample and the limited sample of poorer schools (quintiles one to three). Considering the full grade 12 school sample results, here OLS estimates suggest a statistically significant effect of principal turnover on matriculation outcomes of about a 2.6 percentage point reduction in the percentage of mathematics takers who pass mathematics, a 0.8 percentage point reduction in the average mathematics score and a 2.4 percentage point reduction in the percentage of examination takers who pass the NSC. Once controlling for unobserved school heterogeneity in the three fixed effects specifications, the negative coefficients on principal turnover reduce in magnitude. The coefficients on principal turnover estimates of the percentage pass rate in mathematics and the average mathematics scores are no longer statistically significant after accounting for time-varying school and principal characteristics. However, in a similar estimation of the schools' overall NSC pass

[14] There is likely to be some inaccuracy in using quintile classifications to determine a school's wealth status where the quintile classification is determined not on the basis of the socioeconomic status of students in the school but the infrastructural development of the area in which a school is located. Nevertheless, this classification has been found to distinguish worse from better performing parts of the school system in South Africa (Spaull, 2013) and can probably be regarded as a fair proxy for socio-economic status.

rate, a statistically significant effect of about a 1.3 percentage point decline is identified. This suggests that within 0 to 24 months of a principal leadership change, a school will experience a slight reduction in their NSC matriculation pass rate compared with periods in which no leadership transition takes place. An effect of a principal leadership change on the NSC pass rate remains over and above controlling for differences in the experience of the incoming and outgoing principals.

As expected, when limiting the sample to only quintiles one to three schools the magnitude of the negative coefficients on principal turnover are larger and more significant. For example, in the third fixed effects specification for the poorer school sample in Table 2, principal turnover is associated with a 2.2 percentage point decline in the school's NSC pass rate. Moreover, principal turnover is found to have a statistically significant negative effect on the percentage of mathematics takers who pass this examination (roughly a two percentage point reduction). A one percentage point decline in the average mathematics score is also identified.

Estimation results using grade 10 to 12 promotion rates as the measure of school performance tell quite a different story as reflected in Table 3. Principal turnover is associated with a slight *rise* in promotion rates in both the full sample and in poorer schools. In the OLS regressions a statistically significant increase of 1.4 to 1.8 percentage points in the grade 10 to 12 promotion rate is identified. In the fixed effects regressions, however, the coefficients reduce in magnitude and become statistically insignificant. One possible explanation for this non-negative result is that adjustments to the promotion rate is one mechanism through which matriculation results decline following the introduction of a new principal.[15] If incoming principals are initially less concerned about the schools' reputation in the matriculation examination, they may be more lenient in promoting students to the next grade. A negative association between promotion rates and performance in the NSC is confirmed when including the promotion rate as an additional control in estimations of the NSC pass rate. As identified in Table 4, the magnitude of the principal turnover effect declines after controlling for the promotion rate. Some of the negative impact on school leaving outcomes accompanying the principal leadership change may be attributed to rising promotion rates where a larger group of weaker students are included in a school's examination cohort. The last section of this paper explores another mechanism through which principal leadership changes may affect the school environment namely, through rising levels of teacher turnover.

[15] Another argument is that grade promotion rates are longer term indicators of school performance and may be less sensitive to leadership changes if promotion practices are entrenched in school policy or ways of doing things and are only likely to change with time. While matriculation outcomes may be sensitive to disruptions to short term learning strategies implemented by the principal such as extra lessons or extended tuition hours, grade promotion rates are possibly less amenable to the principal's leadership approach in the short term. This agrees with work by Coelli and Green (2012) who find that principals have a much larger impact on test scores than on graduation rates in the short run.

Principal turnover can be distinguished into two flows: mobility and attrition. Attrition may include exits out of the public education system for retirement or non-retirement reasons including taking up a position in the private sector. To identify whether each flow is likely to have differential impacts on school performance, another set of estimations of matriculation examination outcomes were run as identified in Table 5. Significant negative effects of principal turnover are identified on the principal attrition indicator. Principal attrition is associated with a 1.7 percentage point decline in the percentage of mathematics takers who pass and a 1.5 percentage point decline in the schools' NSC pass rate as shown in the third fixed effects specification. For the poorer school sample, much larger and strongly significant negative effects are observed on the principal attrition indicator for all three examination outcomes. The percentage pass rate in mathematics falls by as much as four percentage points, the average mathematics percentage by 1.8 percentage points and the NSC pass rate declines by 3.2 percentage points in response to a principal exit from a school and the public education system. What is interesting is that compared to schools where the principal stays put, schools whose principal moves to another post in the education system do not experience lower matriculation examination outcomes. This result holds regardless of the performance measure considered or whether one limits the sample to poorer quintile one to three schools. This result may be explained by the possibility that those principals who access other positions in the system may be of better quality, establishing good systems and levels of functionality that can withstand a leadership transition.[16] The non-result could also be attributed to the lack of variation in the principal mobility indicator which results in imprecise estimates.

[16] There is an opposing view here as suggested through recent discussions with school district managers in South Africa. Where dismissals for non-performance are very difficult, an approach taken to rid a school of an underperforming principal is to move the principal to an administrative position in the district.

Table 2: School fixed effects estimations of matriculation examination outcomes

	Schools offering grade 12 (quintiles one to five)											
	% who pass mathematics				Average mathematics %				% who achieve NSC			
	OLS	**FE (1)**	**FE(2)**	**FE (3)**	**OLS**	**FE (1)**	**FE(2)**	**FE (3)**	**OLS**	**FE(1)**	**FE (2)**	**FE (3)**
Principal turnover	-2.643***	-1.141*	-1.342**	-0.812	-0.807**	-0.348	-0.435	-0.212	-2.366***	-1.399**	-1.599**	-1.271**
	(0.726)	(0.649)	(0.640)	(0.754)	(0.313)	(0.269)	(0.265)	(0.316)	(0.596)	(0.545)	(0.531)	(0.627)
Principal controls	X			X	X			X	X			X
School controls	X		X	X	X		X	X	X		X	X
Year fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X		X	X	X
R-squared	0.346				0.475				0.378			
Within R-squared		0.011	0.034	0.036		0.015	0.043	0.046		0.136	0.171	0.175
N (school-years)	12 819	12 819	12 819	12 819	12 819	12 819	12 819	12 819	13 458	13 458	13 458	13 458
N (clusters)		4 273	4 273	4 273		4 273	4 273	4 273		4 486	4 486	4 486
F stat	336.525	31.53	37.061	14.322	265.886	47.17	50.845	19.622	383.74	421.606	227.08	85.071
	Poorer schools offering grade 12 (quintiles one to three)											
	% who pass mathematics				**Average mathematics %**				**% who achieve NSC**			
	OLS	**FE (1)**	**FE(2)**	**FE (3)**	**OLS**	**FE (1)**	**FE(2)**	**FE (3)**	**OLS**	**FE (1)**	**FE(2)**	**FE (3)**
Principal turnover	-4.075***	-1.734**	-1.881**	-2.075**	-1.646***	-0.750**	-0.813**	-1.087**	-3.479***	-2.035**	-2.167**	-2.219**
	(0.919)	(0.868)	(0.856)	(0.984)	(0.361)	(0.325)	(0.320)	(0.370)	(0.765)	(0.732)	(0.717)	(0.825)
Principal controls	X			X	X			X	X			X
School controls	X		X	X	X		X	X	X		X	X
Year fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X		X	X	X
R-squared	0.112				0.16				0.223			
Within R-squared		0.026	0.05	0.052		0.058	0.087	0.09		0.177	0.212	0.216
N (school-years)	9 517	9 517	9 517	9 517	9 517	9 517	9 517	9 517	10 045	10 045	10 045	10 045
N (clusters)		3 373	3 373	3 373		3 373	3 373	3 373		3 560	3 560	3 560
F stat	32.511	50.004	41.503	16.175	41.78	115.798	77.984	29.798	88.854	426.164	226.147	84.905

Notes: Principal controls include their age, gender, previous management experience (position in payroll in 2004), years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. In addition, OLS regressions control for the quintile status of the school, urban location, former department and provincial dummies. Standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Table 3: School fixed effects estimations of the grade 10 to 12 promotion rate

	Schools offering grade 12 (quintile one to five schools)				Schools offering grade 12 (Poorer quintile one to three schools)			
	OLS	**FE(1)**	**FE (2)**	**FE (3)**	**OLS**	**FE(1)**	**FE (2)**	**FE (3)**
Principal turnover	1.398**	0.892	1.116*	0.592	1.778**	1.066	1.178	0.919
	(0.669)	(0.598)	(0.577)	(0.684)	(0.863)	(0.830)	(0.789)	(0.933)
Principal controls	X			X	X			X
School controls	X		X	X	X		X	X
Year fixed effects	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X
R-squared	0.203				0.113			
Within R-squared		0.005	0.072	0.073		0.01	0.083	0.086
N (school-years)	13 514	13 514	13 514	13 514	10 079	10 079	10 079	10 079
N (clusters)		4 518	4 518	4 518		3 585	3 585	3 585
F stat	151.886	13.792	63.355	24.82	42.863	20.596	62.875	24.485

Notes: Principal controls include their age, gender, previous management experience (position in payroll in 2004), years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. In addition, OLS regressions control for the quintile status of the school, urban location and provincial dummies and race of the principal. Standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Sample selection bias due to matching constraints

As mentioned above, an attempt was made to determine whether the results observed are biased due to sample selection concerns where schools connected to principals and school matriculation outcomes across all three waves (2008, 2010 and 2012) are a select group of schools. To test this, estimates from the preceding estimations of principal turnover effects are compared to estimates when re-including schools that are not matched to a school principal in each of the three waves. In re-including unmatched schools, I make the assumption that principal turnover has occurred in these schools in years for which they are unmatched to a school principal. Similar fixed effects regressions are run as in Table 2. However, here it is not possible to control for principal characteristics, which are not available if schools are not matched to a principal. The results are reported in Table A.3. The results as per the second fixed effects regressions in Table 2 do not change substantively when re-including the unmatched schools. Larger differences, however, are observed when limiting this analysis to poorer quintile one to three schools as seen in Table 4. When re-including the non-matched schools into the sample, the magnitude of the negative coefficients actually decrease in size but the overall conclusions of statistically significant negative effects of principal turnover on matriculation outcomes are unchanged. The declining magnitude of the coefficients is surprising where the unmatched sample may include schools that have vacant principal posts following a principal transition with anticipated larger negative effects for school performance. The study now turns to investigating the robustness of the results in light of the identifying assumptions of the fixed effects model.

Table 4: School fixed effects estimations of schools' NSC pass rate, controlling for the grade 10 to 12 promotion rate

	Quintile one to five schools % who achieve the NSC				Poorer quintile one to three schools % who achieve the NSC			
	OLS	**FE (1)**	**FE (2)**	**FE (3)**	**OLS**	**FE (1)**	**FE (2)**	**FE (3)**
Principal turnover	-2.032***	-1.089**	-1.217**	-1.066*	-2.999***	-1.672**	-1.908**	-1.789**
	(0.589)	(0.508)	(0.503)	(0.595)	(0.750)	(0.686)	(0.790)	(0.682)
Grade 10 to 12 promotion rate	-0.219***	-0.384***	-0.361***	-0.359***	-0.246***	-0.382***	-0.356***	-0.357***
	(0.008)	(0.011)	(0.011)	(0.011)	(0.009)	(0.012)	(0.012)	(0.012)
Principal controls	X			X	X			X
School controls	X		X	X	X		X	X
Year fixed effects	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X
R-squared	0.416				0.282			
Within R-squared		0.282	0.291	0.294		0.317	0.328	0.326
N (school-years)	13 410	13 410	13 410	13 410	10 004	10 004	10 004	10 004
N (clusters)		4 486	4 486	4 486		3 560	3 560	3 560
F stat	387.978	701.375	371.436	150.051	112.804	662.08	142.658	352.907

Notes: Principal controls include their age, gender, previous management experience (position in payroll in 2004), years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. Standard errors are in parentheses and are clustered at school level. Statistically significant at * p<0.1, ** p<0.05, ***p<0.001.

Table 5: School fixed effects estimations of matriculation examination outcomes distinguishing between principal turnover flows

	% who pass mathematics				Average mathematics %				% who achieve the NSC			
Schools offering grade 12 (quintiles one to five)												
	OLS	**FE (1)**	**FE (2)**	**FE (3)**	**OLS**	**FE (1)**	**FE (2)**	**FE (3)**	**OLS**	**FE (2)**	**FE (1)**	**FE (3)**
Principal mobility	-1.938*	0.395	0.25	0.527	-0.724	-0.066	-0.116	0.025	-2.288**	-1.067	-1.257	-0.93
	(1.108)	(1.113)	(1.100)	(1.129)	(0.463)	(0.443)	(0.437)	(0.453)	(0.903)	(0.883)	(0.866)	(0.908)
Principal attrition	-3.083***	-1.991**	-2.223**	-1.716*	-0.858**	-0.504	-0.612*	-0.373	-2.415***	-1.583**	-1.789**	-1.502**
	(0.843)	(0.751)	(0.740)	(0.889)	(0.377)	(0.326)	(0.320)	(0.386)	(0.702)	(0.664)	(0.647)	(0.757)
Principal controls	X			X	X			X	X			X
School controls	X		X	X	X		X	X	X		X	X
Year fixed effects	X	X	X	X	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X		X	X	X
R^2/ Within R^2	0.346	0.012	0.035	0.036	0.475	0.015	0.043	0.046	0.378	0.136	0.171	0.175
N (school-years)	12 819	12 819	12 819	12 819	12 819	12 819	12 819	12 819	13 458	13 458	13 458	13 458
N (clusters)		4 273	4 273	4 273		4 273	4 273	4 273		4 486	4 486	4 486
F stat	327.98	24.726	33.022	13.827	259.037	35.533	44.651	18.688	373.948	316.27	198.643	80.796
Poorer schools offering grade 12 (quintiles one to three)												
	% who pass mathematics				**Average mathematics %**				**% who achieve the NSC**			
	OLS	**FE (1)**	**FE (2)**	**FE (3)**	**OLS**	**FE (1)**	**FE (2)**	**FE (3)**	**OLS**	**FE (1)**	**FE (2)**	**FE (3)**
Principal mobility	-3.574**	1.024	0.751	0.469	-1.621**	0.169	0.052	-0.154	-3.139**	-0.728	-0.999	-0.979
	(1.375)	(1.407)	(1.391)	(1.405)	(0.531)	(0.513)	(0.509)	(0.520)	(1.114)	(1.125)	(1.108)	(1.142)
Principal attrition	-4.422***	-3.471***	-3.540***	-4.048***	-1.663***	-1.328***	-1.358***	-1.810***	-3.716***	-2.865**	-2.908**	-3.187**
	(1.095)	(1.026)	(1.014)	(1.210)	(0.439)	(0.395)	(0.389)	(0.462)	(0.935)	(0.912)	(0.894)	(1.039)
Principal controls	X			X	X			X	X			X
School controls	X		X	X	X		X	X	X		X	X
Year effects	X	X	X	X	X	X	X	X	X	X	X	X
School fixed effects		X	X	X		X	X	X		X	X	X
R^2/ Within R^2	0.112	0.027	0.051	0.053	0.16	0.059	0.088	0.091	0.223	0.178	0.213	0.216
N (school-years)	9 517	9 517	9 517	9 517	9 517	9 517	9 517	9 517	10 045	10 045	10 045	10 045
N (clusters)		3 373	3 373	3 373		3 373	3 373	3 373		3 560	3 560	3 560
F stat	31.758	39.581	37.182	15.767	40.716	88.724	68.976	28.747	86.601	320.377	197.833	80.672

Notes: Principal controls include their age, gender, previous management experience, years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. OLS regressions control for the school's quintile status, urban location and provincial dummies and race of the principal. Standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Remaining bias

While attempts were made to control for a key assumption of the fixed effects model that all sources of confoundedness are constant over time, it remains possible that principal departures are still non-random even after conditioning on permanent and where possible time-varying school characteristics. For example, motivation levels of school principals appear to be lower among principals that transition out of their schools compared with those that don't. This is suggested by the significantly higher number of sick leave days taken (out of 36 days of paid sick leave available in a three year cycle) by principals who move out of schools compared with those that don't as reflected in Table 6. This may also suggest that principals may depart from their schools because of health issues.[17] The principal turnover effect will be overestimated where driven by negative selection effects.

Table 6: Sick leave days taken by school principals

	Principal does not move out of school between time t and t+2	Principal moves out of school between time t and t+2
Mean number of sick leave days taken in time t	2.068 (5.76)	4.37* (9.01)
N	8 266	719

Source: Persal-EMIS dataset connected to matriculation examination data. **Notes**: Calculations are obtained for the sample used in OLS estimation of the grade 10 to 12 promotion rate in Table 3. Calculations are for years t = 2008 or 2010. *The mean of turnover group is statistically significantly different from the mean of the non-turnover group using a 95 percent confidence interval. Standard deviations are in parentheses.

Miller (2013) also cautions that the interpretation of fixed effects estimations may be compromised by the presence of non-parallel time trends in performance across schools depending on whether they experience a change in leadership. Although her caution is more applicable where one has a longer panel and is estimating whether a principal transition has longer term *positive* effects for a school[18], it is instructive to identify that there may be non-parallel trends in school performance.

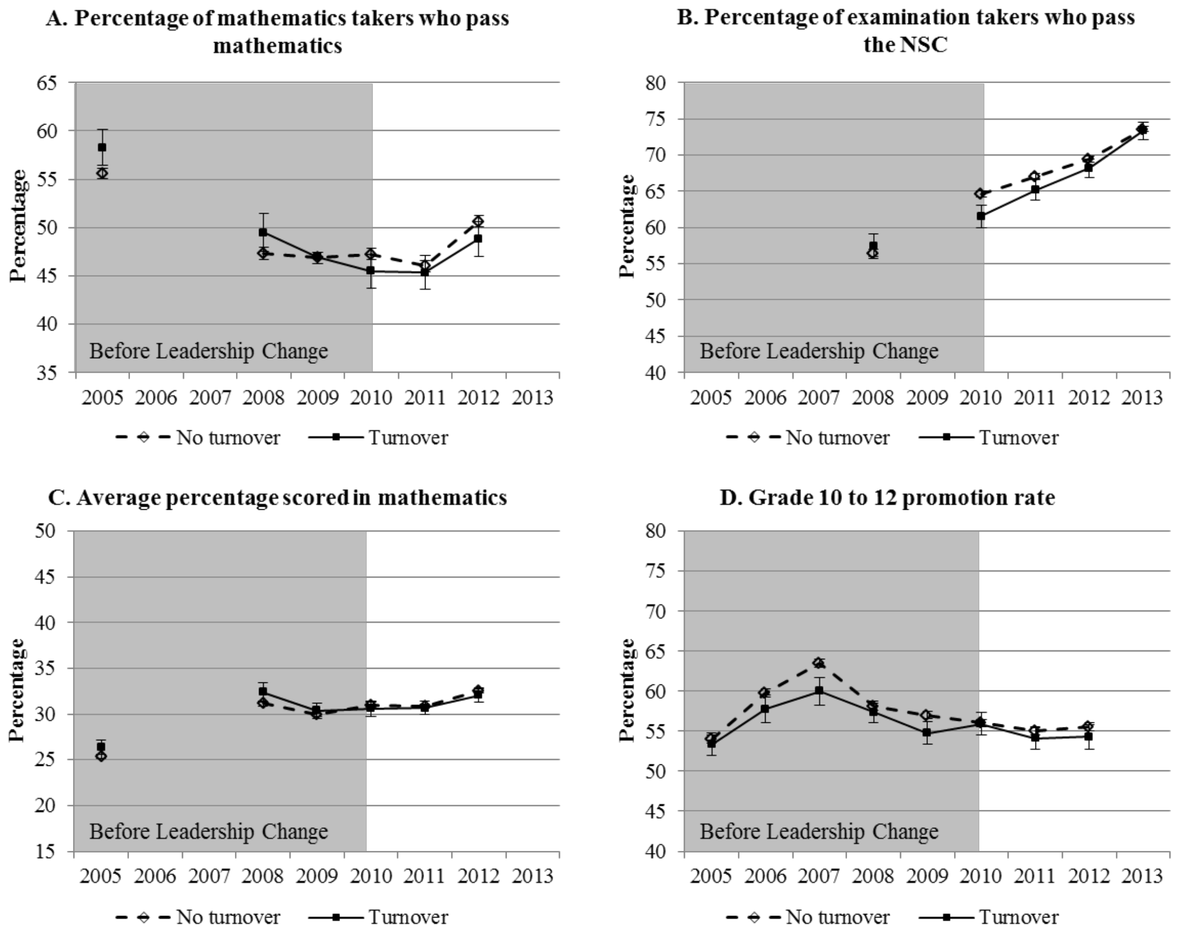
Due to a truncated time series of school performance data available to the author, a clear investigation as to pre-turnover trends in school outcomes is limited. This is further complicated by some schools having missing performance data in some years and difficulties matching across matriculation and EMIS data each year, especially prior to 2008. Despite these constraints, pre-turnover trends in mean

[17] Only two years of data on sick leave days taken is available to the author and therefore it cannot be included as a time-varying control in the school fixed effects regressions.

[18] Drawing on the work of Ashenfelter (1978) in estimating the impact of training programmes on earnings, Miller (2013) argues that dips in school performance preceding a principal departure may be transitory. She notes that "Since the typical school is doing badly relative to its usual performance before a new principal starts, it is entirely possible that the school would have experienced a recovery to its usual performance regardless of whether the principal was replaced(ibid:71)." In establishing whether new principals raise the performance of a school "it is difficult to disentangle the positive effects of having a new principal from what is merely a return to the permanent state of the school (ibid:71)."

school outcomes are compared across schools depending on whether they experience principal turnover between, specifically, 2010 and 2012 as plotted in Figure 1. In each sub-plot, samples are limited to schools with outcome measures in each of the relevant data years in the plots. The sample calculation excludes any schools that experience turnover between 2008 and 2010. These schools may have different outcome trends influencing the observed estimates. In plot D there is no evidence of a dip in promotion rates among principal turnover schools in excess of that experienced by non-turnover schools. Plots B and C of the average mathematics result and percentage pass in the NSC are inconclusive on the matter, particularly in plot B where the data time series is very limited. However, in plot A of the percentage of mathematics takers who pass the examination there is a suggestion of a dip in outcomes for schools prior to principal turnover.

Figure 1: Performance trends across schools by principal turnover (2010 to 2012)



Source: Persal-EMIS dataset connected to matriculation examination data. **Notes**: A principal change is identified for the period 2010 to 2012. The sample of schools in the calculations correspond to the OLS and fixed effects estimation samples in Table 2 but are further limited to i) schools with outcome data for each of the years identified in each graph and ii) schools that do not experience turnover in the earlier period 2008 to 2010. Specifically 3 516 schools are used in plot A, 4146 in plot B, 3 483 in plot C and 4 146 in plot D. Error bars reflect the 95 percent confidence interval about each mean estimate.

Acknowledging the limitations of the school fixed effects estimation in controlling for other sources of bias, I test the robustness of the results by drawing on the work of Heckman, Ichimura and Todd (1997). They propose a strategy that combines the propensity score matching approach with difference-in-difference. The aim is to create a valid counterfactual group of 'control' schools using propensity score matching while relaxing the Conditional Independence Assumption (CIA) by taking the difference in school outcomes before and after 'treatment'. Heckman and Smith (1999) argue that this offers a superior approach over conventional difference-in-difference estimators in reducing estimated selection bias.

5. Robustness check: A propensity score matching approach combined with difference-in-difference estimation

Propensity score matching

Propensity score matching is used to identify a suitable counterfactual group of schools that don't experience a change in school leadership. Under the Conditional Independence Assumption (CIA), schools experiencing a change in principal (the 'treated' group) and the selected control group are then comparable conditional on observed characteristics. This assumption implies that selection is solely based on observable characteristics and that all variables that simultaneously influence whether a principal change takes place and school performance outcomes are observed by the researcher (Caliendo and Kopeinig, 2005; Dehejia and Wahba, 1999). This is clearly an untenable assumption in the likely presence of unobserved heterogeneity. However, by limiting the potential sample of control schools to those that *do* experience principal turnover in a *future* period, but not in the treatment period in question, CIA becomes more defensible. The limited control group are likely to be better matched to the treated schools in terms of unobserved characteristics that encourage the exit of principals from schools and in terms of their school performance trends.[19]

Initially, the treatment group are identified as schools that experience principal turnover between September 2008 and October 2010 and the potential sample of control schools is limited to those that experience turnover between October 2010 and October 2012, but not in the earlier period 2008 to 2010. Two other treatment groups are considered as well: schools that have principals who move to another post in the public education system between 2008 and 2010 and schools with principals that exit the public education system over the period. Similarly, each set of treatment schools are matched to schools that experience the same type of principal turnover in the following period.

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[19] A similar approach is used by Allen and Allnut (2013) in estimating the impacts of Teach First on school performance in the United Kingdom. They match programme schools in one period to those who adopt the programme in a later period and then run a fixed effects model on the matched sample.

I estimate one propensity score for each school using a logistic regression of school and principal characteristics on whether a school experiences a principal leadership change between 2008 and 2010. Matching is achieved using a single propensity score that represents the likelihood of a school experiencing a principal leadership change, conditional upon its being selected in the treatment group.[20] The control group is then restricted to only those observations whose propensity score value falls within the range of the propensity score of the treated group.

Propensity score matching is implemented in Stata using psmatch2 (Leuven and Sianesi, 2003) where schools are matched on the basis of their characteristics and their principals in 2008. Importantly, the choice of matching variables should be limited to those that are not influenced by the principal turnover event itself or the anticipation thereof (Todd, 1999). The set of pre-treatment variables chosen is largely informed by the set of theoretically appropriate variables typically used in the literature investigating teacher and principal turnover, the most important determinant being principals' age. Characteristics conditioned upon in 2008 include the following: principals' age, gender, race, educational qualification levels, their position in 2004, salary in 2008 prices and sick leave days taken (which proxies for motivation). It is argued that conditioning on sick leave days taken is also important for matching on pre-turnover trends in school performance. School controls include its location (urban vs. rural), total student enrolment, total number of educators per one hundred students and indicators for the former department classification as well as current province. An indicator for whether the school experienced a provincial boundary change in 2005 is also included. The logistic regression results identifying the coefficients on these matching variables are shown in the appendix, Table A.5.

Estimating reliable average treatment effects relies critically on i) sufficient overlap between the treated and control groups and ii) balance across the two groups with respect to their observed pre-turnover characteristics. Overlap is evaluated using the Psgraph command in Stata; it provides a visual analysis of the density distribution of the propensity score in both groups as well as an indication of the extent of common support. Two-sample t-tests are used to evaluate whether the samples are balanced, identifying if there are significant differences in the covariate means for both groups. After matching, covariates should be balanced, i.e. there should be no significant differences in the mean characteristics across the two groups.

Figure 2 presents histograms of propensity scores for the treated and control schools while highlighting schools that are off common support. In the estimations that follow, common support is

[20] Matching may be implemented non-parametrically by defining cells using discrete matching. However, conditioning on all relevant covariates is limited in the case of a high dimensional vector of covariates, so that Rosenbaum and Rubin (1983) suggest the use of a parametric approach to achieve one propensity score to address this `curse of dimensionality'.

applied to prevent poor matches from affecting the estimation results.[21] Fortunately, the proportion of schools disregarded through common support is not large, which does not further complicate the interpretation of the results. Where treatment is identified as principal turnover between 2008 and 2010, eight treatment schools are off common support. Where treatment is identified as principal mobility between 2008 and 2010, 13 schools are off common support while 15 schools are off common support when the treatment is principal attrition between 2008 and 2010. The graphs in panel A of the figure reflect that, in general, the quality of the matching is good in terms of overlap, although somewhat thin in the left tails. Moreover, a very strong match is achieved where balance is obtained across all matching variables when comparing mean estimates across treatment and matched schools. This is shown in the appendix, Table A.6, where the treatment in question is principal turnover between 2008 and 2010.

Constraining the control group of schools not experiencing a principal change between 2008 and 2010 to those that experience a change in the later period 2010 to 2012 is critical to the success of the PSM-DiD strategy. This produces a more suitable counterfactual group of treatment schools as evident in the substantially improved overlap in covariates across the treated and control group. The strong overlap when the control group is constrained is graphically identified in panel A of Figure 2. This is contrasted against the lack of overlap identified in panel B where the control group of schools is not constrained.

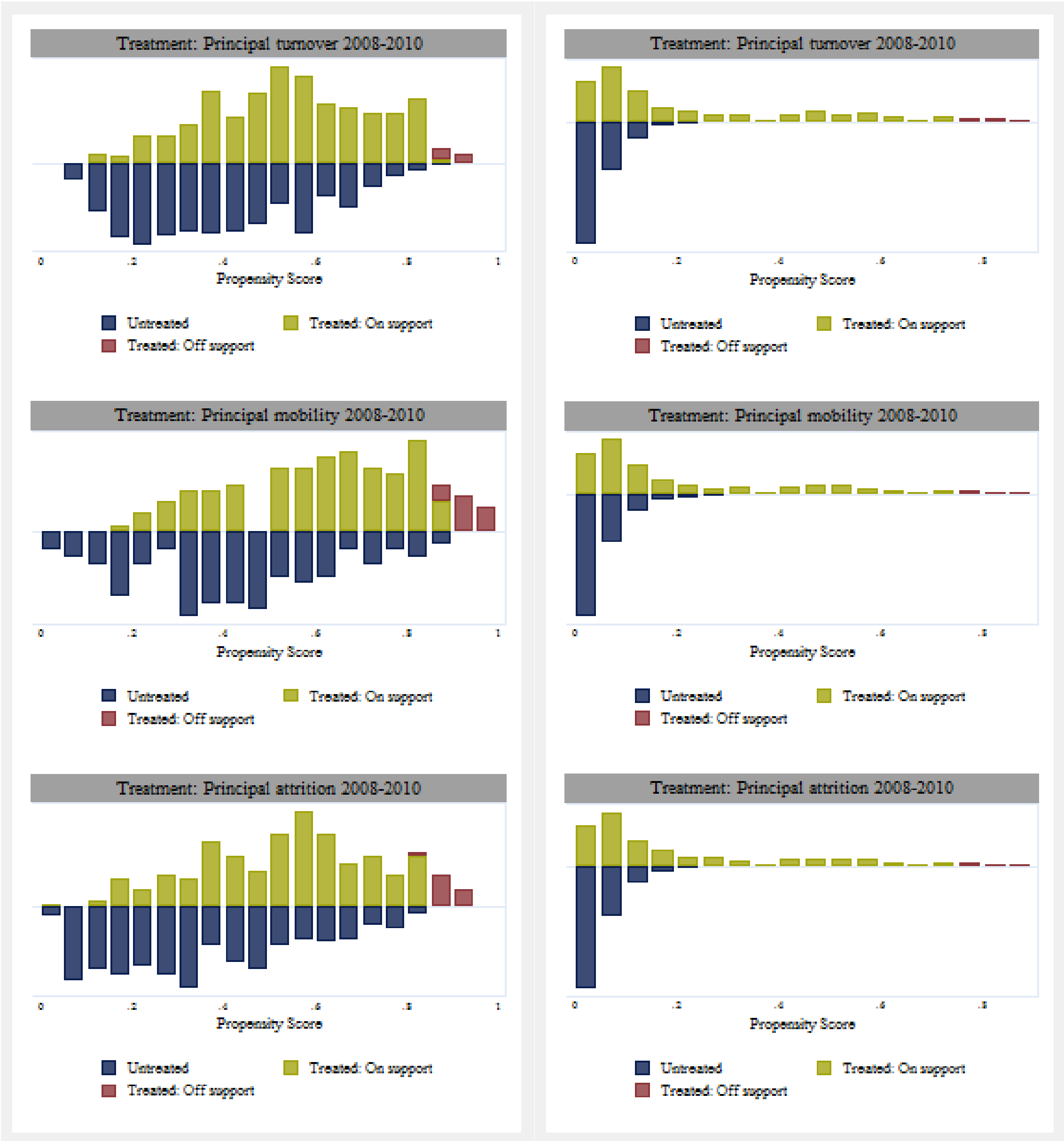
Estimation using the propensity score matched sample

Despite the matching procedure above that aims to create a valid counterfactual group, it remains possible that the Conditional Independence Assumption (CIA) is not met if schools that experience principal turnover in the first period are different from those that experience principal turnover in the second period. This remaining unobserved heterogeneity can be dealt with using difference-in-difference (DiD) estimation. Whereas the matching procedure deals with selection on observable characteristics, the application of the DiD strategy controls for unobserved school level characteristics associated with a principal's decision to leave a school. In this framework, the strong CIA may be relaxed provided that there are now common time trends in the outcomes across the treated and matched control schools. In other words, even if the principal turnover schools are different from the non-turnover schools in unobserved ways, as long as these differences are stable over time, these biases can be eliminated through the specification.

[21] Here one deletes all observations whose propensity score is smaller than the minimum and larger than the maximum of the opposite group.

Figure 2: Histograms of propensity scores

Panel A: Constrained control group **Panel B: Unconstrained control group**



Notes: Treated schools experience a principal leadership change between 2008 and 2010. In panel A, the potential group of control schools are constrained to schools that do not experience a principal change between 2008 and 2010 but do experience a principal leadership change between 2010 and 2012. In panel B, the control group of schools are unconstrained. Propensity scores are calculated using Psmatch2.

DiD is executed by running the school fixed effects estimations of matriculation examination outcomes on a two-year panel of the relevant sample of matched treatment and control schools. The samples correspond to each of the three 'treatments' (principal turnover between 2008 and 2010, principal mobility between 2008 and 2010 and principal attrition between 2008 and 2010). The school fixed effects soak up unobserved school characteristics that remain constant over time while time-varying school and principal characteristics are included as additional covariates intended to account for observed population changes at the school over time. Time-varying principal controls include their age, gender, previous management experience (as proxied by their position in payroll in 2004), years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment.[22]

In addition to using the matched samples of schools, the regressions are weighted using what Li, Morgan and Zaslavsky (2014) refer to as 'overlap weights' to improve the balance in the covariates. The overlap weights are derived directly from the propensity score matching phase and weight each unit proportional to its probability of assignment to the opposite group. The overlap weights effectively give more weight to observations in the covariate space where the distribution for the treatment group most overlaps with the control group. These overlap weights are considered a better alternative to inverse probability weights as they have the advantage of being bounded between zero and one.[23]

The estimation results are presented in Table 7. Estimates are obtained for the three matched samples which correspond to the three treatments in question: i) any type of principal turnover between 2008 and 2010, ii) turnover due to principal mobility between 2008 and 2010 and iii) attrition related turnover between 2008 and 2010 for retirement or other reasons. As expected, a negative coefficient is identified on each of the indicators, regardless of the performance measure used. The treatment 'principal turnover' is statistically insignificant in estimating the average mathematics percentage and the pass rate in the NSC, but weakly significant when the outcome variable in question is the pass rate in mathematics. The lack of significance on the principal turnover indicator is inconsistent with the findings in Table 2.

Nevertheless, the results support earlier conclusions that there may be heterogeneous impacts on school performance across the two flows of principal turnover. When the treatment in question is principal mobility, the negative coefficients identified are consistently insignificant. However, small sample size may also be one of the reasons why the effects may not be significant. By contrast, the coefficient on the indicator for principal attrition (including retirement or leaving the public school system for other reasons) is negative *and* statistically significant when the outcome variables are the

[22] It is arguable that student enrolment and teacher numbers may be influenced by the anticipation of a principal departure from a school. Sensitivity checks were conducted in estimating the results in Table 7 where student enrolment and teachers per one hundred students were excluded as matching variables in the propensity score matching phase. The results of Table 7 are robust too their exclusion.

[23] Using these overlap weights, the estimated coefficients reflect the average treatment effect for the overlapping observations or what Li et al refer to as ATO contrasted against the average treatment on the treated group effect (ATT) (Li et al, 2014:10).

two mathematics school performance measures. Contrary to expectations, the magnitude of these negative coefficients are larger than those observed in Table 5 at negative seven percent and 2.7 percent respectively although the coefficients are estimated imprecisely. It is noted that the results of Table 7 are robust to various sensitivity checks where the matching variables in obtaining the propensity score are varied in their inclusion.[24]

The PSM-DiD approach provides confirmatory evidence of negative and statistically significant effects of principal attrition on school performance. It is confirmed that in the short to medium term school leadership changes - especially when induced by principals exiting public education - have negative impacts on school performance, particularly in the mathematics examinations.

6. Teacher turnover and principal turnover

One of the mechanisms through which principal leadership changes are proposed to influence student learning is in inducing higher levels of teacher turnover in schools (Branch, Hanushek and Rivkin, 2012; Beteille, Kalogrides and Loeb, 2012; Miller, 2013; Young and Fuller, 2009). In North Carolina, Miller (2013) identifies that around the time of a principal leadership change roughly 1.3 percent more teachers leave a school and this rises to 1.6 percent until a year after a new principal is appointed, after which the rate of teacher turnover stabilises.

There are various reasons why teacher turnover may rise in response to a leadership change. Teachers may be unwilling to adjust to what Hart (1991) describes as new "socialisation" of the school organisation induced through the leadership succession process. If they are overlooked in the promotion processes after an incumbent principals vacates a post, they may seek promotion opportunities in other schools. Furthermore, in contexts where principals have control over the hiring and firing of teachers, teacher turnover may rise as incoming principals alter the staff composition of the school. Principals in South Africa, however, do not have control over the hiring and firing of publicly employed teachers. Nevertheless, teacher turnover may still rise in light of the first two reasons.

Rising levels of teacher turnover have been found to negatively affect student achievement by destabilising school environments, but ultimately the effect of teacher turnover on school outcomes depends on whether the best or worst performing teachers leave and the quality of teachers who replace them (Beteille, Kalogrides and Loeb, 2012; Ronfeldt et al., 2011). While it is beyond the scope of this analysis and data to determine how teacher turnover ultimately impacts on school outcomes, I investigate whether teacher turnover rises in response to principal leadership changes.

[24] In addition to excluding student enrolment and teachers per one hundred students as matching variables in the propensity score matching phase, principals' years of service was also included as a matching variable. The results of Table 7 are robust to these variations in the matching variables used.

Table 7: School fixed effects estimations on samples from the propensity score matching approach

	% who pass mathematics			Average mathematics %			% who achieved the NSC		
	PSM matched sample (1)	**PSM matched sample (2)**	**PSM matched sample (3)**	**PSM matched sample (1)**	**PSM matched sample (2)**	**PSM matched sample (3)**	**PSM matched sample (1)**	**PSM matched sample (2)**	**PSM matched sample (3)**
Principal turnover	-4.814*			-1.539			-2.246		
	(2.687)			(1.064)			(1.783)		
Principal mobility		-2.979			-0.593			-1.917	
		(4.041)			(1.519)			(2.313)	
Principal attrition			-6.990**			-2.704**			-3.328
			(2.867)			(1.304)			(2.650)
Principal controls	X	X	X	X	X	X	X	X	X
School controls	X	X	X	X	X	X	X	X	X
Year fixed effects	X	X	X	X	X	X	X	X	X
School fixed effects	X	X	X	X	X	X	X	X	X
Within R-squared	0.091	0.087	0.157	0.095	0.086	0.151	0.105	0.25	0.158
N (school-years)	1 373	673	909	1 373	673	909	1 394	688	919
N (clusters)	693	229	458	693	229	458	698	231	460
F stat	2.981	1.843	4.103	3.487	2.037	4.514	3.394	7.195	4.014

Notes: Estimated on the three matched samples for the years 2008 and 2010. The matched samples are obtained using propensity score matching with the application of common support. Group (1): matched sample includes treatment schools experiencing principal turnover between 2008 and 2010 and matched control schools that experience principal turnover in the later period 2010 to 2012. Group (2): matched sample includes treatment schools whose principals move to another post in public education between 2008 and 2010 and matched control schools whose principals move to another post in public education in the next period 2010 to 2012. Group (3): The matched sample includes treatment schools whose principals move to another post in public education between 2008 and 2010 and matched control schools whose principals move to another post in public education in the next period 2010 to 2012. Time-varying principal controls include their age, gender, previous management experience (position in payroll in 2004), years of service and educational qualifications (REQV). Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. Regressions are weighted using the overlap weights (Li et al, 2014) derived from the propensity score matching approach. Standard errors, in parentheses, are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

A panel dataset of all public sector educators was constructed to examine the relationship between principal turnover and teacher turnover. Persal data for all educators (excluding principals) for the years 2004, 2008, 2010 and 2012 was again linked to the EMIS master list of schools data and Snap data. The panel of educators was then linked to the panel dataset on school principals (the reader is referred to the appendix for more information on the data matching process). Since the outcome measure is now teacher turnover and not school performance, I investigate the relationship between teacher turnover and principal turnover at all school phase levels rather than being limited to schools offering grade 12.

An indicator for whether a teacher moved out of a school between each of the data years is constructed by comparing their linked school identifier across data years. Four years of school identifiers are required to identify three periods of possible transitions; therefore, teacher turnover is identified for only three of the four data years. At most 862 875 teacher-year observations are available for the estimations with some losses in sample size due to missing data on control variables.

A linear probability model[25] is used to predict whether a teacher leaves his or her current school between two adjacent data years as a function of whether the principal leaves the school within that same period as well as other characteristics. In the literature, the relationship between teacher turnover and principal turnover is typically estimated without disaggregating effects across principal turnover flows: mobility and attrition. It is expected, however, that a teacher's decision to move out of a school may differ depending on the reasons for the principal leadership change. For example, if a principal moves out of the school to take up a post in another school, or leaves the public education system for non-retirement reasons, the circumstances surrounding this decision may be more unexpected than an anticipated principal retirement. The former may be more likely to disrupt staff dynamics at a school and more readily induce teacher exits.

In response, the models that follow distinguish principal turnover into its two flows. With a larger number of schools available when compared with the limited matric sample, principal attrition is further distinguished into two types: attrition that is retirement related (identified where a principal's age is close to the common retirement age of 60) and then non-retirement attrition (if the principal is not near retirement age). The model is estimated with the following equation:

$$\Pr(T_{hst} = 1) = \beta_0 + \beta_1 PM_{st} + \beta_2 PR_{st} + \beta_3 PA_{st} + \beta_4 X_{st} + \beta_5 S_t + \pi_t + \pi_s + \epsilon_{hst}$$

[25] Beteille, Kalogrides and Loeb (2012) use a logistic regression to predict the impact of principal turnover on teacher turnover. Incorporating school fixed effects into the logistic regression framework, however, poses challenges for sample size if there is no teacher that moves or all teachers move in a school over the panel. These schools would be dropped from the analysis.

The probability that a teacher h leaves his or her current school s in time t is expressed as a function of whether a principal moves out of the school over the same period where PM_{st} indicates principal mobility, PR_{st} indicates that the principal most likely retired and PA_{st} indicates principal attrition that is non-retirement related (which may include taking up a position in the private sector). The model also controls for a teacher's characteristics (X_{st}), time-varying school characteristics (S_t), year fixed effects (π_t) and in some specifications school fixed effects (π_s). Teacher characteristics controlled for include their age, gender, race, educational qualifications and whether they are a head of department or deputy principal. Time-varying school characteristics include total school enrolment, the percentage of students whose race is black, the number of teachers per one hundred students and the average REQV of teachers[26] in the school. Additional non-time-varying school controls include indicators for school location (urban and province), former department classification and school wealth quintile ranking. Descriptive statistics of the sample are presented in the appendix, Tables A.7 and A.8.

Table 8: Linear probability model of teacher turnover

	Estimating teacher turnover between 2004 to 2008 or 2008 to 2010 or 2010 to 2012			
	OLS			**School fixed effects**
	(1)	**(2)**	**(3)**	
Principal mobility	0.121***	0.115***	0.081***	0.047***
	(0.007)	(0.007)	(0.006)	(0.006)
Principal attrition: retirement	0.003	0.001	-0.006**	0.002
	(0.003)	(0.003)	(0.003)	(0.003)
Principal attrition: non-retirement	0.035***	0.032***	0.007**	0.005
	(0.004)	(0.004)	(0.003)	(0.003)
Teacher controls	X	X	X	X
School controls		X	X	X
Year fixed effects			X	X
School fixed effects				X
R-squared/within R-squared	0.041	0.048	0.075	0.056
N-clusters (schools)	-	-	-	23 484
N (teacher-years)	862 875	860 924	860 924	861 976
F stat	1 637 (0.000)	570 (0.000)	784 (0.000)	1 580 (0.000)

Notes: Teacher controls include their age, gender, race and whether they are a deputy or head of department. Time-varying school controls include total school enrolment, the percentage of students that are black and the number of teachers per one hundred students. Additional school controls in the OLS regressions include quintile status, urban-location, school phase-level indicators, the average REQV of teachers in the school, former department classification and province dummies. Standard errors are clustered by school. Statistically significant at *p<0.1,**p<0.05, ***p<0.001.

[26] It was not possible to control for each teacher's REQV level as this results in a loss of too many observations due to missing data where 2004 REQV data was not available to the author or is missing for some educators in other years. With many teachers still in the school four years later, it is possible to impute an indicator for average REQV levels of teachers in the school in 2004 on the basis of the 2008 data.

The estimation results of the described model are in Table 8. The dependent variable takes on a value of one if a teacher exited a school over a period in question (2004 to 2008, 2008 to 2010 or 2010 to 2012) and zero if they did not. Principal turnover is distinguished into its three flows reflected in three indicator variables (principal mobility, principal attrition for retirement and principal attrition for non-retirement); the reference category includes teachers in schools in which no principal turnover occurred. The specifications vary in their inclusion of controls and fixed effects. The first model only includes indicators of principal turnover flows and teacher characteristics. The second model compares teacher turnover in schools experiencing principal turnover to schools that are similar in observable ways but do not experience principal turnover by including a number of school control variables. The third and fourth models include year and then school fixed effects. Ideally, a model with school fixed effects is preferred in estimating the relationship between teacher and principal turnover because unobservable school characteristics may confound estimation results. However, an effect will only be obtained from the small variation within schools across the three years of data.

It appears that only leadership changes initiated by the outgoing principal moving to another post within the public education system are associated with higher teacher turnover. In the first column of Table 8, the coefficient on principal mobility indicates teachers positioned in schools where the outgoing principal moves to another school post are 12 percent more likely to exit the school over the same period compared to when there is no principal turnover. After adding year fixed effects in the third column, this coefficient on principal mobility reduces to eight percent. In the last column which includes school fixed effects, the coefficient on principal mobility reduces to five percent but remains strongly significant. What is interesting is that retirement related principal exits are not significantly related to teacher turnover; the magnitude of the effect is close to zero. This is in contrast to the estimations of school performance where principal attrition rather than principal mobility had a negative effect on school performance. One explanation for this non-effect is that if a principal exit for retirement purposes is more likely to be anticipated, then staff turnover may occur in an earlier period (not captured here, where principal and teacher turnover are concurrent). Non-retirement related principal attrition also does not appear to be systematically associated with higher levels of teacher turnover. The coefficient on principal attrition for non-retirement reasons is small and insignificant in the school fixed effects regression.

To my knowledge, there are no studies in the public domain that provide direction on the quantitative determinants of teacher turnover in the South African context. Before continuing with the analysis, it is instructive to note where other coefficients on control variables in the school fixed effects regression are significant. Consistent with a U-shaped age profile of the probability of teacher turnover identified in the U.S. literature (Harris and Adams, 2005; Ingersoll, 2001), a similar finding is identified among South African teachers (and principals as identified in Wills (2015b)). Initially, the probability of teacher turnover declines with age until 50 to 54 years and then rises. The results also indicate that female teachers are less likely to move out of their schools than their male counterparts. Compared with black teachers, coloured and white teachers exhibit higher levels of turnover and teachers are more likely to leave schools where the teacher to student ratio is higher.[27]

Even with the inclusion of school fixed effects, this does not resolve the possibility that a two-way causal relationship may exist between principal turnover and teacher turnover. This would confound the estimates observed. To test the robustness of the results to this endogeneity concern, I re-run the linear probability model of teacher turnover but instead include 'lagged' principal turnover indicators to assess whether teacher turnover in a later period rises in response to principal turnover in an earlier period. Teacher turnover between the period 2010 and 2012 is expressed as a function of principal turnover between the periods 2008 to 2010. Again, three indicators for principal turnover are included; the reference category is teachers in 2010 positioned in schools that did not experience a principal change between 2008 and 2010. I also exclude from the sample, schools that experience a principal leadership change between 2010 and 2012 to limit the contemporaneous impact this may have on teacher turnover.

It is not possible to include school fixed effects in this lagged model due to data period constraints. Nevertheless, a number of teacher and school characteristics in 2010 are included in the regression as controls. In addition to the controls used in the OLS regressions in Table 8, I control for a teacher's marital status– a variable which is available to the author only for the year 2010 – where this may inform their career decisions.[28] I also include a continuous variable reflecting the percentage of teachers in the school in 2008 that had moved out of the school by 2010. This is meant to serve as a control for the impact of unobserved factors on teachers' decisions to move between 2010 and 2012 although it will absorb part of the principal turnover impact. If working conditions at the school suddenly deteriorate, this may induce both principals and teachers to move out of the school. In which case, unobserved school factors may entirely inform teacher turnover decisions, rather than the principal leadership changes themselves. It is suspected that unobserved factors, such as a decline in working conditions that would have influenced the principals' decision to leave between 2010 and 2012, would likely be captured by this control variable.

The results presented in the first column of Table 9, for the full sample of schools, are consistent with the findings of Table 8. The coefficient on the indicator for principal mobility between the period

[27] The OLS regressions also indicate that relative to teachers in the poorest schools (quintile one), teachers in wealthier schools are less likely to exit their schools. No association is identified between teacher turnover and the urban/rural status of the schools in this multivariate context. What is also noteworthy is the very low level of variance in teacher turnover explained by the control variables in the OLS models. There are clearly unmeasured factors influencing teachers' job satisfaction and employment decisions which are likely much more important determinants of teachers' career decisions than what is captured in these models.

[28] Marital status is expected to be a significant factor affecting their decision to leave or stay in a job.

2008 and 2010 is positive and significant, while positive but insignificant coefficients are identified on the two principal attrition indicators. This suggests that compared to teachers in schools that do not experience a principal leadership change in the preceding period (2008 to 2010), teachers in schools that do experience a leadership change in the preceding period are more likely to move out of their schools in the next period observed (2010 to 2012); but only where the leadership change was induced by the outgoing principal moving to another post within the public education system. The magnitude of the coefficient on principal mobility is at only 1.5 percent smaller than that observed in Table 8 at nearly five percent.[29] By the very construction of the estimation using lagged indicators, this is expected. The impact of principal turnover on teacher turnover will likely diminish with time.

Table 9: Linear probability model of teacher turnover between 2010 and 2012 in response to principal turnover in the previous period 2008 to 2010

	OLS estimations of teacher turnover between 2010 and 2012				
	All schools	**Primary/ Intermediate schools**	**Secondary**	**Quintile 1-3**	**Quintile 4-5**
Principal mobility (2008-2010)	0.015***	0.026**	0.007	0.015**	0.014
	(0.006)	(0.010)	(0.007)	(0.007)	(0.011)
Principal attrition: retirement (2008-2010)	0.003	0.008	-0.008	0.002	0.001
	(0.004)	(0.005)	(0.006)	(0.005)	(0.007)
Principal attrition: non-retirement (2008-2010)	0.009**	0.018***	-0.002	0.008*	0.012
	(0.004)	(0.007)	(0.007)	(0.005)	(0.008)
Teacher controls	X	X	X	X	X
School controls	X	X	X	X	X
R-squared	0.042	0.046	0.038	0.038	0.057
N (teachers)	261 270	126 399	93 735	186 234	75 036
F stat (p-value)	161 (0.000)	93 (0.000)	57 (0.000)	107 (0.000)	77 (0.000)

Notes: The estimation is run for the year 2010. Teacher turnover between 2010 and 2012 is expressed in relation to principal turnover flows between 2008 and 2010. Principal turnover flows are interpreted in relation to the reference category which includes teachers in schools in 2010 that do not experience a principal leadership change between 2008 and 2010. Excluded from the estimation sample are teachers in schools that experience a principal leadership change between 2010 and 2012 as this may confound the estimates. Teacher controls in 2010 include teachers' age, gender, race, marital status and whether they are a deputy or head of department. School controls include the percentage of teachers in 2008 who left the school by 2010, the percentage of students that are black, total school enrolment, the number of teachers per one hundred students, the average REQV level of teachers in the school, school phase-level, urban-location, quintile status, former department classification and province dummies. Sample sizes vary due to missing data on covariates included. Robust standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.01, **p<0.05, ***p<0.001.

Table 9 also disaggregates results by sub-samples of teachers, namely teachers in poorer schools (quintiles one to three), in wealthier schools (quintiles four and five), in primary schools and secondary schools. Similar results are observed across teachers in poorer and wealthier school samples. However, when comparing estimates across primary and secondary school teachers, there are notable differences. Principal turnover, in particular, has a significant effect in raising levels of

[29] It is noted that these estimations are robust to excluding older teachers from the regressions who may be more likely to exit for retirement reasons.

turnover among primary school teachers. Not only are positive effects of principal mobility on primary school teacher turnover identified, but the coefficient on the non-retirement related principal attrition indicators is also positive and significant in this sample. By contrast, none of the indicators for principal turnover flows are significant in the secondary school sample. On the basis of these results, teacher turnover does not provide a useful explanation for why school performance in the matriculation examination declines in response to a change in school leadership.

7. Conclusion

With an aging population of school principals in South Africa, leadership changes are gaining momentum in schools, albeit from a very low base. The research has provided evidence that these leadership changes indeed result in negative consequences for school performance in the short to medium term. Evidence of significant negative effects of principal turnover on school leaving outcomes was identified through the school fixed effects model, with larger and more significant effects observed in poorer schools. Distinguishing principal turnover into its two flows, it appears that principal attrition (which includes principal retirements or exits for non-retirement reasons including taking on work in the public sector), rather than principal mobility, is driving the negative results observed. In quintile one to five schools offering grade 12, principal attrition is associated with a 1.7 percentage point decline in matriculation mathematics pass rates and a 1.5 percentage point decline in schools' overall NSC pass rates. When limiting the sample to poorer (quintiles one to three) schools, the percentage pass rate in mathematics falls by four percentage points, the average mathematics percentage falls by 1.8 percentage points and the NSC pass rate declines by 3.2 percentage points in response to the school's principal exiting public education.

Acknowledging that the school fixed effects strategy may not sufficiently control for remaining sources of endogeneity, a second identification strategy combining propensity score matching with difference-in-difference estimation was used to check the robustness of the results. The propensity score matching approach generated a well matched control group of schools that are likely to be similar to treatment schools in terms of their unobserved characteristics and pre-turnover trends in school performance. Constraining the potential control group of schools to those experiencing a principal leadership change in a subsequent period was critical to the success of the matching approach. This strategy confirmed that school performance, particularly in the grade 12 mathematics examinations, falls in response to a principal exiting public education. The magnitude of the principal turnover effects when estimated on the propensity score matched sample, were actually larger than in the full fixed effects regressions.

In the short to medium term, school leadership changes are a risk to school performance, especially when initiated by principals exiting public education. This is a concern where a number of principal retirements are taking place across the system. In response, district and circuit managers should provide support to schools in managing the leadership succession process. This may involve, amongst other things, meeting with soon to retire principals to ensure that they are prepared for a hand-over of their principal position. Preparation may involve documenting and disseminating information to school management teams on existing systems processes and various informal arrangements that affect the day-to-day functioning of a school. This may mitigate losses in institutional knowledge accompanying a principal's exit. District involvement in the leadership succession process may also involve supporting newly appointed principals in their role or encouraging outgoing principals to mentor or coach their successors. Effective induction training may also assist newly appointed principals in adjusting to their roles; particularly in understanding policies, legislation and codes of practice affecting their work and responsibilities. In earlier work I show that there is place for an increased roll-out of induction training for newly appointed principals in South Africa (Wills, 2015b).

The study also explored two mechanisms which may explain why school performance declines in response to a principal leadership change. There is some evidence (albeit weak) that rising promotion rates accompany a leadership succession. In this respect, the decline in matriculation outcomes could be accounted for by a slightly weaker group of students sitting the matriculation examination.

Using a full sample of schools (not limited to those offering grade 12), results suggest that teacher turnover is likely to rise in response to a change in principal leadership. In primary schools, in particular, teacher turnover rises in response to a leadership change, regardless of whether this was induced by the outgoing principal moving to another position in the public education system or whether they exited public education for non-retirement reasons. Among secondary school teachers, however, no significant relationship between principal turnover flows and teacher turnover is identified. It follows that rising teacher turnover cannot account for the decline in matriculation examination outcomes following a principal leadership change. In these secondary schools, principal turnover is likely impacting on learning outcomes through disrupting other aspects of school functionality or teacher behaviour.

While the panel dataset constructed for this study provides new avenues for educational research, the analysis would benefit from an extended panel. With a longer panel, event history modelling techniques could be applied to the research problem. Furthermore, only contemporaneous impacts of leadership changes could be considered in this analysis. It may be more instructive to understand how school leadership replacements impact on learning outcomes as time progresses. As evidenced in other research, it takes many years before new school principals can have their full effect on the school organisation (Coelli and Green, 2012).

Appendix

Table A.1: The characteristics of schools offering grade 12, depending on whether the school is connected to a principal in all three waves (2008, 2010 and 2012)

	Schools offering grade 12 in 2008, 2010 and 2012			**Principals in schools offering grade 12**	
	Connected to principal in all three 'waves'	**Connected to a principal in less than three 'waves'**	**All**	**in 2010**	**in 2012**
Principal turnover (2008 to 2010)	0.075			0.146	
	(0.004)			(0.005)	
Principal turnover (2010 to 2012)	0.088				0.152
	(0.004)				(0.005)
Grade 10 to 12 promotion rate	56.669	58.779*	57.133		
	(0.368)	(0.740)	(0.330)		
NSC pass rate (%)	64.312	59.369*	63.224		
	(0.344)	(0.656)	(0.306)		
Total school enrolment	673.151	617.236*	660.845		
	(5.694)	(10.752)	(5.040)		
Total number of educators	25.251	23.106*	24.779		
	(0.203)	(0.371)	(0.179)		
School location: urban	0.394	0.369*	0.388		
	(0.007)	(0.013)	(0.006)		
% of students that are black	87.004	90.697*	87.817		
	(0.439)	(0.697)	(0.376)		
N (observations)	**4 557**	**1 286**	**5 843**	**5 480**	**5 458**

Source: Persal-EMIS matched dataset. **Notes:** Missing data results in a loss of 22 schools from the available population of 5865 schools with grade 12 students in 2008, 2010 and 2012. *Mean estimate of the sample of schools that are not connected to a principal in all three waves is statistically significantly different from the mean estimate of the sample of schools connected to a principal in all three waves using a 95 percent confidence interval. Standard errors are in parentheses.

Table A.2: Descriptive statistics of schools offering grade 12 in 2008, 2010 and 2012 that could be linked to a principal in each year and are used in the estimations

	Mean	Standard deviation
Principal turnover 2004 to 2008	0.171	0.377
Principal turnover 2008 to 2010	0.074	0.261
Principal turnover 2010 to 2012	0.088	0.283
Principal characteristics:		
Age: 26-34 years	0.003	0.053
Age: 35-39 years	0.037	0.189
Age: 40-44 years	0.141	0.348
Age: 45-49 years	0.259	0.438
Age: 50-54 years	0.301	0.459
Age: 55-59 years	0.203	0.402
Age: 60+	0.057	0.232
Gender: Female	0.156	0.363
Race: African	0.799	0.401
Race: Asian	0.032	0.176
Race: Coloured	0.058	0.234
Race: White	0.111	0.314
Educational qualification: REQV	14.920	1.013
Position in 2004: Principal	0.718	0.450
Position in 2004: Deputy	0.125	0.330
Position in 2004: Head of department	0.080	0.271
Position in 2004: Other	0.077	0.267
School characteristics:		
Total school enrolment	680.829	390.025
The number teachers per one hundred students	3.935	1.322
Urban location	0.392	0.488
% of students that are black	87.110	29.480
Former Department Classification:		
Department of Education and Training (black)	0.202	0.401
Independent Homeland	0.134	0.340
Non-independent homeland	0.363	0.481
House of Assemblies (White)	0.101	0.302
House of Delegates (Indian/Asian)	0.027	0.161
House of Representatives (Coloured)	0.050	0.217
New school	0.103	0.304
Unknown	0.021	0.144
N (school-years)	13 548	

Source: Persal-EMIS matched dataset. **Notes:** Descriptive statistics are calculated for the estimation sample used in the OLS regression of the percentage of examination takers who achieve the National Senior Certificate in Table 3.2.

Table A.3: School fixed effects estimations of matriculation outcomes including schools not matched to a principal in three waves (quintiles one to five)

	Connected to a principal in all three 'waves'				Connected to a principal in less than three 'waves'			
	% who pass maths	**Average maths %**	**% who achieve the NSC**	**Grade 10-12 promotion rate**	**% who pass maths**	**Average maths %**	**% who achieve the NSC**	**Grade 10-12 promotion rate**
Turnover	-1.342**	-0.435	-1.599**	1.116*	-1.285***	-0.510***	-1.224***	0.248
	(0.640)	(0.265)	(0.531)	(0.577)	(0.437)	(0.177)	(0.375)	(0.405)
Time-varying school controls	X	X	X	X	X	X	X	X
Year fixed effects	X	X	X	X	X	X	X	X
School fixed effects	X	X	X	X	X	X	X	X
Within R-squared	0.034	0.043	0.171	0.072	0.036	0.046	0.166	0.076
N (school-years)	12 819	12 819	13 458	13 514	17 012	17 012	17 461	17 510
N (clusters)	4 273	4 273	4 486	4 518	5 778	5 778	5 829	5 860
F	37.061	50.845	227.08	63.355	51.912	72.502	277.591	82.093

Notes: Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. No principal controls have been included in the sample as schools that are not connected to a principal in a year would be dropped from the estimation. Principal turnover is coded as one in years that schools are not connected to a principal. Standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Table A.4: School fixed effects estimations of matriculation outcomes including schools not matched to a principal in three waves (quintiles one to three)

	Connected to a principal in all three 'waves'				Connected to a principal in less than three 'waves'			
	% who pass maths	**Average maths %**	**% who achieve the NSC**	**Grade 10-12 promotion rate**	**% who pass maths**	**Average maths %**	**% who achieve the NSC**	**Grade 10-12 promotion rate**
Principal turnover	-1.881**	-0.813**	-2.167**	1.178	-1.319**	-0.522**	-1.068**	0.109
	(0.856)	(0.320)	(0.717)	(0.789)	(0.543)	(0.206)	(0.478)	(0.520)
Time-varying school controls	X	X	X	X	X	X	X	X
Year fixed effects	X	X	X	X	X	X	X	X
School fixed effects	X	X	X	X	X	X	X	X
Within R-squared	0.05	0.087	0.212	0.083	0.051	0.088	0.204	0.087
N (school-years)	9 517	9 517	10 045	10 079	12 814	12 814	13 192	13 217
N (clusters)	3 373	3373	3 560	3 585	4 624	4 624	4 675	4 699
F stat	41.503	77.984	226.147	62.875	58.051	105.047	271.746	82.995

Notes: Time-varying school controls include the percentage of students who are black, the number of teachers per one hundred students and total school enrolment. No principal controls have been included in the sample as schools that are not connected to a principal in a year would be dropped from the estimation. Principal turnover is coded as one in years that schools are not connected to a principal. Standard errors are in parentheses and are clustered at the school level. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Table A.5: Logistic regressions of the propensity score matching approach

	Estimating principal turnover between 2008-2010 (1)		Estimating principal mobility between 2008-2010 (2)		Estimating principal attrition between 2008-2010 (3)	
	Coeff.	**Std. error**	**Coeff.**	**Std. error**	**Coeff.**	**Std. error**
Principal characteristics:						
Age: 26-34	0.571	(0.871)	0.186	(0.991)	1.060	(0.955)
Age: 35-39	-0.0389	(0.459)	-0.347	(0.590)	0.756	(0.528)
Age: 40-44	0.261	(0.308)	0.0226	(0.412)	-0.163	(0.440)
Age: 50-54	-0.348	(0.288)	-0.655	(0.468)	-0.442	(0.407)
Age: 55-59	-0.626**	(0.270)	-0.344	(0.576)	0.855**	(0.435)
Age: 60+	0.690**	(0.308)	1.083	(0.950)	1.007**	(0.417)
REQV 10-13	0.519*	(0.314)	0.0952	(0.555)	0.498*	(0.281)
REQV 14	0.148	(0.217)	-0.226	(0.408)	-0.0197	(0.272)
REQV 16-17	-0.229	(0.213)	-0.643*	(0.373)	0.0283**	(0.0112)
Sick leave days taken	0.0260***	(0.00927)	0.0238	(0.0193)	-0.764	(1.003)
Race: Indian/Asian	-1.081	(0.760)	-2.433*	(1.358)	0.526	(0.732)
Race: Coloured	-0.0137	(0.543)	0.285	(1.072)	-0.176	(0.524)
Race: White	-0.0116	(0.435)	0.548	(0.926)	-0.391	(0.297)
Gender: Female	-0.251	(0.232)	0.393	(0.446)	-0.339	(0.470)
Position in 2004: Deputy	-0.535*	(0.322)	-0.920*	(0.481)	-1.508**	(0.704)
Position in 2004: HOD	-1.433***	(0.488)	-1.866**	(0.752)	-0.356	(1.036)
Position in 2004: Other	-0.143	(0.524)	-0.419	(0.697)	-0.00640	(0.00534)
Salary (R 1000's in 2008 prices)	-0.009**	(0.004)	-0.010	(0.007)	0.001**	(0.000)
School characteristics:						
Total school enrolment	0.001**	(0.000))	0.000	(0.001)	0.270**	(0.126)
No. of teachers per 100 students	0.105	(0.101)	-0.290	(0.219)	-0.230	(0.290)
Urban location	-0.0208	(0.239)	0.758	(0.505)	-0.667	(0.465)
Former department:						
Independent homeland	-0.656*	(0.363)	-0.901	(0.699)	0.0352	(0.411)
Non-independent homeland	0.235	(0.328)	0.674	(0.611)	0.00479	(0.578)
House of Assemblies	0.0190	(0.459)	-0.285	(0.943)	-0.0355	(1.032)
House of Delegates	-0.185	(0.860)	-0.281	(1.820)	-0.758	(0.793)
House of Representatives	-0.360	(0.594)	-1.339	(1.158)	0.419	(0.488)
New School	0.545	(0.355)	0.616	(0.603)	1.492	(1.134)
Classification Unknown	0.364	(0.726)	-0.175	(1.058)		

Province:						
Free State	0.805*	(0.419)	-0.186	(0.772)	1.578***	(0.547)
Gauteng	0.144	(0.409)	-0.816	(0.814)	0.498	(0.514)
KwaZulu-Natal	-0.418	(0.414)	-0.631	(0.767)	-0.413	(0.551)
Limpopo	0.817**	(0.411)	0.316	(0.775)	1.202**	(0.534)
Mpumulanga	-0.0275	(0.431)	-0.792	(0.827)	0.384	(0.543)
Northern Cape	-0.393	(0.630)	-1.780	(1.250)	0.569	(0.801)
North West	0.599	(0.419)	0.902	(0.890)	0.742	(0.512)
Western Cape	0.553	(0.455)	0.571	(0.842)	0.562	(0.616)
Provincial boundary change	-0.807*	(0.462)	-0.484	(0.927)	-0.869	(0.554)
Constant	1.065	(0.977)	3.602**	(1.706)	-0.905	(1.445)
Observations	712		253		471	
Log likelihood	-436.6		-146.2		-279.2	
Pseudo R-squared	0.113		0.164		0.139	

Notes: Group (1): The estimation sample includes treatment schools experiencing principal turnover between 2008 and 2010 and potential control schools that experience principal turnover in the next period 2010 to 2012 but not between 2008 and 2010. Group (2): The estimation sample includes treatment schools whose principals move to another post in public education between 2008 and 2010 and potential control schools whose principals move to another post in public education in the next period 2010 to 2012. Group (3): The estimation sample includes treatment schools whose principals move out of public education between 2008 and 2010 and potential control schools whose principals move out of public education in the next period 2010 to 2012 but not in the first period. The reference categories are age 45 to 49, REQV 15, principal's race is black, position in 2004 was a principal, former DET (black) schools, Eastern Cape province, no provincial boundary change. Statistically significant at *p<0.1, **p<0.05, ***p<0.001.

Table A.6: Covariate means estimates before and after propensity score matching (pstest)

		Means			% bias	t-test	
Matching variables		**Treated**	**Control**	**%bias**	**reduction**	**t**	**p>t**
Principal characteristics:							
Age: 26-34	Before	0.01	0.01	4.00		0.53	0.60
	After	0.01	0.01	1.10	72.90	0.13	0.90
Age: 35-39	Before	0.05	0.05	1.40		0.18	0.86
	After	0.05	0.04	4.50	-228.70	0.59	0.56
Age: 40-44	Before	0.16	0.13	11.00		1.47	0.14
	After	0.16	0.17	-1.80	83.20	-0.22	0.82
Age: 50-54	Before	0.18	0.20	-5.30		-0.71	0.48
	After	0.18	0.18	1.30	75.10	0.17	0.86
Age: 55-59	Before	0.22	0.36	-31.30		-4.16	0.00
	After	0.23	0.23	0.00	99.90	0.00	1.00
Age: 60+	Before	0.22	0.11	29.40		3.95	0.00
	After	0.21	0.22	-3.50	88.00	-0.41	0.68
REQV 10-13	Before	0.12	0.09	9.30		1.25	0.21
	After	0.11	0.12	-3.40	64.10	-0.41	0.68
REQV 14	Before	0.28	0.25	6.70		0.89	0.37
	After	0.28	0.26	4.80	28.40	0.61	0.54
REQV 16-17	Before	0.24	0.29	-13.00		-1.73	0.08
	After	0.24	0.24	1.10	91.80	0.14	0.89
Sick Leave	Before	5.94	4.45	16.10		2.15	0.03
	After	5.73	4.92	8.70	45.70	1.11	0.27
Race: Asian	Before	0.01	0.04	-14.00		-1.85	0.07
	After	0.02	0.01	0.80	94.20	0.14	0.89
Race: Coloured	Before	0.08	0.08	0.10		0.01	0.99
	After	0.08	0.07	2.30	-2350.20	0.30	0.76
Race: White	Before	0.18	0.16	3.60		0.47	0.64
	After	0.18	0.18	-1.90	46.70	-0.24	0.81
Gender: Female	Before	0.16	0.19	-8.70		-1.16	0.25
	After	0.16	0.16	0.20	97.50	0.03	0.98
Position in 2004: Deputy	Before	0.07	0.10	-9.70		-1.28	0.20
	After	0.07	0.08	-2.50	74.60	-0.33	0.74
Position in 2004: Head of Department	Before	0.02	0.06	-17.50		-2.31	0.02
	After	0.02	0.02	0.30	98.60	0.04	0.97
Position in 2004: Other	Before	0.04	0.02	10.00		1.34	0.18
	After	0.04	0.03	6.60	33.50	0.80	0.42
Salary (R 1000's) in 2008 prices	Before	256.25	257.90	-4.70		-0.63	0.53
	After	256.29	257.23	-2.70	42.70	-0.34	0.73
Total enrolment	Before	0.05	0.06	-5.70		-0.76	0.45
	After	0.05	0.05	0.70	87.50	0.10	0.92
Number of teachers per 100 students	Before	0.13	0.06	23.20		3.11	0.00
	After	0.12	0.09	7.30	68.40	0.88	0.38
Urban location	Before	0.01	0.02	-0.90		-0.12	0.91
	After	0.02	0.01	2.90	-235.80	0.40	0.69
Former department:							
Independent homeland	Before	726.57	710.62	4.00		0.53	0.60
	After	721.63	728.87	-1.80	54.60	-0.23	0.82
Non-independent homeland	Before	3.88	3.86	2.50		0.33	0.74
	After	3.90	3.91	-1.50	38.50	-0.18	0.86
House of Assemblies	Before	0.49	0.48	1.30		0.17	0.87
	After	0.48	0.49	-1.30	-3.60	-0.17	0.87

House of Delegates	Before	0.09	0.15	-18.80		-2.48	0.01
	After	0.09	0.08	2.80	85.00	0.42	0.68
House of Representatives	Before	0.27	0.28	-0.60		-0.08	0.93
	After	0.28	0.31	-6.60	-953.30	-0.83	0.41
New School	Before	0.14	0.14	0.50		0.07	0.94
	After	0.15	0.15	-0.20	64.00	-0.02	0.98
Unknown	Before	0.01	0.03	-12.20		-1.61	0.11
	After	0.01	0.01	-0.60	95.50	-0.09	0.93
Province:							
Free State	Before	0.13	0.08	16.80		2.25	0.03
	After	0.13	0.12	1.40	91.70	0.16	0.87
Gauteng	Before	0.15	0.16	-4.50		-0.60	0.55
	After	0.15	0.15	0.50	89.20	0.06	0.95
KwaZulu-Natal	Before	0.12	0.20	-22.70		-3.01	0.00
	After	0.12	0.13	-2.90	87.40	-0.40	0.69
Limpopo	Before	0.19	0.11	23.70		3.18	0.00
	After	0.19	0.19	2.10	90.90	0.25	0.80
Mpumulanga	Before	0.10	0.13	-11.10		-1.47	0.14
	After	0.10	0.11	-4.50	59.50	-0.59	0.55
Northern Cape	Before	0.02	0.04	-11.10		-1.47	0.14
	After	0.02	0.02	0.60	94.40	0.10	0.92
North West	Before	0.11	0.07	14.50		1.94	0.05
	After	0.10	0.09	3.40	76.20	0.42	0.67
Western Cape	Before	0.11	0.09	8.40		1.13	0.26
	After	0.11	0.11	-1.60	81.30	-0.19	0.85
Provincial boundary change	Before	0.03	0.07	-17.20		-2.27	0.02
	After	0.03	0.02	5.20	69.70	0.92	0.36

Notes: Pstest results are only shown for group (1): the sample includes treatment schools experiencing principal turnover between 2008 and 2010 and control schools that experience principal turnover in the latter period 2010 to 2012 but not between 2008 and 2010. 'Before' estimates are identified before matching and 'after' estimates after matching.

Table A.7: Principal and teacher turnover in the teacher-principal dataset

	2004-2008	2008-2010	2010-2012
Teacher turnover	0.316	0.153	0.162
	(0.464)	(0.360)	(0.368)
Principal turnover by type:			
Mobility	0.075	0.031	0.032
	(0.264)	(0.173)	(0.176)
Attrition: retirement	0.066	0.045	0.068
	(0.248)	(0.208)	(0.251)
Attrition: non-retirement	0.079	0.036	0.046
	(0.269)	(0.187)	(0.209)
N (teachers)	251 977	295 521	313 426

Source: Persal-EMIS matched dataset. **Notes:** Estimates are obtained from the estimation sample used in the third OLS regression in Table 8. Standard deviations are in parentheses.

Table A.8: Descriptive statistics of the teacher-principal dataset

	Mean estimate	Standard deviation
Teacher characteristics		
Teacher turnover between t and t`	0.204	0.403
Age	42.421	7.999
Female	0.692	0.462
African	0.795	0.404
Indian/Asian	0.031	0.172
Coloured	0.080	0.272
White	0.095	0.293
Is a head of department	0.092	0.289
Is a deputy principal	0.025	0.154
School characteristics		
Percentage of students that are black	84.778	31.756
Total school enrolment	748.589	400.221
Number of teachers per 100 students	3.359	1.141
Average REQV of teachers in the school	13.831	0.462
School phase: Primary	0.512	0.500
School phase: Combined	0.135	0.342
School phase: Secondary	0.353	0.478
DBE wealth quintile: 1	0.244	0.429
DBE wealth quintile: 2	0.202	0.402
DBE wealth quintile: 3	0.260	0.439
DBE wealth quintile: 4	0.157	0.363
DBE wealth quintile: 5	0.137	0.344
Former department classification:		
Department of Education and Training (black)	0.256	0.436
Independent Homeland (black)	0.167	0.373
Non-independent Homeland	0.279	0.449
House of Assemblies (white)	0.094	0.291
House of Delegates (Indian/Asian)	0.030	0.170
House of Representatives (coloured)	0.084	0.277
New school	0.070	0.256
Unknown classification	0.020	0.141
N (teacher-years)	860 924	

Source: Persal-EMIS matched dataset. **Notes:** Estimates are obtained from the estimation sample used in the third OLS regression in Table 8. Province indicators are not shown.

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