Understanding school management with public data: A new measurement approach and applications*

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Abstract

Why do some students learn more in some schools than others? One consideration receiving growing attention is school management. To study this, researchers need to be able to measure school management accurately and cheaply at scale. This paper introduces a new approach to measuring management practices and outcomes using existing public data and exemplifies the methodology using two large existing datasets: PISA, covering about 15,000 schools across 65 countries, and Prova Brasil, covering nearly all public schools in Brazil across 6 waves over 10 years. Both indices show a strong, positive relationship between school management and student learning. The value of the approach is demonstrated in two applications: an extension of the Akhtari et al. (2022) analysis of political turnover and student learning, and an exploration of the mechanisms behind the key performance relationship.

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JEL codes: M5, I2, J3

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1 Introduction

Despite global calls for improvements in education, progress towards learning for all is slow. This deficit is particularly pronounced for poor children and children in low-income countries (Akmal and Pritchett, 2019; Cullen et al., 2013). But why do some students learn more in some schools than others? While there are many contributing factors at system, school, and household-level, one consideration receiving growing attention is school management—the processes and practices used by principals day-to-day as they run their schools (World Bank, 2018).

Academics and practitioners interested in this issue face a problem: how to measure school management accurately and cost-effectively at scale across schools and countries. Our paper addresses this challenge. We develop a new approach to measurement that can, in principle, be used with any existing public dataset containing items about school management, illustrating with two examples: the OECD's Programme for International Student Assessment (PISA), and the Brazilian school census survey, Prova Brasil.

The essence of our approach is to benchmark against the well-established, but expensive, World Management Survey (WMS) for schools developed by Bloom et al. (2015).[1] We show how questions from these public surveys can be classified into management practices measured in the WMS (53 PISA questions into 14 WMS management practices and 29 Prova Brasil questions into 5 WMS management practices), how the responses can be coded following the spirit of the WMS scoring rubric, and how these scores can then be built into a school management index. Our PISA-based index covers over 15,000 schools across 65 countries, and our Prova Brasil-based index covers nearly all public schools in Brazil. We supplement these management indices by using questions relating to teacher shortages, motivation and effort, and household engagement, to construct measures of school functioning, both for PISA and Prova Brasil. Our indices are well-validated and can be used by researchers interested in studying the role of management in education systems across a far wider range of countries and schools than was previously possible.[2]

We illustrate the value of these new indices in two applications. The first application demonstrates how our approach can be used to deepen understanding of variation in student learning. Akhtari et al. (2022) study the public services impact of mayoral elections in 2008 and 2012 in Brazil. Using a regression discontinuity (RD) design based on close elections, they show that political turnover within the governments that run municipal schools lowers student performance on standardised tests in both math and Portuguese. They argue that changes in political leadership trigger changes in school personnel and that this "upheaval" results in lower student learning. We use our new measurement approach to probe this issue, exploring whether political turnover

[1]The WMS methodology was originally developed to study firms (Bloom and Van Reenen, 2007). In addition to schools, it has subsequently been adapted to a range of public sector institutions, including universities (Bloom et al., 2015; McCormack et al., 2014), healthcare facilities (Bloom et al., 2015, 2019), social programs (Delfgaauw et al., 2011; McConnell et al., 2009), and the civil service (Rasul and Rogger, 2016).

[2]Wössmann (2016) provides a review of education systems research using large, cross-country surveys. Many of these studies use PISA data and could easily be extended using our PISA-based management index.

negatively impacts student test scores via school management.

Merging our Prova Brasil-based management index into the Akhtari et al. (2022) replication data, we reproduce the authors' RD analysis using the quality of management practices in the year after the mayoral election as the outcome variable, rather than student test scores. We find that the subsequent quality of management practices in municipal schools is lower in cities where the incumbent mayor narrowly loses an election than in cities where the incumbent mayor narrowly wins. This RD establishes that political turnover negatively impacts the quality of school management. Next, we pursue the hypothesis that this is due to new municipal governments making changes in school leadership. Re-running the RD analysis on the sub-sample of municipal schools in which the school principal is *not* replaced after the mayoral election, we find no evidence of a discontinuity in either the quality of school management or student test scores, implying that the RD results in the full sample are driven by "upheaval" within the school. We conclude from this that one reason why political turnover negatively impacts student learning is a deterioration in the quality of school management practices: new school principals appointed by new municipal governments fail to retain the better management practices of their predecessors and/or to implement improvements.

Our second application tackles a related question: why does school management matter for student learning? Here, we develop a theoretical framework that builds out causal pathways from school management to school functioning (how the school functions in terms of teacher recruitment, motivation and effort, and its ability to engage households) and from these intermediate outcomes into student learning. We then explore the predictions of this framework using our indices for PISA and Prova Brasil.

This theoretical framework has two building blocks. The first is an education production function in which student learning depends on teacher effort, teacher ability, and household effort. The second is the impact of management, where we assume that good management practices enable managers to: cultivate the intrinsic motivation of their staff; free up resources to offer a higher level of pay; and build a stimulating environment for students and parents. These modelling choices create three mechanisms—teacher incentives, teacher selection and household incentives—that link management to student learning.[3] The mechanisms produce behavioural responses in terms of school functioning, which give us testable predictions to take to the data. Specifically, there should be a negative relationship between school management and teacher shortages (via teacher selection) but a positive relationship between school management and teacher motivation/effort (via teacher selection and incentives). There should also be a positive relationship between school management and household engagement (via household incentives). Regressing our school management indices on the four school functioning indices (using country fixed effect specifications for PISA

[3]There is a large literature in personnel economics exploring incentives and selection in public sector organizations (see Dal Bó and Finan (2020) and Finan et al. (2017) for recent reviews). Lazear (2003), Dohmen and Falk (2010) and Leaver et al. (2021) emphasise the potential selection margin of teacher performance pay. A selection margin also features in the dynamic occupational model of Rothstein (2015) and the Roy model of Biasi (2021). In this paper, we focus on other aspects of school management (rather than performance pay) and provide an intuitive decomposition of the impact of these practices on student learning.

and year/school fixed effect specifications for Prova Brasil), we find strong support for all four of these hypotheses. The coefficient on the management index is always statistically significant with the predicted sign and, in most cases, the effect size is economically important.

These two applications illustrate that our measurement approach is cheap and easy to use at scale and can deliver new results with policy insights. Our finding that political turnover in Brazilian municipal governments negatively impacts student test scores, *inter alia*, via a school management channel highlights the importance of offering management training and support to new school heads. While empirical support for causal pathways from the quality of management practices to student test scores suggests targeted interventions in the bottom tail of poorly-managed public schools that could yield significant learning gains.

2 How to measure management in schools?

Until the early 2000s, management was typically viewed as an un-measurable productivity shifter, relegated to the residual in performance regressions (Bloom and Van Reenen, 2007). Since then, improvements in survey methodology and data access have allowed for substantial advances in measurement. Currently, the leading approach uses a dedicated survey—the World Management Survey (WMS)—to measure establishments' adoption of structured management practices. While the WMS offers uniquely rich information about management practices, it costs approximately USD400 per interview and takes about 4 months to conduct a single country wave. In view of these costs, it may not be well-suited to every context (Scur et al., 2021).

We propose an alternative approach that can, in principle, be used with any existing public dataset containing information on management practices. We start with the WMS as a benchmark, and identify the set of questions in the public survey that elicit information on the management practices that are also measured in the WMS.[4] We then code answers in line with the WMS scoring methodology—that is, more structured practices are assigned higher scores—and build a set of indices from these individual question scores. We use this approach to build a management index that we then benchmark to the WMS, and also to build new indices that measure principal perceptions of teacher shortages, teacher motivation, teacher effort and household effort. The latter are new indices and thus have no equivalent in the WMS. We illustrate this approach with questionnaires and data from both a global dataset, PISA, and a national dataset, Prova Brasil. Since Brazil and several other PISA countries are part of the Bloom et al. (2015) sample, we can compare the (within-country) distribution of each index with the corresponding (within-country) distribution of the WMS index. As we show below, both indices are well-validated and can therefore

[4] Our approach follows the spirit of the re-casting of the original phone-based World Management Survey into the US Census Management and Organizational Practices Survey (MOPS) administered to the population of US manufacturing establishments as a self-reported questionnaire (Bloom et al., 2019). The MOPS has been replicated in a number of other countries. Its questions follow the WMS topics and look to measure similar practices, but with self-reported answers.

be used by researchers interested in studying management across a wider range of countries and schools than was previously possible.

2.1 Overview of the World Management Survey methodology

The WMS was developed to measure adoption of structured management best practices in establishments across a range of countries and industries.[5] The rigorous data collection is based on double-blind, semi-structured interviews conducted by highly-trained analysts and monitored by supervisors experienced on the survey methodology. Following its successful implementation in the private sector, the WMS was subsequently extended to public sector organizations (Bloom et al., 2015, 2019); in this paper, we focus on the latter.

The public-sector WMS covers 20 topics across two main areas: *operations management* and *people management*. Broadly speaking, operations management in schools covers practices including: whether the school has standardization of instructional processes across classrooms while allowing for within-classroom personalization of learning; whether and how the school uses assessments and data; and whether and how the school sets and uses targets and keeps track of progress. People management covers practices in handling good and bad performance, measuring whether there is a systematic approach to identifying good and bad performance, rewarding school teachers proportionately, dealing with underperformers, and promoting and retaining good performers.

For each WMS topic, there is a scoring grid ranging from 1 to 5, which serves as a guide to evaluate answers to questions during the semi-structured interviews. A score between 1 to 2 refers to a school with practically no structured management practices or very weak management practices implemented; a score between 2 to 3 refers to a school with some informal practices implemented, but these practices consist mostly of a reactive approach to managing the school; a score between 3 to 4 refers to a school where a good, formal management process is in place (though not yet consistently enough) and these practices consist mostly of a proactive approach to managing a school; and a score between 4 to 5 refers to well-defined, strong processes in place which are often seen as best practices in education. The overall management index, which measures the level of adoption of structured management best practices, is simply the average of the scores for these 20 topics. The practices measured by the survey seem to matter: Bloom et al. (2015) show that their school management score is strongly positively correlated with school-level student outcomes across 6 countries (Brazil, Canada, India, Sweden, UK and US). They find a strong positive correlation for these countries: moving from the bottom to the top quartile of management is associated with a large increase in student learning outcomes, equivalent to approximately 0.4 standard deviations.

[5] See Bloom and Van Reenen (2007) for the survey's inception and Scur et al. (2021) for a recent review with a focus on policy implications.

2.2 A new approach using existing public datasets

We now describe our approach, illustrating with the examples of PISA and Prova Brasil. Full details to enable replication with these (and alternative) data sources are provided in the Online Appendix.

2.2.1 Construction of indices

Alongside its student proficiency tests, PISA also runs a school principal survey. This survey includes a wide-range of questions that measure the management practices used within the school, as well as the principal's assessment of how the school is functioning. We focus on the 2012 survey wave across 65 countries since it contains a particularly rich set of questions, especially relating to people management.[6] We identify 53 questions that fall under one of the WMS topics and assign scores for each question following the spirit of the scoring grid of the WMS and the US Census Management and Organizational Practices Survey (MOPS). This gives us our *management* index.[7] Next, we use the questions relating to school functioning to construct four further indices. Here, we identify: 4 questions that ask whether the school's capacity to provide instruction is hindered by a shortage of teachers to create a *teacher shortage* index; 14 questions that ask about teacher morale and work attitudes to create a *teacher motivation* index; 3 questions that measure teacher absenteeism and punctuality to create a *teacher effort* index; and 19 questions that ask about student commitment and parental involvement to create a *household effort* index.

Prova Brasil is a national census-like survey of school principals, teachers, and students that has near universal coverage in Brazil's public education sector across multiple years.[8] We focus on the six biennial survey waves running from 2007-2017. We follow the steps outlined above for PISA to create five Prova Brasil-based indices. To construct the management index, we classify 29 questions (19 from the school principal questionnaire and 10 from the teacher questionnaire) into 5 WMS topics, and code responses following the same rubric as for PISA. The questions that we use to construct the teacher shortage, teacher motivation, teacher effort and household effort indices are drawn from these same questionnaires, as described in the Online Appendix.

[6] We discuss the possibility of using the 2015 and later survey waves in the Online Appendix.

[7] In 2012, the PISA dataset included a PISA-built 'leadership and management' measure. This is distinctively different from ours, as it was based off a section of the questionnaire that was titled 'management' and contained only a small subset of questions. This index fails to take advantage of the full questionnaire and the information available elsewhere that also speaks to managerial practices used in the schools. More pertinently, PISA's measure does not compare well to the (empirically robust) management index derived from the World Management Survey (see Liberto et al. (2015)).

[8] Many countries conduct similar national surveys in addition to administering standardized tests across grades. Latin America is particularly prolific: in addition to Brazil's Prova Brasil, Colombia's SABER, Chile's SIMCE, and Peru's ECE are all available to researchers.

2.2.2 Pros and cons

The public datasets described above have different strengths: PISA provides a global view and includes a sample of both public and private schools, while Prova Brasil provides far greater coverage of the public sector and contains school identifiers to enable matching with external datasets (as we will exploit below). Both, however, share the downside that the data are self-reported.

One concern with self-reported data is measurement equivalence. To address potential measurement error driven by cross-cultural understandings and norms in answering questions, we standardize our PISA-based management index *within countries*. This has an important implication: since all 65 countries have a mean score of zero, our index cannot be used to construct cross-country rankings of school management. Instead, the value of our PISA-based index lies in enabling academics and practitioners to study the (within-country) relationship between management and other variables for a far wider set of countries than was previously possible. This issue of cross-cultural norms is less of a concern for our Prova Brasil-based index since it is, by construction, within-country.

Another concern with self-reported data is that it is difficult to assess whether respondents are being accurate and truthful. The WMS methodology includes strategies to elicit truthful information during the interview (such as always asking open-ended questions and asking for examples), but these are not available in self-reported questionnaires. As we describe in the section below, we address this issue by focusing on the topics that have a direct equivalent in the WMS to allow for a clear validation process.

2.2.3 Validation of new management indices

We conduct two validation exercises for our new management indices: the distribution of scores, and the correlation between our new indices and student learning outcomes. For PISA, we compare the distribution of scores and the performance correlations for the common (WMS and PISA) countries as there are no school identifiers available. For Prova Brasil, we use school identifiers to match schools directly and hence provide a one-to-one comparison of the index values. We describe these exercises for PISA and Prova Brasil in turn.

PISA Figure 1a reports the distributions of our PISA-based management index (solid red plot) alongside the distribution of the WMS management index (dashed black plot), for all countries appearing in both datasets. The PISA and WMS distributions are reassuringly similar. The Kolmogorov-Smirnov test for equality of distributions rejects in only one of the 9 cases, Italy, where the PISA-index is somewhat more dispersed.

In Figure 1b we conduct a basic check of the correlation between our management index and a key outcome variable of interest: student learning outcomes. For each country, we separate schools into quartiles of the management measure and show, for each quartile, the average PISA test scores for math, reading and science (in deviations from the global mean). The graph includes all students and schools across the 65 countries available in the 2012 PISA dataset. This figure shows that students in schools in the bottom quartile of (within-country) management score are, on average, performing about 6 points lower than the PISA global mean. In contrast, students in schools in the top quartile of (within-country) management score are, on average, performing about 5.5 points higher than the PISA global mean. To put this into context, 40 PISA points are the equivalent of an average year of learning.[9] The range of our results mirror how much, for example, the UK average science score changed between 2009 and 2015 (5 points), and how much the Brazilian average science score decreased over the same period (4 points).

In Table 1 we formalize these relationships by reporting the average correlations between our PISA-based management index and student test scores in reading (Columns 1 to 3), math (Columns 4 to 6) and science (Columns 7 to 9).[10] We report the standard errors in parentheses and p-values in square brackets. The standard errors are clustered at the school level and use the appropriate survey weights.[11] In these PISA specifications, we include country fixed effects, and successively introduce school controls (a dummy for private school, dummies for school location, student-teacher ratio, log of the number of students, ratio of computers connected to the web used as a proxy for school resources, and share of government funding relative to total funding the school receives) and then student controls (gender, grade, socio-economic status and immigration status). The top panel includes all schools, and the bottome panel just schools in Brazil for comparison with the Prova Brasil data. Sample sizes (of the number of students and schools) and the R-squared are reported within each panel.

Column (1) shows the raw relationship between the PISA-based school management index and student performance, only controlling for country fixed effects. The coefficient for all 65 countries is 3.785 points, and for Brazil is 7.483 points. PISA is standardized across years and countries such that the mean is 500 and the standard deviation is 100. As 40 points on the PISA scale is equivalent to one year of learning, the correlation in Column (1) in the top panel indicates a one standard deviation increase on our management index is associated with higher PISA reading test score points equivalent to about one month's worth of learning. For Brazil, this is equivalent to almost two months. Columns (4) and (7) report similar relationships for math and science scores. Columns (2), (5) and (8) include school controls, which absorb some of the variation, and Columns (3), (6) and (9) report the fully-specified regression with student controls. Including school and student controls substantially reduces most of the coefficients, but (in the top panel, for all schools) the correlations remain significant and economically important.

Prova Brasil Unlike PISA, the Prova Brasil dataset includes school identifiers that allow for a one-to-one match with the schools surveyed for the WMS. We are able to match 267 schools in the

[9]See OECD (2019), "How PISA results are reported: What is a PISA score?", in PISA 2018 Results (Volume I): What Students Know and Can Do, OECD Publishing, Paris, https://doi.org/10.1787/35665b60-en.

[10]For these estimates, we use the student-level PISA 2012 dataset and the OECD's `repest` Stata command, which uses the five available test score plausible values for each student and subject.

[11]See Jerrim et al. (2017) for a thorough review of how to best use PISA scores and survey weights.

2013 waves of both surveys. Figure 2a shows a binned scatter plot of the WMS management score against the standardized Prova Brasil-based management score for these 267 schools. Each circle represents the average of 5 schools. There is a positive and significant correlation of 0.12, suggesting reasonable internal validation of the Prova Brasil index. In Figure 2b, we show the average scores of students for math and language (here, Portuguese) across quartiles of management score, focusing on Grade 9 in 2013 to maintain comparability with Figure 1b for PISA. This exercise confirms that the pattern we see across the world in the PISA data also holds in Brazil, with this independently collected data.

In Table 2 we formalize these relationships by reporting the average correlations between our Prova Brasil-based management index and student scores in Portuguese (Columns 1 to 5) and math (Columns 6 to 10). We use the student-level dataset between 2007 and 2017 (6 rounds), for both grades 5 and 9, and run standard OLS regressions clustering standard errors at the school level. We use the standardized management index and standardized scores for Portuguese and math. Columns (1) and (2) add year and then state fixed effects. Column (3) adds the set of controls that matches those found in the PISA dataset (school controls: dummies for school location, student-teacher ratio, log of the number of students, and dummies for a computer lab and for internet access; student controls: gender, socio-economic status, and race). Column (4) includes additional controls available in the Prova Brasil data (school controls: dummies for principal age, education, race, and other employment, share of male teachers, white teachers, and teachers holding a college degree, average teacher tenure; student control: dummies for mother's education). Finally, Column (5) adds school fixed effects (and drops state fixed effects). The fully specified regression suggests that one standard deviation higher management score is associated with a 0.02 standard deviation higher score in both Portuguese and Math.

We have shown that both our PISA-based and Prova Brasil-based management indices are well-validated, both in terms of 'fit' to the WMS distribution (for overlapping countries or schools) and their correlation with student learning outcomes. In the next section, we illustrate how these new indices can be used in two applications.

3 Applications

There are myriad uses of these new indices. In this section, we provide two applications, exploring the relationship between: political turnover and the quality of school management practices, and then school management practices, school functioning, and student learning.

3.1 Political turnover and the quality of school management

Akhtari et al. (2022) study mayoral elections in 2008 and 2012 in Brazil and find that when cities get a new government there is an "upheaval" in the municipal bureaucracy, including school principals. They note that there is an "increase in the replacement rate of personnel in schools controlled by the municipal government" and that this is accompanied by "test scores that are 0.05 to 0.08 standard deviations lower. In contrast, turnover of the mayor's party does not impact local (non-municipal) schools." They argue that changes in political leadership trigger changes in school personnel (both school principals and teachers) which, in turn, negatively affect test scores. We use our Prova Brasil-based management index to further explore this claim. Specifically, we ask: does political turnover negatively impact student test scores through a school management channel?

To answer this question, we merge our Prova Brasil management index into the Akhtari et al. (2022) replication dataset. Figure 3 replicates the main regression discontinuity design graphs but with the quality of management practices as the outcome variable instead of student test scores.[12] In Panel (a), we plot the incumbent vote margin in the 2008 and 2012 mayoral elections against the subsequent quality of management practices (in 2009 and 2013) in schools that are run by the municipal government. There is a clear discontinuity; the subsequent quality of management practices in municipal schools is *lower* in cities where the incumbent mayor narrowly loses an election than in cities where the incumbent mayor narrowly wins. Panel (b) shows that this discontinuity is not present in non-municipal schools run by the local (rather than municipal) government. This is an important placebo test since these schools could not have been subject to "upheaval" associated with political turnover.

Akhtari et al. (2022) argue that changes in political leadership trigger changes in school personnel, and that this translates into lower test scores. But what if school principals are not replaced? Then we should see no post-election decline in management scores and (hence) a smaller impact on test scores. Figure 3 Panel (c) confirms that, for the sub-sample of municipal schools where the mayor (new or otherwise) did not replace the school principal after the election, there is no discontinuity. The subsequent quality of management practices in municipal schools is the same in cities where the incumbent narrowly loses an election and *the incoming mayor does not replace the school principal* as in cities where the incumbent narrowly wins an election and does not replace the school principal. In the Appendix A we also confirm that, for this sub-sample of municipal schools with no school principal replacement, there is no statistically significant discontinuity in test scores.

Table 3 shows the associated regression analysis. The dependent variable is the quality of school management practices in the year after the election. Following Akhtari et al. (2022), the running variable of the RD is the incumbent vote margin (computed as the vote share of the incumbent political party minus the vote share of the incumbent party's strongest opponent). The treatment variable is $\mathbf{1}\left\{IncumbVoteMargin < 0\right\}$, which is an indicator variable equal to one if the incumbent political party lost the election (and hence the municipality experienced political party turnover) and zero otherwise.[13] Panel A reports results for municipal schools, Panel B results for

[12] We reproduce the original RD graphs from Akhtari et al. (2022), with student test scores as the outcome variable, in the Appendix for ease of comparison.

[13] All specifications include the quality of school management practices in the year prior to the election as a baseline control, as well as an interaction between the running variable and the treatment variable.

non-municipal schools, and Panel C results for the sub-sample of schools with no school principal replacement (the principal reports being in post in their current school for at least two years on the Prova Brasil school principal questionnaire). Columns (1) and (2) use the optimal bandwidth, first without controls and then including the same controls as in Akhtari et al. (2022). Columns (3)-(6) repeat this exercise using the bandwidths in Akhtari et al. (2022). In Panel A, in every specification, the coefficient on the dummy variable indicating mayoral turnover is negative and strongly significant. The management index is between 2 and 3 percentage points lower in a school that is controlled by a newly formed municipal government than in a school that is controlled by a government that has not been subject to such upheaval. By contrast, in Panels B and C, the coefficient on the dummy variable indicating mayoral turnover is positive and never significant.

The results in Figure 3 and Table 3 show a simple, but powerful, application of our measurement approach. We took existing public data from Prova Brasil and linked them to data in the American Economic Review replication archives. With no further survey costs, we were able to extend the analysis in Akhtari et al. (2022) to explore further mechanisms around how political turnover affects student learning outcomes. Our findings suggest that one channel is a deterioration in the quality of school management practices: new school principals appointed by new municipal governments fail to retain the better management practices of their predecessors and/or to implement improvements. This highlights the potential importance of offering management training and support to new school heads.

3.2 School management practices, school functioning, and student learning

It is now well established that good management practices in schools are associated with better student learning outcomes (c.f. the disussion in Section 2). In this second application, we use our new management indices, together with our indices of school functioning, to explore why this positive relationship exists so consistently across contexts. To do this, we develop a simple theoretical framework in which good management practices drive student learning by improving school functioning, and then take the predictions of this model to the PISA and Prova Brasil data.

The framework focuses on teachers. Our aim is not to provide a theoretical contribution *per se*, but rather to formalize intuitions around teacher incentive and selection mechanisms and their relationship to management practices and student performance. We take wider system-level factors—in particular hiring and firing autonomy, admissions autonomy and competition between schools—as given and assume that teachers and students make choices within the confines of this environment.

Real-world education systems are diverse, particularly in terms of the type of private sector offerings. In some contexts, private schools target affluent households, and jobs in private schools are seen as more attractive than jobs in public schools, typically providing some form of performance-based compensation. In other contexts, there has been a growth of 'low-cost private schools' that deliberately cater for the lower end of the income distribution and, in these settings, jobs in the public sector typically confer significant rents relative to the private sector. In view of this diversity, we restrict our analysis to the sector that attends to the largest share of students across countries, namely public schools.

3.2.1 Theoretical framework

We focus on a teacher who must decide whether to accept a job offer in her assigned public school, or decline it and apply to a private school or the outside sector.

The teacher is risk neutral and cares about her compensation w and effort e. When working in the education sector, the teacher's preferences are $w - (e^2 - c\ e)$. The parameter c captures her *intrinsic motivation*. This is because for $e < c/2$ she derives a marginal benefit from exerting an extra unit of effort in teaching; it is only when $e > c/2$ that effort costs kick in. We assume that $c = \tau + \Delta$. The first component τ denotes the teacher's baseline intrinsic motivation. This can be thought of as the realization of a random variable. The teacher observes this realization perfectly, while (at the time of hiring) employers observe nothing. The second component Δ is a motivational increment that, as we describe below, is determined by the management practices in the teacher's chosen school. When working in the other sector, the teacher's preferences are simply $w - e^2$; intrinsic motivation plays no role. We abstract from student heterogeneity and focus on a representative household (student plus parents). This household cares only about its effort level a, and has preferences $-(a^2 - \gamma\ a)$. The parameter γ is a motivational increment that is also determined by management practices.

Let y_1 denote a representative student's learning outcome in a school that hires the teacher, and y_0 denote a representative student's learning outcome in a school that does not hire the teacher. To the extent that teachers contribute to learning, one would expect $y_1 > y_0$. We capture this in a simple way by assuming $y_1 = \theta e + a + \varepsilon$ and $y_0 = a + \varepsilon$. If the teacher is not hired by a school but instead chooses to work in the outside sector, her performance is $z = \theta e + \varepsilon$. The component θ denotes the teacher's *ability.* This can also be thought of as the realization of a random variable, assumed to be independent of τ. The teacher observes this realization perfectly, while (at the time of hiring) employers observe nothing. Draws of the error term ε are independent across employments. We assume throughout that ε is mean zero and distributed $U\left[\underline{\varepsilon}, \overline{\varepsilon}\right]$.

Public schools offer a wage of G. Private schools offer a base wage of W plus a bonus B if the teacher's performance exceeds a threshold $\bar{y}$. The outside sector offers a low base wage (normalized to zero) and a bonus β if performance exceeds a threshold $\bar{z}$.

We assume that management has three effects. The first relates to teacher motivation: good management practices enable managers to cultivate the intrinsic motivation of their staff, increasing Δ. The second relates to compensation: good management practices free up resources and enable managers to offer a higher level of pay. The third relates to household effort: good management practices help to create a stimulating environment for students and parents, increasing γ. Our interest lies in establishing how these three effects translate into student learning. We do not model the government's assignment rule, or the school principal's choice of management practices.

For simplicity, we classify schools as either high or low management. In a high management school, Δ, base pay, and γ are all higher than in a low management school. Below is a summary of this description of the model.

1. Nature chooses the teacher's two-dimensional type. This realization (τ, θ) is observed by the teacher but not by employers.

2. Employers announce management practices and compensation schemes.

3. The teacher is assigned (by government) to a public school and decides whether to accept this post or decline it and apply either to a private school or the outside sector.

4. Having made an occupational choice, the teacher chooses an effort level. Simultaneously, if the teacher is in the education sector, households choose effort levels.

5. A performance metric is realized. The teacher is rewarded in accordance with the compensation scheme announced at Stage 2.

3.3 Mechanisms

We use this framework to show how public schools with good management can produce better student outcomes. Specifically, we compare outcomes in a high management public school with outcomes in a low management public school, assuming both compete with a high management private school and the outside sector. The index $i = L, H$ denotes the quality of management in these public schools.

Public school i hires its assigned teacher if, given her (θ, τ) type, she expects to receive a higher payoff from teaching in this school compared to a high management private school or working in the outside sector. We use the notation $\mathcal{T}^i$ to denote the set of (θ, τ) types that can be hired to this school. The expected learning outcome of a representative student (*ex ante*, prior to occupational and effort choices) is

$$\mathrm{E}\left[y^i\right] = \mathrm{E}\left[y_1^i \cdot 1_{\{(\theta,\tau)\in\mathcal{T}^i\}}\right] + \mathrm{E}\left[y_0^i \cdot 1_{\{[(\theta,\tau)\notin\mathcal{T}^i\}}\right],$$

where $1_{\{(\theta,\tau)\in\mathcal{T}^i\}}$ and $1_{\{[(\theta,\tau)\notin\mathcal{T}^i\}}$ are indicator functions for the hiring and not hiring events. In keeping with the empirical application, we will refer to $\mathrm{E}\left[y^i\right]$ as the expected test score in school i.

The difference in expected test scores between high and low management public schools can be written as

$$\mathrm{E}\left[y^H\right] - \mathrm{E}\left[y^L\right] = \mathrm{E}\left[y_1^H \cdot 1_{\{(\theta,\tau)\in\mathcal{T}^H\}}\right] - \mathrm{E}\left[y_1^L \cdot 1_{(\theta,\tau)\in\mathcal{T}^L\}}\right] + \mathrm{E}\left[y_0^H \cdot 1_{\{(\theta,\tau)\notin\mathcal{T}^H\}}\right] - \mathrm{E}\left[y_0^L \cdot 1_{\{(\theta,\tau,)\notin\mathcal{T}^L\}}\right].$$

In the Appendix, we derive teacher and household effort in high and low management public schools. These optimal choices are $e^i = \frac{\tau+\Delta^i}{2}$ and $a^i = \frac{\gamma^i}{2}$ for $i = L, H$. Substituting for these expressions, we can decompose the difference in expected test scores as

$$\mathrm{E}\left[y^H\right] - \mathrm{E}\left[y^L\right] = \underbrace{\mathrm{E}\left[\theta\left(\frac{\Delta^H - \Delta^L}{2}\right)\cdot 1_{\{(\theta,\tau)\in\mathcal{T}^H\}}\right]}_{\text{teacher incentives}} + \underbrace{\mathrm{E}\left[\theta\left(\frac{\tau + \Delta^L}{2}\right)\cdot\left(1_{\{(\theta,\tau)\in\mathcal{T}^H\}} - 1_{\{(\theta,\tau)\in\mathcal{T}^L\}}\right)\right]}_{\text{teacher selection}} + \underbrace{\frac{\gamma^H - \gamma^L}{2}}_{\text{household incentives}}. \quad (1)$$

The first term on the RHS of equation (1) is what we term the *teacher incentive effect* of good management. Here, we compare the expected teacher contribution to the test score outcome in a high management public school, in the event that the teacher is hired to such a school, against the expected teacher contribution in a low management public school, in the counterfactual event that the teacher is hired to a high management public school. In this way, we hold the set of (θ, τ) types fixed and just consider how the incentive environment for the teacher contributes to test scores. This expression shows that the test score is higher in a high management public school, in part, because good management practices increase the intrinsic motivation of any given (θ, τ) type of teacher, who then exerts more effort than she would in a low management public school.

The second term in equation (1) captures what we term the *teacher selection effect* of good management practices. Here, we compare the expected teacher contribution to the test score outcome in a low management public school, in the event that the teacher is hired to such a school, against the expected teacher contribution in a low management public school, in the counterfactual event that the teacher is hired to a high management school. The test score is higher in a high management public school, in part, because good management practices encourage better (θ, τ) types to select in, and these types exert more effort and are of greater ability than would be the case in a low management school.

Figure 4 provides an illustration of this teacher selection effect.[14] The unshaded area in the top panel depicts the set of (θ, τ) types that are hired by a high management public school, while the unshaded area in the bottom panel depicts the set of (θ, τ) types that are hired by a low management public school. Note that the high management public school hires *more* types than the low management public school: the unshaded area is larger in the top panel relative to the bottom panel. It also hires *better* types: average θ and average τ, shown by the (x, y) coordinates of the blue dot, are higher relative to the bottom panel.[15] The third term in equation (1) captures

[14] Details of the construction of Figure 4 are provided in the Appendix. Bonus pay in the private education sector and in the outside sector is assumed to be higher than the public sector wage. In the Appendix, we also consider the case where public sector pay exceeds pay in the private education sector (so called 'low-cost' private schools).

[15] As we discuss in the Appendix, the prediction that the high management school hires better θ types is sensitive to parameter assumptions and, for instance, does not hold in our numerical example with 'low-cost' private schools.

what we term the *household incentive effect* of good management practices. We see from this expression that the test score is higher in a high management public school, in part, because good management practices increase the motivation of parents and students who then exert more effort than they would in a low management public school.

3.4 Predictions and evidence from PISA and Prova Brasil

Our theoretical framework proposes three mechanisms—teacher incentives, teacher selection and household incentives—that could explain the positive correlation between management scores and student learning outcomes apparent in the WMS, PISA and Prova Brasil data. If these mechanisms are correct, then we should see behavioural responses in school functioning. Below, we set out these predictions and explore whether they hold empirically using our PISA and Prova Brasil-based indices.

Teacher shortages The theoretical framework predicts that the probability of hiring the teacher in a high management public school is higher than the probability of hiring the teacher in a low management public school (via teacher selection). Table 4 explores this empirically for the PISA and Prova Brasil data for public schools. In Column (1) and (2), the dependent variable is the teacher shortage index and the explanatory variable of interest is the school management index. In both panels, these indices are standardised within-country. In Panel A, for PISA, Column (1) includes only country fixed effects. Column (2) adds school and student controls. Consistent with the theoretical prediction, there is a negative relationship: a one standard deviation increase in the school management index is associated with a 0.06 standard deviation decrease in the teacher shortage index. In Panel B, for Prova Brasil, Column (1) includes only year effects. Column (2) adds PISA-like controls, additional Prova Brasil controls, and school fixed effects. Again, there is a negative relationship: a one standard deviation increase in the school management index is associated with a 0.09 standard deviation decrease in the teacher shortage index.

Teacher motivation The theoretical framework predicts that the expected intrinsic motivation of a teacher hired to a high management public school is higher than the expected intrinsic motivation of a teacher hired to a low management public school (via teacher selection), at least in settings without low-cost private schools. Column (3) and (4) in Table 4 report regression coefficients on the school management index with the teacher motivation index as the dependent variable. As predicted, there is a positive relationship in both panels. In Panel A, for PISA, a one standard deviation increase in the school management index is associated with a 0.33 standard deviation increase in the teacher motivation index. In Panel B, for Prova Brasil, a one standard deviation increase in the school management index is associated with a 0.22 standard deviation increase in the teacher motivation index.

Teacher effort The prediction here is that the expected effort level of a teacher hired to a high management public school is higher than the expected effort level of a teacher hired to a low management public school (via teacher selection and incentives). Column (5) and (6) in Table 4 report regression coefficients on the school management index with the teacher effort index as the dependent variable. Again, there is a positive relationship. In Panel A, for PISA, a one standard deviation increase in the school management index is associated with a 0.07 standard deviation increase in the teacher effort index. In Panel B, for Prova Brasil, a one standard deviation increase in the school management index is associated with a 0.06 standard deviation increase in the teacher effort index.

Household effort The final prediction is that expected household effort in a high management public school is higher than expected household effort in a low management public school (via household incentives). Column (7) and (8) in Table 4 report regression coefficients on the school management index with the household effort index as the dependent variable. Once again there is a positive relationship. In Panel A, for PISA, a one standard deviation increase in the school management index is associated with a 0.28 standard deviation increase in the household effort index. In Panel B, for Prova Brasil, a one standard deviation increase in the school management index is associated with a 0.06 standard deviation increase in the household effort index.

These findings suggest that the causal pathways from the quality of management practices to student learning posited in the theory—selection and incentives within and beyond the school—are empirically plausible across a wide range of countries. Given such pathways, policymakers should feel reassured that interventions targeting the quality of management will bring dividends in terms of student learning. The within-country variation in the quality of management practices apparent in our data indicates that there is substantial scope to drive up the bottom tail in government-run schools. People management practices such as performance pay, while common in the private sector, may not be possible in public schools. But there would seem to be fewer barriers to conducting assessments to judge teacher effectiveness, and letting such appraisals lead to changes in public recognition, opportunities for professional development, likelihood of career advancement, and/or greater responsibilities. Our analysis also suggests a role for policymakers to encourage principals in public schools with weak operations management to follow best practice. Specific areas include processes that facilitate: personalization of learning; dialogue among staff, students and parents focused on continuous improvement; and collection and use of student assessment data.

4 Conclusion

Policy makers have begun to set ambitious, universal learning goals. To achieve these targets it will be necessary to understand why, within and across current education systems, some students are learning more in some schools than others. Although there are likely many factors at work, at least part of this variation in learning stems from how well managed schools are. To explore this issue and develop policy, academics and practitioners need to be able to measure school management accurately and cost-effectively at scale across schools and countries, and be in a position to postulate mechanisms behind any observed relationship between school management and student learning outcomes.

The key contribution of this paper is the development of new approaches to measurement at scale, using existing public data sources to facilitate further work – in both academic research and policy spaces. It is striking that both of our new school management indices confirm the strong positive correlation of school management scores with school-level student outcomes first reported in Bloom et al. (2015). It also provides two additional contributions in demonstrating two potential applications of this new methodology: the first showcases the opportunities for extension of current work, exploring the role of management practices as a potential mechanisms in important published papers. In extending Akhtari et al. (2022), we show that a key reason behind the drop in student learning following a change in school leadership is likely linked to the destruction of organizational capital: when principals leave, *actual practices* at the school also cease to be carried out. An important implication from this finding is that actions that preserve *formal practices* could mitigate the "upheaval" and minimize disruption to student learning.

The second additional contribution provides a new theoretical framework of *how* management structures might impact student learning, formalizing a set of potential mechanisms and taking these to the new data to test the validity of this model. We show empirical support for three mechanisms: teacher incentives, teacher selection and household incentives. Researchers and policy-makers with access to more granular data on school employees and broader labor markets could match their data to our new indices and further characterize these mechanisms.

In all, improvements to management practices present an untapped opportunity for large improvements in educational outcomes, particularly in cash-strapped regions of the world. One possible way of effecting change is to support existing school principals to introduce stronger people and operations management practices, for instance via training and resources that could mitigate disruptive changes in leadership. Fryer (2014, 2017) reports positive results from RCTs injecting best management practices into U.S. public schools. Another possibility is to contract new managers into existing public schools. Romero et al. (ming) report mixed results from an RCT in Liberia in which (non-governmental) management teams were contracted to run public schools: contracting-in raised learning outcomes, but new managers spent more and may have engaged in strategic behaviour. Investigating *how* to implement strong people and operations management practices to drive learning for all is an important area for future research.

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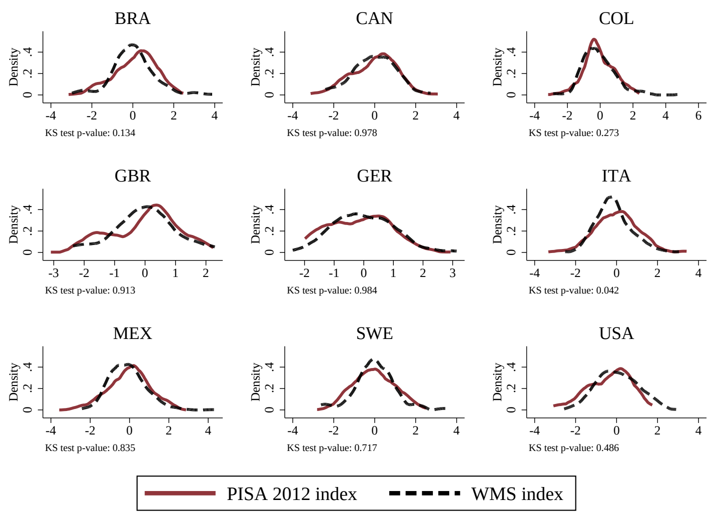
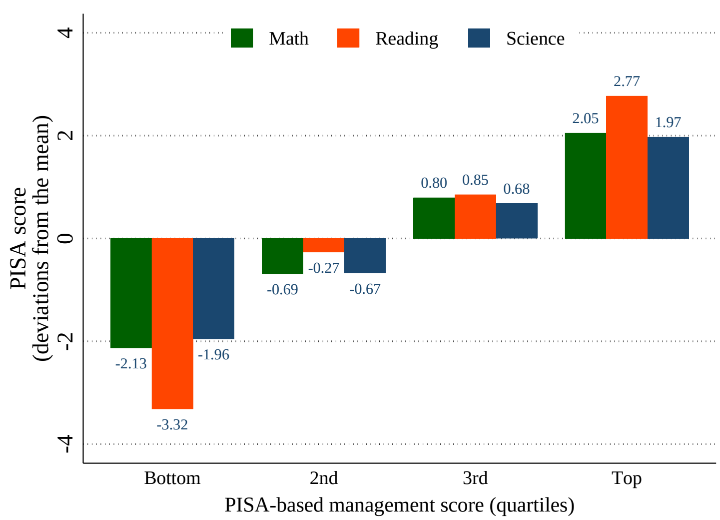
Figures and Tables

Figure 1: Index validation, PISA

(a) Distribution of overall management scores



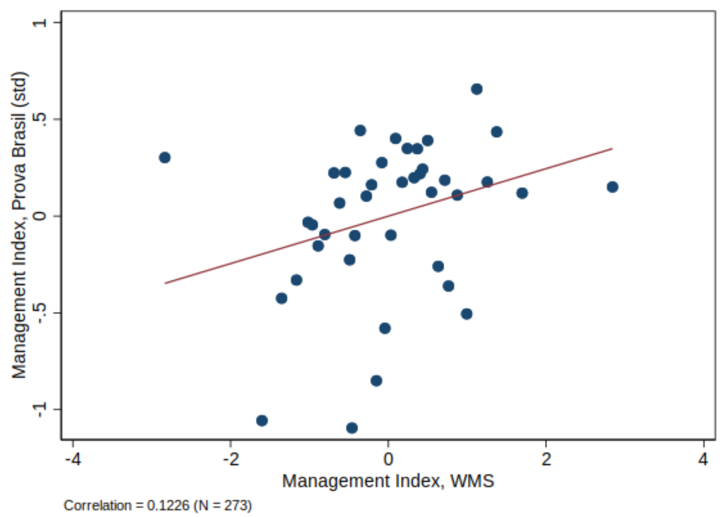
(b) Management and student learning outcomes



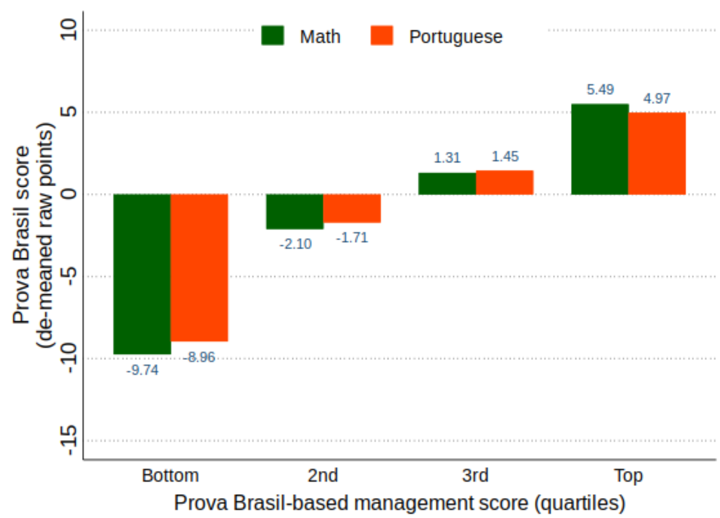
Note: Panel(a): Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at www.worldmanagementsurvey.org. PISA 2012 management index standardized within country. WMS management index also standardized within countries. Kernel density curves estimated using WMS sampling weights (calculated as the inverse probability of being interview on log of number of students, public status, and population density by state, province, or NUTS 2 region as a measure of location) for the WMS data and school final weights for the PISA data. Samples include both public and private secondary schools for both datasets, with the exception of Colombia where WMS data is only available for public primary schools. Number of observations are as follows (WMS/PISA): Brazil = 510/561, Canada = 129/770, Colombia = 467/268, Great Britain = 89/422, Germany = 102/158, Italy = 284/926, Mexico = 157/1,327, Sweden = 85/179, United States = 263/136. Panel (b): Number of observations: 15,196 schools from 65 countries available in PISA 2012 data. Student outcomes are estimated using five plausible values and collapsed at the school level using PISAs senate weights. Quartiles of the management index are built at the country level. Test scores are presented as deviations from the subject-specific global mean.

Figure 2: Index validation, Prova Brasil

(a) School-specific score correlation, std



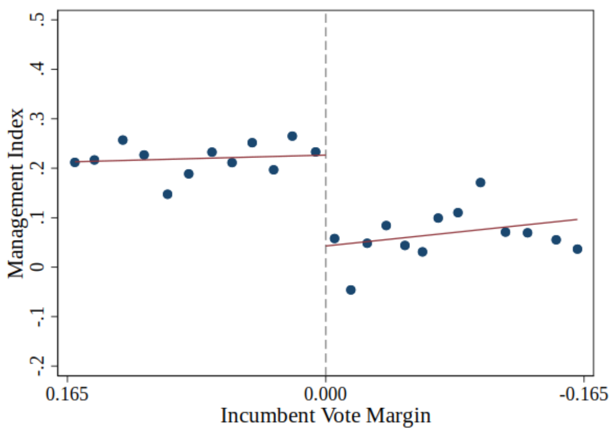
(b) Management and test scores, raw scores



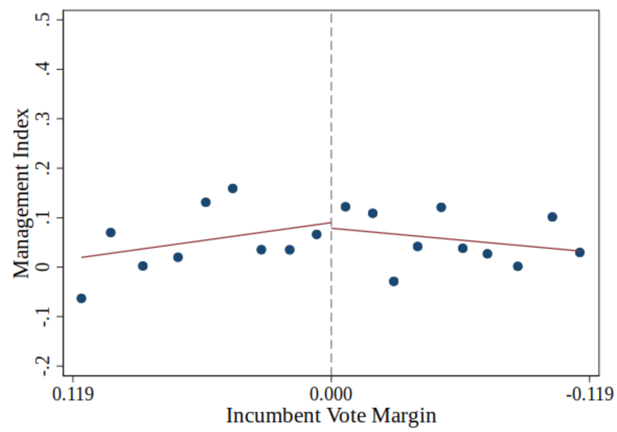
Note: Panel(a): This graph is a binned scatter plot using 40 quantiles. The sample contains schools which have data for both Prova Brasil and WMS in 2013. PB-based management index is standardized within this subsample. WMS management index is also standardized within this subsample. Panel(b): Number of observations: 33,344 schools in PB dataset for which we have data in 2013. Sample restricted to schools offering grade 9. Quartiles of the management index are built from this subsample. Test scores are presented as deviations from the subject-specific mean, also within this subsample.

Figure 3: Political turnover and school management scores

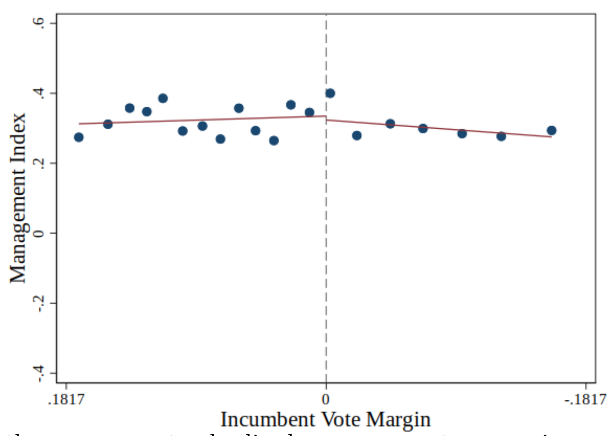
(a) Municipal schools: all



(b) Non-municipal schools (placebo): all

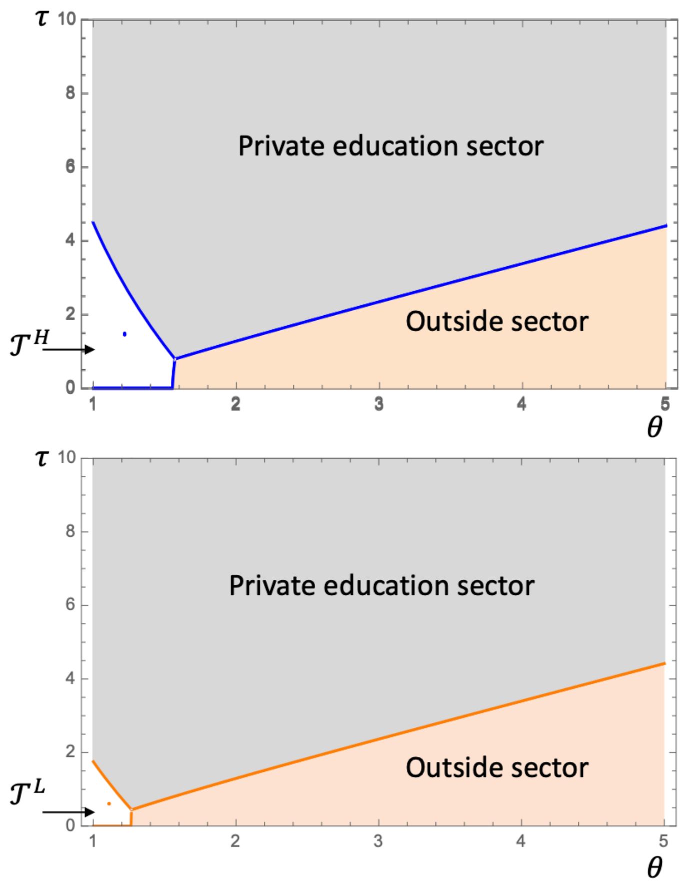


(c) Municipal schools: with no post-election school principal replacement



Note: Panel (a) shows the average standardized management score in municipal schools by bins of $IncumbVoteMargin$, controlling for the standardized management score in the baseline year (year before the election). Municipalities with $IncumbVoteMargin < 0$ experienced a change in the political party of the mayor. Municipalities with $IncumbVoteMargin > 0$ did not experience a change in the political party of the mayor. Note that values to the right side of the zero are negative (political turnover), while values on the left side are positive (no political turnover). Selected bandwidth follows Calonico et al. (2017). Panel (b) repeats the analysis for non-municipal schools (a placebo test). Panel (c) repeats the analysis for municipal schools where the school principal was not replaced after the election (the principal reports being in post in his/her current school for at least two years on the Prova Brasil school principal questionnaire).

Figure 4: Teacher selection



Note: Teacher ability is distributed $\theta \sim U[1, 5]$ and teacher intrinsic motivation is distributed $\tau \sim U[0, 10]$. In the low management public school $G^L = 30$, $\Delta^L = 0$, and $\gamma^L = 1$. In the high management public school, $G^H = 35$, $\Delta^H = 0.5$ and $\gamma^H = 2$. Other parameters are set at $W = 15$, $B = 40$, $\bar{y} = 4.5$, $\beta = 50$, and $\bar{z} = 1$. The blue point in the top panel shows average teacher ability and average baseline intrinsic motivation among teacher types who select into a high management public school. The (x, y)-coordinates are $(1.21, 1.47)$. The orange point in the bottom panel shows average teacher ability and average baseline intrinsic motivation among teacher types who select into a low management public school. The (x, y)-coordinates are $(1.11, 0.60)$.

Table 1: Management and student performance, PISA

	Reading PISA Points			Math PISA Points			Science PISA Points		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All Schools									
Management Index	3.785	2.441	2.281	3.166	2.081	1.837	2.937	1.957	1.766
	(1.040)	(0.992)	(0.830)	(1.021)	(1.011)	(0.822)	(1.006)	(1.012)	(0.817)
	[0.000]	[0.014]	[0.006]	[0.002]	[0.040]	[0.025]	[0.003]	[0.053]	[0.031]
Private=1		11.180	2.766		11.078	1.809		9.871	1.092
		(2.868)	(2.549)		(2.844)	(2.641)		(2.738)	(2.371)
		[0.000]	[0.278]		[0.000]	[0.493]		[0.000]	[0.645]
Students	410701	410200	410200	410701	410200	410200	410701	410200	410200
Schools	15196	15176	15176	15196	15176	15176	15196	15176	15176
R-Squared	0.243	0.289	0.423	0.306	0.341	0.449	0.299	0.329	0.431
Brazil									
Management Index	7.483	3.493	1.460	8.921	4.980	2.826	10.123	6.230	4.319
	(2.984)	(2.508)	(1.910)	(2.555)	(2.314)	(1.795)	(2.557)	(2.266)	(1.853)
	[0.012]	[0.164]	[0.445]	[0.000]	[0.031]	[0.115]	[0.000]	[0.006]	[0.020]
Private=1		40.236	31.638		39.691	28.895		35.983	26.429
		(16.713)	(13.821)		(15.617)	(13.303)		(12.086)	(9.726)
		[0.016]	[0.022]		[0.011]	[0.030]		[0.003]	[0.007]
Students	14949	14949	14949	14949	14949	14949	14949	14949	14949
Schools	561	561	561	561	561	561	561	561	561
R-Squared	0.009	0.173	0.352	0.014	0.219	0.391	0.018	0.200	0.342
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y	Y		Y	Y		Y	Y
Student Controls			Y			Y			Y

Note: Standard errors in parentheses, p-values in square brackets. OLS regressions were run with the student-level PISA dataset using the OECDs `repest` Stata command. Standard errors are clustered at the school level and use all 5 plausible values for each subject and student final weights. Main independent variable is the PISA-based management index standardized using the overall distribution. All specifications include country fixed effects (except for panel B, which is restricted to Brazil). School controls: school location (set of dummies for village, small town, town, city, and large city), student-teacher ratio, log of the number of students, ratio of computers connected to the web as a proxy for school resources, and share of government funding relative to total school funding. Student controls: gender, grade compared to modal grade of students taking the PISA exam in the country, an index of economic, social, and cultural status, and immigration status (set of dummies for native, first generation, and second generation). For control variables, missing variables are replaced with a value of -99 and we include an indicator variable with a value of 1 for each imputed value.

Table 2: Management and student performance, Prova Brasil

	Portuguese Score					Mathematics Score				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Management Index	0.121	0.050	0.036	0.032	0.017	0.134	0.052	0.040	0.036	0.019
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Students	23829018	23829018	23829018	23829018	23829018	23827854	23827854	23827854	23827854	23827854
Schools	72683	72683	72683	72683	72683	72683	72683	72683	72683	72683
R-Squared	0.063	0.107	0.133	0.158	0.221	0.042	0.101	0.124	0.149	0.229
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
State FE		Y	Y	Y			Y	Y	Y	
PISA-Like Controls			Y	Y	Y			Y	Y	Y
PB Controls				Y	Y				Y	Y
School FE					Y					Y

Note: Standard errors in parentheses, p-values in square brackets. OLS regressions for PB were run with the student-level PB dataset, pooling grades 5 and 9, for years 2007 to 2017. Standard errors clustered at the school level. Test scores are normalized within grade. All specifications include year fixed effects. PISA-like controls are taken from PB data set and attempt to match school controls and student controls in PISA regressions (Table 1): indicator variable for urban schools, student-teacher ratio, log of the number of students, dummies indicating the presence of a computer lab and whether the school has internet access, gender, student households' consumption index, and a set of dummies for race. Given the availability of principal characteristics, PB controls include principals' age, set of dummies for principals' race, principals' educational attainment (set of dummies for less than high school, high school, undergraduate (pedagogy), undergraduate (math), undergraduate (Portuguese), undergraduate (others), masters, doctoral), indicator for whether the principal holds another job. PB controls also include the class-year-level share of white teachers, share of teachers holding a college degree, and average teacher tenure. For the students, PB controls include dummies for mother educational attainment (grades 1-5, grades 6-9, secondary grades 10-12, and college). For control variables, missing variables are replaced with a value of -99 and we include an indicator variable with a value of 1 for each imputed value.

Table 3: Political turnover and school management scores

	Outcome: Management Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.198	-0.188	-0.229	-0.222	-0.262	-0.249
	(0.038)	(0.036)	(0.056)	(0.054)	(0.044)	(0.043)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Baseline Management Index	0.350	0.315	0.337	0.298	0.333	0.297
	(0.011)	(0.010)	(0.014)	(0.014)	(0.012)	(0.012)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	12637	12637	6117	6117	9080	9080
R-Squared	0.155	0.172	0.149	0.170	0.144	0.162
Clusters	2689	2689	1563	1563	2130	2130
Using Bandwidth	0.165	0.165	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.165	0.165	0.165	0.165	0.165	0.165
Non-Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.012	-0.004	0.032	0.058	-0.001	0.010
	(0.054)	(0.052)	(0.069)	(0.064)	(0.056)	(0.053)
	[0.825]	[0.932]	[0.647]	[0.363]	[0.983]	[0.854]
Baseline Management Index	0.395	0.365	0.384	0.349	0.391	0.359
	(0.015)	(0.015)	(0.018)	(0.017)	(0.015)	(0.014)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	6115	6115	3965	3965	5663	5663
R-Squared	0.173	0.191	0.166	0.189	0.172	0.193
Clusters	1977	1977	1390	1390	1875	1875
Using Bandwidth	0.119	0.119	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.119	0.119	0.119	0.119	0.119	0.119
Munic. Schools, No Headm. Replac.						
$1\{IncumbVoteMargin < 0\}$	-0.068	-0.070	-0.100	-0.110	-0.064	-0.077
	(0.047)	(0.047)	(0.074)	(0.074)	(0.061)	(0.062)
	[0.147]	[0.131]	[0.178]	[0.137]	[0.297]	[0.211]
Baseline Management Index	0.391	0.371	0.366	0.343	0.370	0.348
	(0.014)	(0.014)	(0.020)	(0.021)	(0.018)	(0.018)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	5122	5122	2222	2222	3329	3329
R-Squared	0.212	0.220	0.195	0.208	0.197	0.208
Clusters	1607	1607	804	804	1143	1143
Using Bandwidth	0.182	0.182	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.182	0.182	0.182	0.182	0.182	0.182
Controls		Y		Y		Y

Note: Panel (a): Standard errors in parentheses, p-values in square brackets. This table reports the coefficient on political party turnover from regressing standardized management scores in municipal schools on the running variable of the RDD ($IncumbVoteMargin$), political party turnover ($IncumbVoteMargin < 0$), and the interaction of these two variables for the set of municipalities with $IncumbVoteMargin < UsingBandwidth$. We also control for baseline standardized management scores in the year before the election. Controls include school-level controls (whether: the school is located in an urban or rural area, the school is connected to the electric grid, the school is connected to the water network, the school is connected to the sewage system, the schools trash is regularly collected, and the school has Internet) and a 2012 election-cycle indicator. Optimal bandwidth follows Calonico et al. (2017). Panel (b): repeat of the analysis in Panel A using non-municipal schools (state and federal schools). Only public schools participate in the Prova Brasil exam. Panel (C): repeat of the analysis in panel A for the municipal schools where the headmaster was not replaced. New headmasters are those that report being the headmaster of their current school for less than two years on the Prova Brasil headmaster questionnaire.

Table 4: Management and school functioning

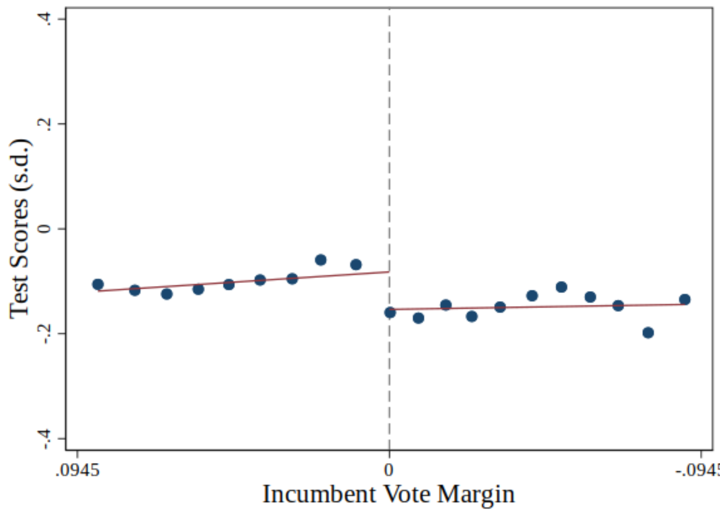
	Teachers						Households	
	(1) shortage	(2) shortage	(3) motivation	(4) motivation	(5) effort	(6) effort	(7) effort	(8) effort
PISA								
Management Index	-0.060	-0.060	0.306	0.325	0.049	0.075	0.255	0.283
	(0.023)	(0.023)	(0.027)	(0.025)	(0.024)	(0.023)	(0.029)	(0.027)
	[0.009]	[0.009]	[0.000]	[0.000]	[0.043]	[0.001]	[0.000]	[0.000]
Observations	12133	12133	12133	12133	12133	12133	12133	12133
Schools	12133	12133	12133	12133	12133	12133	12133	12133
R-Squared	0.030	0.049	0.093	0.125	0.011	0.063	0.077	0.155
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y		Y		Y		Y
Student Controls		Y		Y		Y		Y
Prova Brasil								
Management Index	-0.033	-0.088	0.229	0.218	0.017	0.059	0.044	0.054
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	322127	322127	315885	315885	322273	322273	322313	322313
Schools	72658	72658	72321	72321	72686	72686	72688	72688
R-Squared	0.001	0.448	0.052	0.377	0.000	0.490	0.002	0.481
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
PISA-Like Controls		Y		Y		Y		Y
PB Controls		Y		Y		Y		Y
School FE		Y		Y		Y		Y

Note: Standard errors in parentheses, p-values in square brackets. Panel (a): All regressions use data from public schools only. The table reports coefficients from school-level regressions of the PISA-based management index standardized using the overall distribution on each of the intermediate school outcomes (also standardized). All specifications include PISA school final weights and country fixed effects. School controls: school location (set of dummies for village, small town, town, city, and large city), student-teacher ratio, log of the number of students, ratio of computers connected to the web as a proxy for school resources, and share of government funding relative to total school funding. Student controls: gender, grade compared to modal grade of students taking the PISA exam in the country, an index of economic, social, and cultural status, and immigration status (set of dummies for native, first generation, and second generation). Panel (b): PB exam is applied in public schools only. The table reports coefficients from school-level regressions of the PB-based management index standardized using the overall distribution on each of the intermediate school outcomes (also standardized). All specifications include year fixed effects. PISA-like controls are taken from PB data set and attempt to match school controls and student controls in PISA regressions (Table 1): indicator variable for urban schools, student-teacher ratio, log of the number of students, dummies indicating the presence of a computer lab and whether the school has internet access, gender, student households' consumption index, and a set of dummies for race. Given the availability of principal characteristics, PB controls include principals' age, set of dummies for principals' race, principals' educational attainment (set of dummies for less than high school, high school, undergraduate (pedagogy), undergraduate (math), undergraduate (Portuguese), undergraduate (others), masters, doctoral), indicator for whether the principal holds another job. PB controls also include the class-year-level share of white teachers, share of teachers holding a college degree, and average teacher tenure. For the students, PB controls include dummies for mother educational attainment (grades 1-5, grades 6-9, secondary grades 10-12, and college). In both panels: For control variables, missing variables are replaced with a value of -99 and we include an indicator variable with a value of 1 for each imputed value.

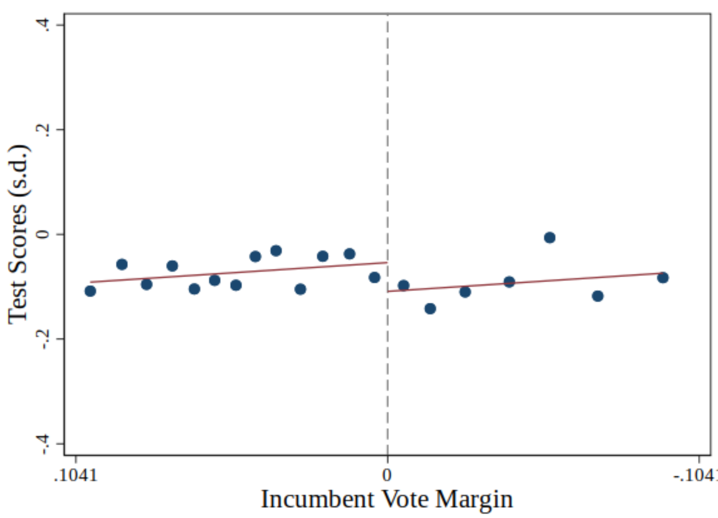
A Appendix: Additional Figures and Tables

Figure A.1: Political turnover and test scores

(a) Municipal schools: all



(b) Municipal schools: with no post-election school principal replacement



Note: Panel (a) shows the average of individual-level test scores by bins of $IncumbVoteMargin$ in municipal schools, pooling students from grade 5 and grade 9 and controlling for the average, school-level test scores for the respective grade at baseline. Municipalities with $IncumbVoteMargin < 0$ experienced a change in the political party of the mayor. Municipalities with $IncumbVoteMargin > 0$ did not experience a change in the political party of the mayor. Note that values to the right side of the zero are negative (political turnover), while values on the left side are positive (no political turnover). Selected bandwidth follows Calonico et al. (2017). Panel (b) repeats the analysis for municipal schools where the school principal was not replaced after the election (the principal reports being in post in his/her current school for at least two years on the Prova Brasil school principal questionnaire).

Table A.1: Political turnover and test scores

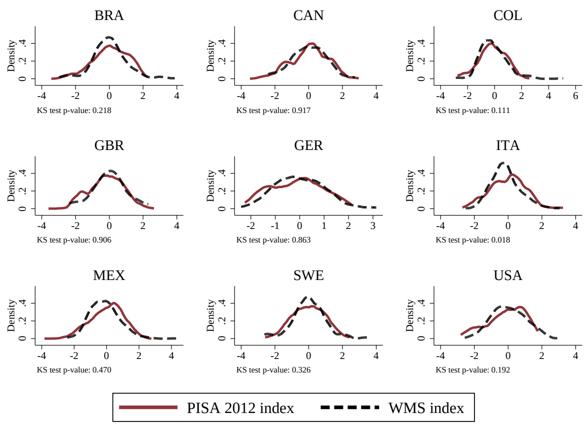
	Outcome: Test Scores					
	(1)	(2)	(3)	(4)	(5)	(6)
Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.067	-0.053	-0.077	-0.067	-0.064	-0.052
	(0.022)	(0.021)	(0.024)	(0.023)	(0.020)	(0.019)
	[0.002]	[0.012]	[0.001]	[0.004]	[0.002]	[0.007]
School-Level Baseline Test Scores	0.846	0.741	0.843	0.740	0.839	0.735
	(0.011)	(0.011)	(0.013)	(0.012)	(0.010)	(0.010)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	550460	550460	422025	422025	621148	621148
R-Squared	0.201	0.228	0.198	0.225	0.200	0.227
Clusters	1952	1952	1585	1585	2163	2163
Using Bandwidth	0.095	0.095	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.095	0.095	0.095	0.095	0.095	0.095
Munic. Schools, No Headm. Replac.						
$1\{IncumbVoteMargin < 0\}$	-0.044	-0.045	-0.049	-0.052	-0.040	-0.041
	(0.030)	(0.029)	(0.036)	(0.035)	(0.029)	(0.029)
	[0.149]	[0.123]	[0.180]	[0.136]	[0.171]	[0.154]
School-Level Baseline Test Scores	0.847	0.750	0.844	0.753	0.843	0.747
	(0.015)	(0.015)	(0.017)	(0.018)	(0.014)	(0.015)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	213008	213008	151434	151434	222225	222225
R-Squared	0.210	0.234	0.204	0.227	0.208	0.231
Clusters	1111	1111	810	810	1153	1153
Using Bandwidth	0.104	0.104	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.104	0.104	0.104	0.104	0.104	0.104
Controls		Y		Y		Y

Note: Standard errors in parentheses, p-values in square brackets. Panel (a): This table reports the coefficient from regressions of individual-level test scores on the running variable of the RDD ($IncumbVoteMargin$), political party turnover ($IncumbVoteMargin < 0$), and the interaction of these two variables for the set of municipalities with $IncumbVoteMargin < UsingBandwidth$, pooling students from grade 5 and grade 9. We also control for the average, school-level test scores for the respective grade at baseline. Test scores are from the Prova Brasil exam and are standardized based on the distribution of individual-level test scores in municipalities with no change in the ruling party. Controls include school-level controls (whether: the school is located in an urban or rural area, the school is connected to the electric grid, the school is connected to the water network, the school is connected to the sewage system, the schools trash is regularly collected, and the school has Internet), individual-level controls (an indicator variable for gender, whether the student is white, and whether the student sees their mother reading), and a 2012 election-cycle indicator. Optimal bandwidth follows Calonico et al. (2017). Panel (b): repeat of the analysis in panel A for the municipal schools where the headmaster was not replaced. New headmasters are those that report being the headmaster of their current school for less than two years on the Prova Brasil headmaster questionnaire.

B Appendix: Alternative Index Building

Figure B.1: Index validation, Distribution of overall mgmt. scores, PISA

(a) Anderson



(b) PCA

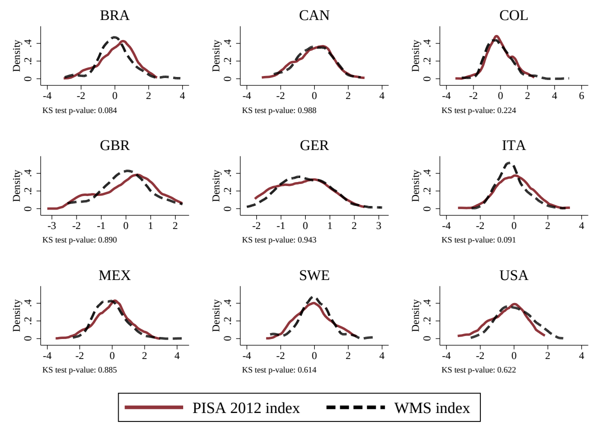
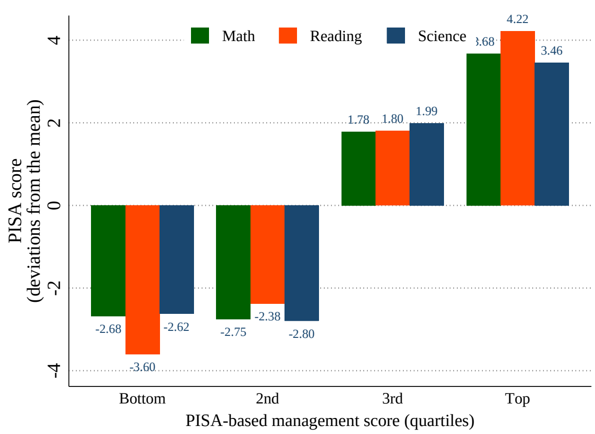


Figure B.2: Index validation, Management and student learning outcomes, PISA

(a) Anderson



(b) PCA

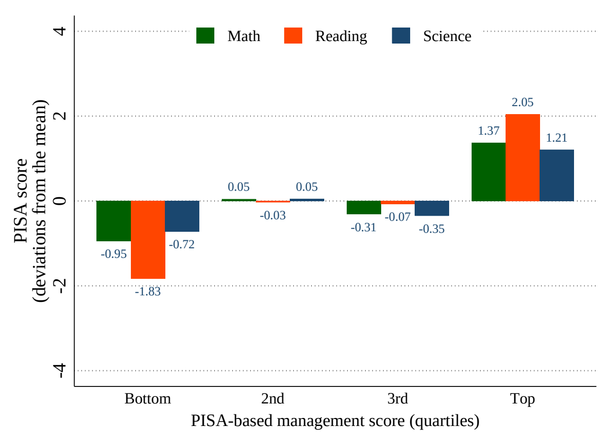


Figure B.3: Index validation, School-specific score correlation, std, Prova Brasil

(a) Anderson (b) PCA

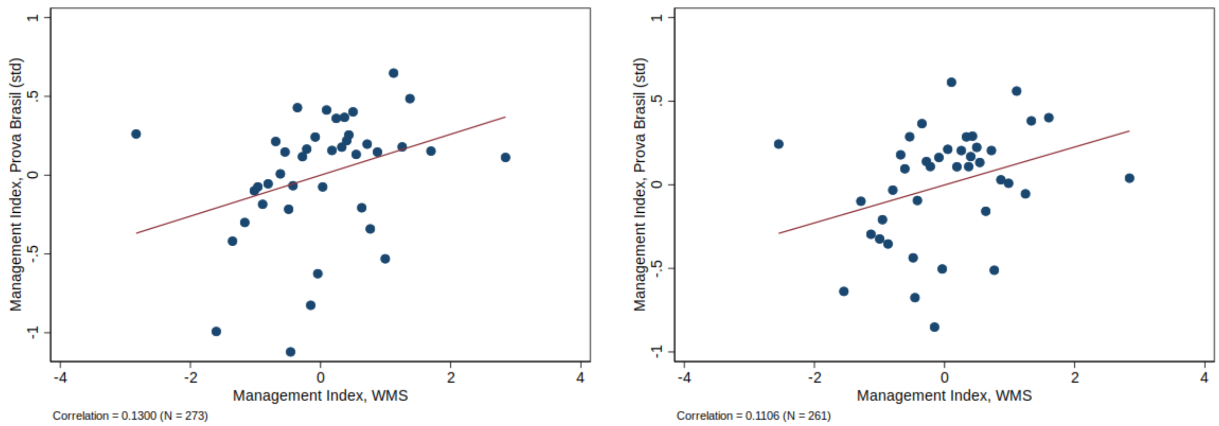


Figure B.4: Index validation, School-specific score correlation, std, Prova Brasil

(a) Anderson (b) PCA

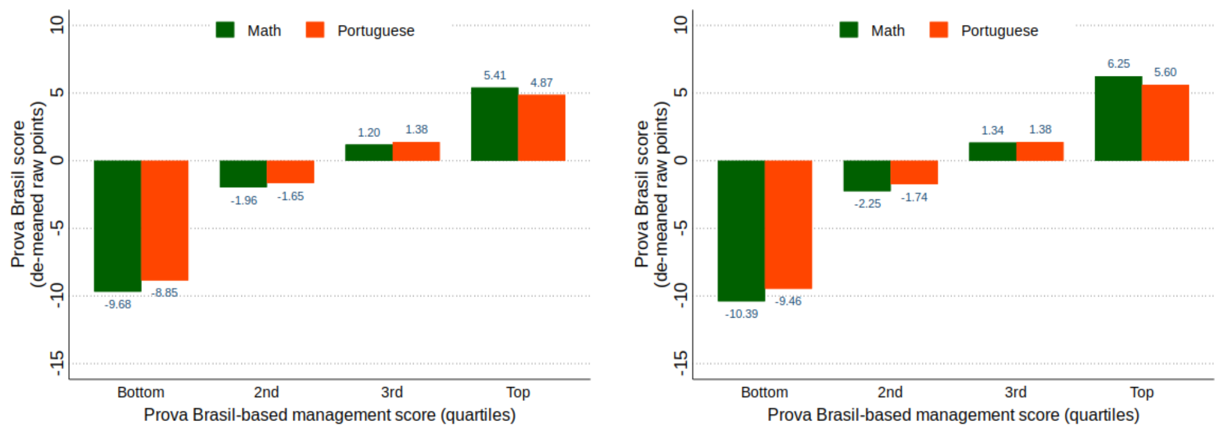
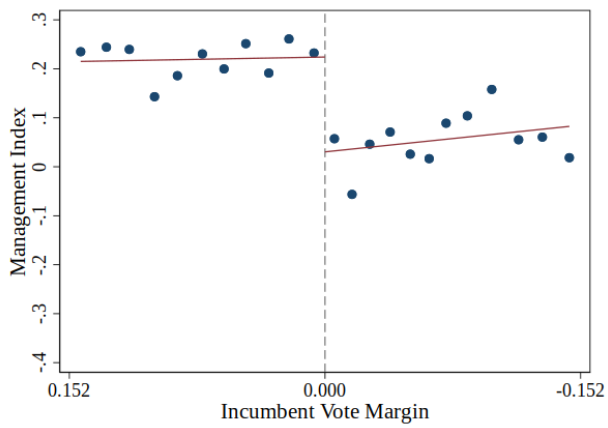
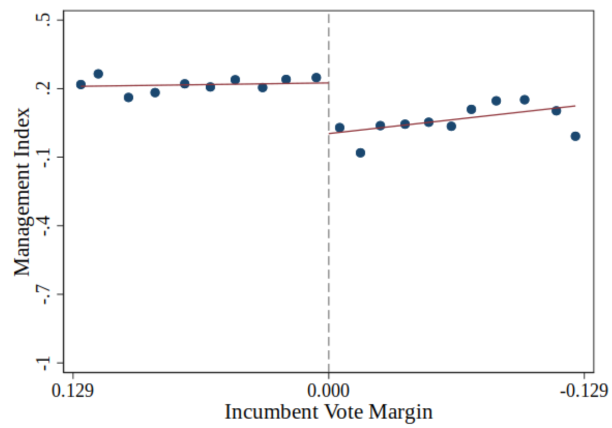


Figure B.5: Political turnover and management scores

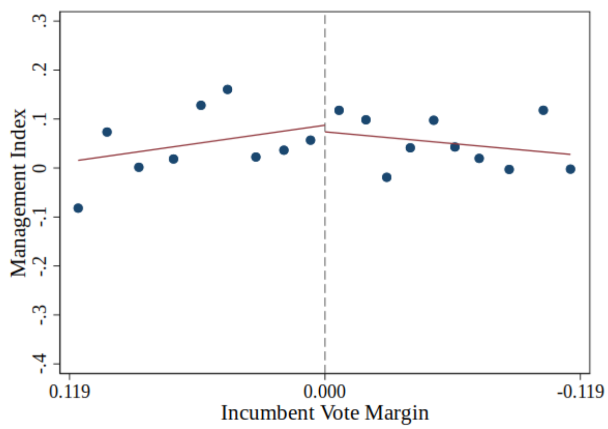
(a) Municipal schools (treated): Anderson



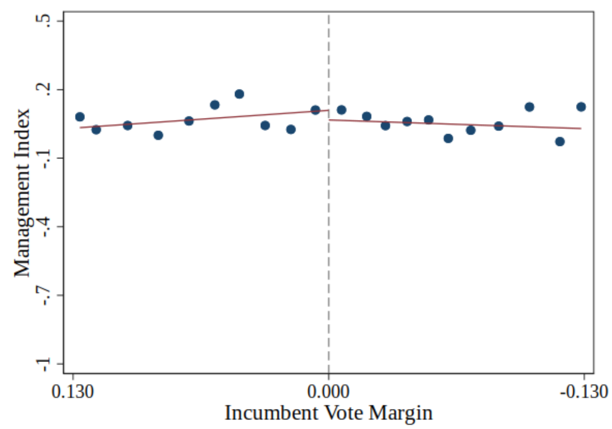
(b) Municipal schools (treated): PCA



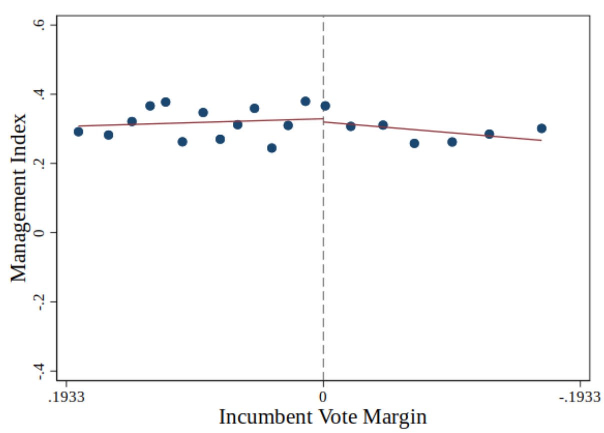
(c) Placebo schools (non-municipal): Anderson



(d) Placebo schools (non-municipal): PCA



(e) Munic., no principal replac.: Anderson



(f) Munic., no principal replac.: PCA

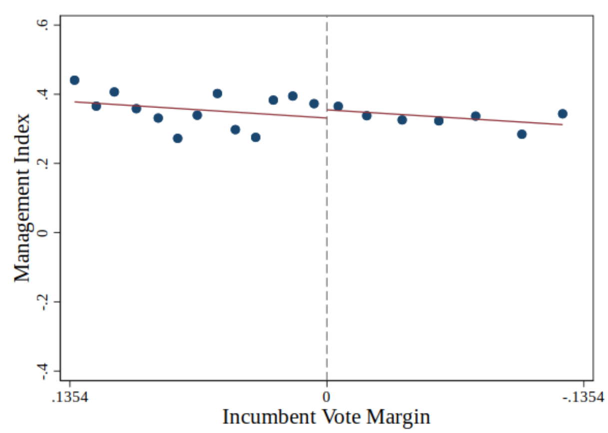


Table B.1: Management and student performance, PISA: Anderson

	Reading PISA Points			Math PISA Points			Science PISA Points		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All Schools									
Management Index	4.238	2.984	2.280	3.965	2.943	2.140	3.595	2.677	1.930
	(1.088)	(1.014)	(0.912)	(1.146)	(1.098)	(0.936)	(1.112)	(1.082)	(0.916)
	[0.000]	[0.003]	[0.012]	[0.001]	[0.007]	[0.022]	[0.001]	[0.013]	[0.035]
Private=1		11.268	2.767		11.223	1.865		9.991	1.122
		(2.913)	(2.587)		(2.896)	(2.670)		(2.781)	(2.399)
		[0.000]	[0.285]		[0.000]	[0.485]		[0.000]	[0.640]
Students	410701	410200	410200	410701	410200	410200	410701	410200	410200
Schools	15196	15176	15176	15196	15176	15176	15196	15176	15176
R-Squared	0.243	0.290	0.423	0.307	0.342	0.450	0.299	0.330	0.431
Brazil									
Management Index	9.119	3.672	2.233	10.572	5.339	3.793	10.501	5.445	4.045
	(3.148)	(2.237)	(1.789)	(2.849)	(1.928)	(1.546)	(2.784)	(2.030)	(1.678)
	[0.004]	[0.101]	[0.212]	[0.000]	[0.006]	[0.014]	[0.000]	[0.007]	[0.016]
Private=1		41.318	31.984		41.214	29.646		38.117	27.849
		(17.121)	(14.349)		(16.059)	(13.932)		(12.224)	(10.066)
		[0.016]	[0.026]		[0.010]	[0.033]		[0.002]	[0.006]
Students	14949	14949	14949	14949	14949	14949	14949	14949	14949
Schools	561	561	561	561	561	561	561	561	561
R-Squared	0.014	0.173	0.353	0.022	0.220	0.392	0.022	0.199	0.341
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y	Y		Y	Y		Y	Y
Student Controls			Y			Y			Y

Table B.2: Management and student performance, PISA: PCA

	Reading PISA Points			Math PISA Points			Science PISA Points		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
All Schools									
Management Index	3.104	1.891	1.947	2.433	1.458	1.465	2.213	1.334	1.379
	(1.045)	(0.972)	(0.791)	(0.988)	(0.952)	(0.766)	(0.967)	(0.957)	(0.765)
	[0.003]	[0.052]	[0.014]	[0.014]	[0.126]	[0.056]	[0.022]	[0.163]	[0.071]
Private=1		11.128	2.252		10.819	1.258		9.921	0.848
		(2.933)	(2.542)		(2.888)	(2.643)		(2.809)	(2.404)
		[0.000]	[0.376]		[0.000]	[0.634]		[0.000]	[0.724]
Students	409029	408528	408528	409029	408528	408528	409029	408528	408528
Schools	15139	15119	15119	15139	15119	15119	15139	15119	15119
R-Squared	0.241	0.288	0.422	0.305	0.340	0.449	0.297	0.327	0.429
Brazil									
Management Index	6.172	2.906	0.909	7.773	4.578	2.463	9.020	5.815	3.949
	(3.068)	(2.595)	(1.967)	(2.747)	(2.461)	(1.885)	(2.659)	(2.342)	(1.882)
	[0.044]	[0.263]	[0.644]	[0.005]	[0.063]	[0.191]	[0.001]	[0.013]	[0.036]
Private=1		40.284	31.793		39.467	28.804		35.910	26.464
		(16.490)	(13.659)		(15.428)	(13.106)		(12.049)	(9.645)
		[0.015]	[0.020]		[0.011]	[0.028]		[0.003]	[0.006]
Students	14777	14777	14777	14777	14777	14777	14777	14777	14777
Schools	555	555	555	555	555	555	555	555	555
R-Squared	0.006	0.173	0.352	0.010	0.220	0.391	0.014	0.200	0.342
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y	Y		Y	Y		Y	Y
Student Controls			Y			Y			Y

Table B.3: Management and student performance, Prova Brasil: Anderson

	Portuguese Score					Mathematics Score				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Management Index	0.118	0.051	0.037	0.033	0.016	0.131	0.054	0.042	0.038	0.019
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Students	23829018	23829018	23829018	23829018	23829018	23827854	23827854	23827854	23827854	23827854
Schools	72683	72683	72683	72683	72683	72683	72683	72683	72683	72683
R-Squared	0.062	0.107	0.133	0.159	0.221	0.041	0.101	0.124	0.149	0.229
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
State FE		Y	Y	Y			Y	Y	Y	
PISA-Like Controls			Y	Y	Y			Y	Y	Y
PB Controls				Y	Y				Y	Y
School FE					Y					Y

Table B.4: Management and student performance, Prova Brasil: PCA

	Portuguese Score					Mathematics Score				
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Management Index	0.133	0.061	0.046	0.041	0.022	0.148	0.064	0.051	0.046	0.024
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Students	22496848	22496848	22496848	22496848	22496848	22495956	22495956	22495956	22495956	22495956
Schools	71832	71832	71832	71832	71832	71832	71832	71832	71832	71832
R-Squared	0.068	0.110	0.136	0.161	0.223	0.047	0.104	0.126	0.151	0.230
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
State FE		Y	Y	Y			Y	Y	Y	
PISA-Like Controls			Y	Y	Y			Y	Y	Y
PB Controls				Y	Y				Y	Y
School FE					Y					Y

Table B.5: Political turnover and school management scores: Anderson

	Outcome: Management Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.202	-0.186	-0.232	-0.223	-0.266	-0.249
	(0.040)	(0.038)	(0.058)	(0.055)	(0.046)	(0.044)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Baseline Management Index	0.336	0.301	0.326	0.286	0.323	0.287
	(0.011)	(0.010)	(0.014)	(0.014)	(0.012)	(0.012)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	11957	11957	6117	6117	9080	9080
R-Squared	0.142	0.163	0.137	0.162	0.133	0.154
Clusters	2575	2575	1563	1563	2130	2130
Using Bandwidth	0.152	0.152	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.152	0.152	0.152	0.152	0.152	0.152
Non-Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.005	0.003	0.033	0.059	-0.001	0.010
	(0.054)	(0.052)	(0.069)	(0.064)	(0.055)	(0.053)
	[0.926]	[0.959]	[0.629]	[0.355]	[0.985]	[0.846]
Baseline Management Index	0.381	0.353	0.370	0.338	0.375	0.347
	(0.015)	(0.015)	(0.018)	(0.017)	(0.015)	(0.014)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	6122	6122	3965	3965	5663	5663
R-Squared	0.157	0.174	0.152	0.173	0.156	0.175
Clusters	1978	1978	1390	1390	1875	1875
Using Bandwidth	0.119	0.119	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.119	0.119	0.119	0.119	0.119	0.119
Munic. Schools, No Headm. Replac.						
$1\{IncumbVoteMargin < 0\}$	-0.070	-0.071	-0.102	-0.110	-0.062	-0.074
	(0.046)	(0.046)	(0.076)	(0.076)	(0.063)	(0.063)
	[0.132]	[0.125]	[0.180]	[0.148]	[0.326]	[0.242]
Baseline Management Index	0.386	0.367	0.361	0.339	0.366	0.345
	(0.014)	(0.014)	(0.020)	(0.021)	(0.018)	(0.018)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	5299	5299	2222	2222	3329	3329
R-Squared	0.200	0.210	0.183	0.196	0.186	0.196
Clusters	1657	1657	804	804	1143	1143
Using Bandwidth	0.193	0.193	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.193	0.193	0.193	0.193	0.193	0.193
Controls		Y		Y		Y

Table B.6: Political turnover and school management scores: PCA

	Outcome: Management Index					
	(1)	(2)	(3)	(4)	(5)	(6)
Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.238	-0.237	-0.259	-0.256	-0.285	-0.278
	(0.043)	(0.041)	(0.058)	(0.056)	(0.047)	(0.045)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Baseline Management Index	0.373	0.334	0.373	0.333	0.368	0.329
	(0.011)	(0.011)	(0.014)	(0.014)	(0.012)	(0.012)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	9338	9338	5352	5352	7997	7997
R-Squared	0.175	0.193	0.177	0.199	0.170	0.188
Clusters	2194	2194	1424	1424	1961	1961
Using Bandwidth	0.129	0.129	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.129	0.129	0.129	0.129	0.129	0.129
Non-Municipal Schools						
$1\{IncumbVoteMargin < 0\}$	-0.021	-0.023	0.028	0.054	-0.036	-0.028
	(0.052)	(0.050)	(0.071)	(0.068)	(0.057)	(0.055)
	[0.678]	[0.649]	[0.692]	[0.423]	[0.528]	[0.606]
Baseline Management Index	0.432	0.402	0.420	0.386	0.427	0.396
	(0.014)	(0.014)	(0.018)	(0.017)	(0.015)	(0.014)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	5677	5677	3387	3387	4839	4839
R-Squared	0.212	0.229	0.203	0.226	0.207	0.225
Clusters	1940	1940	1267	1267	1717	1717
Using Bandwidth	0.130	0.130	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.130	0.130	0.130	0.130	0.130	0.130
Munic. Schools, No Headm. Replac.						
$1\{IncumbVoteMargin < 0\}$	-0.028	-0.045	-0.061	-0.070	-0.030	-0.048
	(0.054)	(0.054)	(0.078)	(0.078)	(0.063)	(0.064)
	[0.601]	[0.406]	[0.436]	[0.365]	[0.633]	[0.456]
Baseline Management Index	0.412	0.389	0.389	0.363	0.403	0.376
	(0.016)	(0.016)	(0.019)	(0.020)	(0.018)	(0.019)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	3987	3987	2111	2111	3174	3174
R-Squared	0.229	0.241	0.216	0.232	0.219	0.231
Clusters	1309	1309	779	779	1113	1113
Using Bandwidth	0.135	0.135	0.070	0.070	0.110	0.110
Optimal Bandwidth	0.135	0.135	0.135	0.135	0.135	0.135
Controls		Y		Y		Y

Table B.7: Management and school functioning: Anderson

	Teachers						Households	
	(1) shortage	(2) shortage	(3) motivation	(4) motivation	(5) effort	(6) effort	(7) effort	(8) effort
PISA								
Management Index	-0.076	-0.072	0.250	0.260	0.048	0.065	0.204	0.216
	(0.023)	(0.022)	(0.025)	(0.024)	(0.026)	(0.024)	(0.027)	(0.025)
	[0.001]	[0.001]	[0.000]	[0.000]	[0.064]	[0.008]	[0.000]	[0.000]
Observations	12133	12133	12133	12133	12133	12133	12133	12133
Schools	12133	12133	12133	12133	12133	12133	12133	12133
R-Squared	0.032	0.052	0.061	0.083	0.011	0.060	0.047	0.090
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y		Y		Y		Y
Student Controls		Y		Y		Y		Y
Prova Brasil								
Management Index	-0.046	-0.090	0.244	0.236	0.016	0.059	0.044	0.052
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	322127	322127	315885	315885	322273	322273	322313	322313
Schools	72658	72658	72321	72321	72686	72686	72688	72688
R-Squared	0.002	0.448	0.059	0.375	0.000	0.484	0.002	0.443
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
PISA-Like Controls		Y		Y		Y		Y
PB Controls		Y		Y		Y		Y
School FE		Y		Y		Y		Y

Table B.8: Management and school functioning: PCA

	Teachers						Households	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	shortage	shortage	motivation	motivation	effort	effort	effort	effort
PISA								
Management Index	-0.066	-0.064	0.261	0.283	0.042	0.074	0.211	0.242
	(0.025)	(0.024)	(0.027)	(0.025)	(0.026)	(0.025)	(0.031)	(0.030)
	[0.008]	[0.008]	[0.000]	[0.000]	[0.111]	[0.003]	[0.000]	[0.000]
Observations	10847	10847	10847	10847	10847	10847	10847	10847
Schools	10847	10847	10847	10847	10847	10847	10847	10847
R-Squared	0.035	0.055	0.072	0.112	0.014	0.068	0.060	0.132
Country FE	Y	Y	Y	Y	Y	Y	Y	Y
School Controls		Y		Y		Y		Y
Student Controls		Y		Y		Y		Y
Prova Brasil								
Management Index	-0.033	-0.080	0.327	0.360	0.087	0.041	0.125	0.063
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Observations	296610	296610	298011	298011	300137	300137	293873	293873
Schools	71556	71556	71462	71462	71711	71711	71320	71320
R-Squared	0.001	0.470	0.106	0.423	0.008	0.502	0.015	0.589
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
PISA-Like Controls		Y		Y		Y		Y
PB Controls		Y		Y		Y		Y
School FE		Y		Y		Y		Y

C Appendix: Theoretical Framework

We first present a result that establishes effort levels in high and low management public schools, high management private schools, and the outside sector.

Lemma 1. *Assume that the government assigns the teacher to public school $i = L, H$.*

1. *If the teacher accepts the government's offer, then she exerts effort $e^i = \frac{\tau+\Delta^i}{2}$.*
2. *If the teacher declines the government's offer and is hired by a high management private school, then she exerts effort $e^P = \frac{\theta\ B}{2(\overline{\varepsilon}-\underline{\varepsilon})} + \frac{\tau+\Delta^H}{2}$.*
3. *If the teacher declines the government's offer and is hired by an outside employer, then she exerts effort $e^O = \frac{\theta\ \beta}{2(\overline{\varepsilon}-\underline{\varepsilon})}$.*

Proof. Part 1. When working in public school i, a teacher with baseline motivation τ chooses effort to solve

$$\max_e\ G - (e^2 - (\tau + \Delta^i) \cdot e).$$

Differentiation to obtain the first order condition yields the solution stated above. (Here, as in the cases below, the second order condition necessary for a maximum holds.)

Part 2. When working in a high management private school, a teacher with baseline motivation τ and ability θ chooses effort to solve

$$\max_e\ P \cdot B + W - (e^2 - (\tau + \Delta^H) \cdot e)$$

where P is the probability that y_1^H exceeds the threshold $\bar{y}$ given teacher and household effort. Using the uniform distribution for ε, we can rewrite this probability as

$$P = \Pr\left(\theta\ e + a + \varepsilon > \bar{y}\right) = \Pr\left(\theta\ e + a - \bar{y} > -\varepsilon\right) = \frac{\overline{\varepsilon} + \theta\ e + a - \bar{\bar{y}}}{\overline{\varepsilon} - \underline{\varepsilon}}.$$

The first order condition for this optimization problem is

$$\frac{\theta\ B}{\overline{\varepsilon} - \underline{\varepsilon}} = 2e - (\tau + \Delta^H),$$

which yields the solution stated above.

Part 3. When working in the outside sector, a teacher chooses effort to solve

$$\max_e\ P^O \cdot \beta - e^2,$$

where P^O is the probability that z exceeds the threshold $\bar{z}$ given effort. We can rewrite this probability as

$$P^O = \Pr\left(\theta\ e + \varepsilon^O > \overline{z}\right) = \Pr\left(\theta\ e - \overline{z} > -\varepsilon^O\right) = \frac{\overline{\varepsilon} + \theta\ e - \overline{z}}{\overline{\varepsilon} - \underline{\varepsilon}}.$$

The first order condition for this optimization problem is

$$\frac{\theta\ \beta}{\overline{\varepsilon} - \underline{\varepsilon}} = 2e,$$

which yields the solution stated above. □

We now use these effort levels to construct Figure 7. Calculations were performed in Mathematica; the notebook file is available on request.

Derivation of Figure 7 The figure is based on the following numerical example. Teacher intrinsic motivation is distributed $\tau \sim U[0,10]$, and teacher ability is distributed $\theta \sim U[1,5]$. In the low management public school $G^L = 30$, $\Delta^L = 0$, and $\gamma^L = 1$. In the high management public school, $G^H = 35$, $\Delta^H = 0.5$ and $\gamma^H = 2$. Other parameters are set at $W = 15$, $B = 40$, $\bar{y} = 4.5$, $\beta = 50$, and $\bar{z} = 1$.

The unshaded region in the top panel of Figure 7 shows $\mathcal{T}^H$, the set of (θ, τ) types for whom the payoff from accepting a job in the assigned high management public school (weakly) exceeds both the expected payoff of declining and accepting a job in a high management private school and the expected payoff of declining and accepting a job in the outside sector. This region is bounded by two functions

$$\tau_P^H = \frac{7}{\theta} - 2\theta - \tfrac{1}{2}, \quad \tau_O^H = \sqrt{25\theta^2 - 60} - \tfrac{1}{2}.$$

The function τ_P^H traces out the loci of (θ, τ) types who, anticipating subsequent teacher and household effort, are indifferent between accepting the job in the assigned high management public school and declining it in favour of a job in a high management private school, i.e. types for whom

$$G - (e^H)^2 + \left(\tau + \Delta^H\right) e^H = W + B\left(\frac{\bar{\varepsilon} + \theta\, e^P + a^P - \bar{y}}{\bar{\varepsilon} - \underline{\varepsilon}}\right) - (e^P)^2 + (\tau + \Delta^H)\, e^P.$$

Substituting for e^H and e^P from Lemma 1, together with the parameters in the numerical example (implying $a^P = 1$), and rearranging yields the expression for τ_P^H stated above. Fixing θ, for any $\tau < \tau_P^H(\theta)$, the teacher's payoff from accepting the government's offer is strictly higher than her expected payoff from declining and accepting a job in a high management private school.

The function τ_O^H traces out the loci of (θ, τ) types who, anticipating subsequent teacher effort, are indifferent between accepting the job in the assigned high management public school and declining it in favour of a job in the outside sector, i.e. types for whom

$$G - (e^H)^2 + (\tau + \Delta^H)\, e^H = \beta\left(\frac{\bar{\varepsilon} + \theta\, e^O - \bar{z}}{\bar{\varepsilon} - \underline{\varepsilon}}\right) - (e^O)^2.$$

Substituting for e^H and e^O from Lemma 1, together with the parameters in the numerical example, and rearranging for τ yields the expression for τ_O^H stated above. Fixing θ, for any $\tau > \tau_O^H(\theta)$, the teacher's payoff from accepting the government's offer is strictly higher than her expected payoff from declining and accepting a job in the outside sector.

The values for average ability and average baseline intrinsic motivation (the coordinates of the blue dot) are obtained by numerical integration.

The unshaded region in the bottom panel of Figure 7 shows $\mathcal{T}^L$, the set of (θ, τ) types for whom the payoff from accepting a job in the assigned low management public school (weakly) exceeds both the expected payoff of declining and accepting a job in a high management private school and the expected payoff of declining and accepting a job in the outside sector. This region is bounded by two functions

$$\tau_P^L = \frac{36}{8\theta+1} - 2\theta - \tfrac{1}{4}, \quad \tau_O^L = \sqrt{25\theta^2 - 40}.$$

The function τ_P^L traces out the loci of (θ, τ) types who, anticipating subsequent teacher and household effort, are indifferent between accepting the job in the assigned low management public school and declining it in favour of a job in a high management private school, i.e. types for whom

$$G - (e^L)^2 + \left(\tau + \Delta^L\right) e^L = W + B\left(\frac{\overline{\varepsilon} + \theta\, e^P + a^P - \overline{y}}{\overline{\varepsilon} - \underline{\varepsilon}}\right) - (e^P)^2 + (\tau + \Delta^H)\, e^P.$$

Substituting for e^L and e^P from Lemma 1, together with the parameters in the numerical example (implying $a^P = 1$), and rearranging yields the expression for τ_P^L stated above. Fixing θ, for any $\tau < \tau_P^L(\theta)$, the teacher's payoff from accepting the government's offer is strictly higher than her expected payoff from declining and accepting a job in a high management private school.

The function τ_O^L traces out the loci of (θ, τ) types who, anticipating subsequent teacher effort, are indifferent between accepting the job in the assigned low management public school and declining it in favour of a job in the outside sector, i.e. types for whom

$$G - (e^L)^2 + (\tau + \Delta^L)\, e^L = \beta\left(\frac{\overline{\varepsilon} + \theta\, e^O - \overline{z}}{\overline{\varepsilon} - \underline{\varepsilon}}\right) - (e^O)^2.$$

Substituting for e^L and e^O from Lemma 1, together with the parameters in the numerical example, and rearranging for τ yields the expression for τ_O^L stated above. Fixing θ, for any $\tau > \tau_O^L(\theta)$, the teacher's payoff from accepting the government's offer is strictly higher than her expected payoff from declining and accepting a job in the outside sector.

The values for average ability and average baseline intrinsic motivation (the coordinates of the orange dot) are also obtained by numerical integration.

Low-cost private schools We complete the analysis by considering an alternative numerical example, where pay in a high management private school is *below* the level in both high and low management public schools. All parameters take the same values as in the previous numerical example, except $W = 5$ and $B = 20$. In this numerical example,

$$\tau_P^H = \frac{27}{\theta} - \theta - \tfrac{1}{2}, \quad \tau_O^H = \sqrt{25\theta^2 - 60} - \tfrac{1}{2}$$

and

$$\tau_P^L = \frac{88}{4\theta+1} - \theta - \tfrac{1}{4}, \quad \tau_O^L = \sqrt{25\theta^2 - 40}.$$

These functions are plotted in Figure 9. As before, the probability of hiring the teacher in a high management public school is higher than the probability of hiring the teacher in a low management public school (the unshaded region is larger in the top panel than in the bottom panel). The expected intrinsic motivation of a teacher hired to a high management public school is now slightly *lower* than the expected intrinsic motivation of a teacher hired to a low management public school (compare the height of the orange dot at 5.98 with the height of the blue dot at 5.81). The difference is small, however, and not sufficient to reverse the effort effect: the expected effort level of a teacher hired to a high management public school is higher than the expected intrinsic motivation of a teacher hired to a low management public school ($\mathrm{E}\left[\frac{\tau+\Delta^H}{2}|(\theta,\tau)\in\mathcal{T}^H\right]=3.16>$ $\mathrm{E}\left[\frac{\tau+\Delta^L}{2}|(\theta,\tau)\in\mathcal{T}^L\right]=2.99$). Household effort levels in public schools are unchanged.

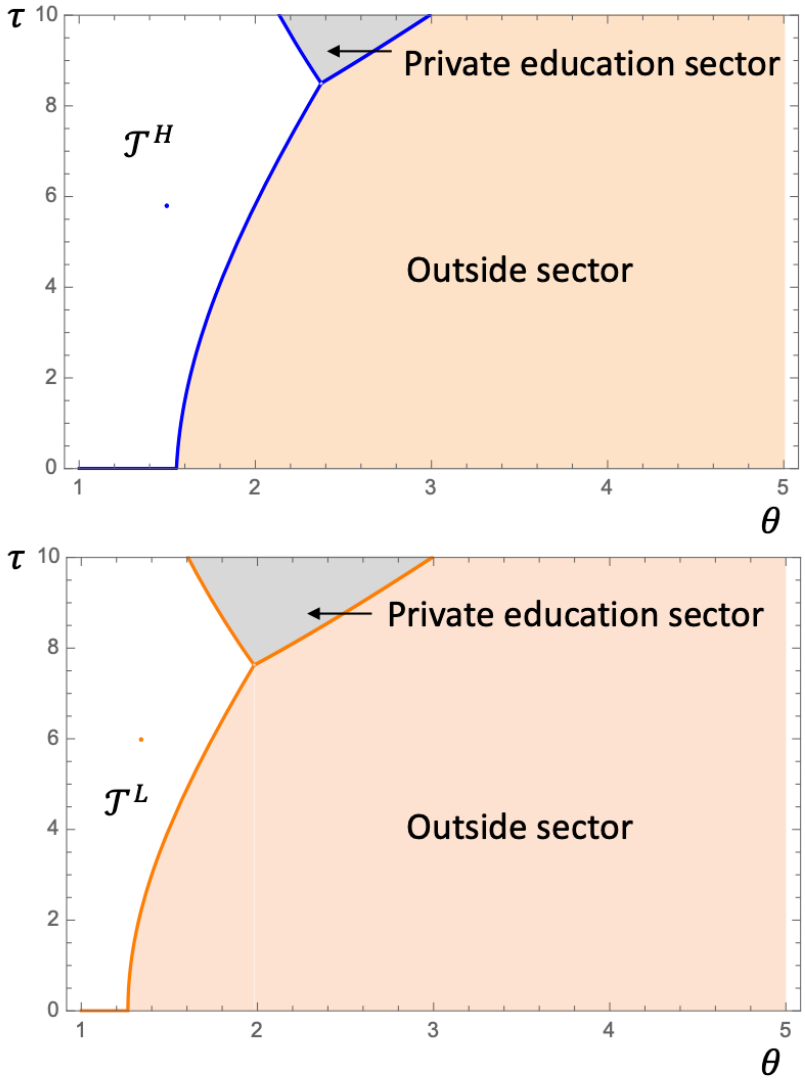


Figure C.1: Teacher selection, with 'low cost' private schools

Note: Teacher ability is distributed $\theta \sim U[1,5]$ and teacher intrinsic motivation is distributed $\tau \sim U[0,10]$. In the low management public school $G^L=30$, $\Delta^L=0$, and $\gamma^L=1$. In the high management public school, $G^H=35$, $\Delta^H=0.5$ and $\gamma^H=2$. Other parameters are set at $W=5$, $B=20$, $\bar{y}=4.5$, $\beta=50$, and $\bar{z}=1$. The blue point in the top panel shows average teacher ability and average baseline intrinsic motivation among teacher types who select into a high management public school. The (x,y)-coordinates are $(1.50,5.81)$. The orange point in the bottom panel shows average teacher ability and average baseline intrinsic motivation among teacher types who select into a low management public school. The (x,y)-coordinates are $(1.34,5.98)$.