BSG Working Paper Series

Providing access to the latest policy-relevant research

Measuring and explaining management in schools

New approaches using public data

BSG-WP-2019/029

October 2019

Clare Leaver, Blavatnik School of Government, University of Oxford

Renata Lemos, World Bank

Daniela Scur, Dyson School of Applied Economics and Management, Cornell University

Measuring and explaining management in schools: New approaches using public data

Clare Leaver
Blavatnik School of Government,
University of Oxford
CEPR

Renata Lemos
World Bank
CEP-LSE

Daniela Scur
Dyson School of Applied
Economics and Management,
Cornell University
CEPR, CEP-LSE

This version: October 17, 2019

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, and also explain any observed relationship between school management and student learning. This paper introduces a new approach to measurement using existing public data, and applies it to build a management index covering 15,000 schools across 65 countries, and another index covering nearly all public schools in Brazil. Both indices show a strong, positive relationship between school management and student learning. The paper then develops a simple model that formalizes the intuition that strong management practices might be driving learning gains via incentive and selection effects among teachers, students and parents. The paper shows that the predictions of this model hold in public data for Latin America, and draws out implications for policy.

Keywords: management, teacher selection, teacher incentives, cross-country
JEL codes: M5, I2, J3

Acknowledgements: We thank Melissa Adelman and Justin Sandefur for helpful discussions and comments on earlier drafts. We also thank participants at the World Bank's Regional Study authors' workshop, RISE Annual Conference 2018, SIOE 2019, Cornell University Development seminar, Nikki Shure, Chris Barrett, John Hoddinott, Vicente Garcia for useful suggestions. José Mola, Raissa Ebner, Maria José Vargas, Claudia Rivas, and Ildo Lautharte provided excellent research assistance. Leaver is grateful for the hospitality of Toulouse School of Economics, 2018-19.

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]. 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 two challenges: how to measure school management accurately and cost-effectively at scale across schools and countries; and how to explain any observed relationship between school management and learning outcomes in a way that elucidates the underlying mechanisms to guide policy. This paper addresses both of these challenges.

Our first contribution is to develop a new approach to measurement that can, in principle, be used with any existing public dataset containing items about school management. We illustrate using two public datasets as 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 "state of the art", but expensive, World Management Survey (WMS) in Bloom et al. [2015a]. We show how questions from these public surveys can be classified into WMS topics (53 PISA questions into 14 WMS topics and 33 Prova Brasil questions into 8 WMS topics), how the responses can be coded using the WMS scoring rubric, and finally how these grades can 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. These 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.[1] All three indices, WMS, PISA, and Prova Brasil, show a strong, positive (within-country) correlation between school management and student learning outcomes, echoing recent causal evidence from randomized controlled trials in the U.S. [Fryer, 2014, 2017].

Our second contribution is to develop a framework to explore why management matters for schools. We set out, in general terms, how the impact of school management can be decomposed into learning gains that arise because given actors (teachers, students and parents) become more productive, and learning

[1] For example, see Wössmann [2016] for a review of education systems research using large, cross-country surveys.

gains that arise because different actors join the school. To explore why these incentive and selection effects might arise, we turn to a specific model that captures key features of education systems in Latin America.

This model has two main building blocks. The first is the education production function: we assume that student learning depends on teacher ability, teacher effort, and household effort. The second is the impact of management practices where, considering the personnel policy restrictions the public sector faces, we distinguish between operations and people management. Good people management practices enable managers to observe and contract on the performance of their employees, as well as to cultivate the intrinsic motivation of their staff. Good operations management practices enable managers to use resources efficiently and hence offer a higher level of teacher compensation and a more stimulating environment for students.[2]

Our framework predicts that good people management practices increase expected test scores through two channels. A teacher with a given ability and intrinsic motivation to teach exerts more effort because these practices provide extrinsic, and cultivate intrinsic, incentives. Compounding this, good people management practices improve selection: a teacher with high ability and high intrinsic motivation prefers a school with performance pay over alternative employments because she anticipates that she will work hard and be rewarded for producing student learning. We focus on Latin American countries and find support for both mechanisms in our PISA data. Principals in schools with higher PISA-based people management scores (predominantly private schools) are less likely to report experiencing teacher shortages and also report higher levels of teacher motivation and effort, compared to principals in schools with lower PISA-based people management scores.

Our framework also predicts that good operations management practices increase expected test scores through two channels. There is no teacher incentive effect but the selection effect remains, now driven by the level rather than structure of compensation. This is reinforced by a household incentive effect that arises because strong operations management practices encourage both students and parents to increase their inputs. We also find evidence of these mechanisms in our PISA data for Latin America. Principals in public schools with higher PISA-based operations management scores are less likely to report experienc-

[2] This assumption echoes the observation made by Baker et al. [1988] that compensation plans featuring explicit financial rewards seldom account for all of a worker's rewards.

ing teacher shortages and also report higher levels of teacher motivation, teacher effort and household effort, compared to principals in public schools with lower PISA-based operations management scores.

While this is not definitive causal evidence, this combination of theory and descriptive empirical analysis offers a novel insight into why management matters in schools and we therefore move on to consider policy implications. 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. That is, these people management practices help to attract, develop and reward good performers, and, our analysis suggests, should improve both teacher selection and incentives.

There is also substantial variation in the strength of operations management practices within the public sector. This suggest a role for government to encourage principals in public schools with weak operations management to follow best practices. Specific areas suggested by our analysis 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.

Related literature. Our first contribution—a new approach to measure management practices in schools—relates to two bodies of work. The first is the literature that has evolved since the creation of the WMS dataset first described in Bloom and Van Reenen [2007]. The WMS methodology has been adapted to a range of public sector institutions, including schools and universities [Bloom et al., 2015a, McCormack et al., 2014], healthcare facilities [Bloom et al., 2015b, 2019b], social programs [Delfgaauw et al., 2011, McConnell et al., 2009], and the civil service [Rasul and Rogger, 2016], as well as to low-income settings [Lemos and Scur, 2016]. However, it is expensive and time-consuming to implement at scale; our approach is a feasible alternative. The second is the literature studying the role of education systems and institutions in determining student performance across countries [Wössmann, 2016]. Many recent papers use PISA data and have looked at this issue through the lens of autonomy [Hanushek et al., 2013, Wössmann et al., 2007], competition [West and Wössmann, 2010], student tracking [Hanushek and Wössmann, 2006, Ruhose and Schwerdt, 2016], external exams [Wössmann, 2005], and instructional time [Lavy, 2015]. Our PISA-based index enables researchers to consider school management in such studies.

Our second contribution—a framework to explain why management matters in schools—relates to the literature in personnel economics exploring incentives and selection. These channels have featured in prior work seeking to explain the performance of private sector employees [Bender et al., 2018, Cornwell et al., 2019, Lazear, 2000], public sector employees [Finan et al., 2017, Prendergast, 2007] and politicians [Besley, 2004, 2006, Gagliarducci and Nannicini, 2013, Martinez-Bravo, 2014]. Most closely related is Lazear [2003], who emphasises the potential selection margin of teacher performance pay, albeit without fully working up a formal model.[3] A selection margin also features in the dynamic occupational model of Rothstein [2015] and the Roy model of Biasi [2019]. We study a wider range of management practices (beyond just performance pay) and provide an intuitive decomposition of the impact of these practices on student learning into incentives and selection.

The remainder of this paper is organized as follows. In Section 2, we set out our approach to measure management practices in schools, illustrating with the construction and validation of PISA-based and Prova Brasil-based management indices. In Section 3, we describe our theoretical framework, its testable predictions, a series of corroborative descriptive analyses from across Latin America, and the policy implications of these results. Section 4 concludes.

[3] See also Dohmen and Falk [2010] who briefly sketch out theoretical reasons why fixed wage contracts and piece rates might be expected to have different impacts on sorting by ability.

2 How to measure management in schools?

Until the early 2000s, management was typically viewed as an unmeasurable productivity shifter, to be relegated to the residual in any performance regression [Bloom and Van Reenen, 2007]. Since then, improvements in survey methodology and data access have allowed for advances in measurement. The current "state of the art" approach uses a dedicated survey—the World Management Survey (WMS)—to measure establishments' adoption of structured management best 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 [Bloom et al., 2016]. In view of these costs, it may not be well-suited to every context.

In this section, we propose an alternative three-step approach than can, in principle, be used with any existing public dataset containing information on management practices. The first step is to use the original WMS phone survey as a benchmark, and to look for questions in the public survey that elicit information on the management practices already measured by the WMS.[4] The second step is to code answers in line with the WMS methodology. And the final step is to create a management index. In Section 2.1, we provide a brief overview of the WMS questions and coding. In Section 2.2, we describe our approach using two existing public datasets as examples: PISA and the Brazilian school census survey, Prova Brasil. Since Brazil and several other PISA countries are part of the Bloom et al. [2015a] sample, we can compare the (within-country) distribution of each index with the corresponding (within-country) distribution of the WMS index. Both indices are well-validated and can therefore 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 experi-

[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., 2019a]. 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.

[5] See Bloom and Van Reenen [2007] for the survey's inception and Bloom et al. [2016] for a recent review.

enced on the survey methodology. Following its successful implementation in the private sector, the WMS was subsequently extended to public sector organizations [Bloom et al., 2015a, 2019b]; 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 consistent 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. [2015a] show that their school management score is strongly positively correlated with school-level student outcomes across 6 WMS countries (Brazil, Canada, India, Sweden, UK and US).[6] 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.

[6] We replicate the primary figure from Bloom et al. [2015a] in Figure B.3 in Appendix B. It plots the school-level student learning outcomes by each quartile of school management score.

2.2 A new approach using existing public datasets

We now describe our approach, illustrating with the examples of PISA and Prova Brasil.[7].

Construction. In 2012, alongside its famous student proficiency tests, PISA ran school principal surveys across 65 countries which included a wide-range of questions on both operations and people management.[8] As a first step, we classified each of the PISA questions that could fall under one of the WMS topics, identifying 53 PISA questions that fit into 14 of the WMS topics.[9] As a second step, we manually assigned scores for each of these PISA questions following the spirit of the scoring grid of the WMS and the US Census Management and Organizational Practices Survey (MOPS). As a final step, we built the overall management index, and the operations and people management sub-indices, following Anderson [2008]. This methodology weights the impact of the included variables by the sum of their row in the inverse variance-covariance matrix, thereby assigning greater weight to questions that carry more "new information".[10]

PISA data is excellent for cross-country analysis, but it precludes in-depth analyses within countries as the sample of schools per country is typically small and does not include the necessary identifiers. Many countries, however, conduct their own national detailed surveys with school principals, teachers, and students in addition to administering standardized tests across grades. Latin America is particularly prolific: for example, Brazil's Prova Brasil, Colombia's SABER, Chile's SIMCE, and Peru's ECE are all available to researchers. These questionnaires provide rich information about practices at the school, as reported by a range of actors. In addition, the samples are usually large (often census-based) and contain school identifiers, thereby enabling researchers to explore heterogeneity and answer a wide range of policy-relevant questions. We illustrate how our approach can be applied widely to other national surveys using the example of Prova Brasil. This national survey plays a significant role in Brazil's education policy because its test results, along with promotion, dropout, and retention rates, are the main inputs to the Índice de Desenvolvimento da Educação Básica (IDEB), a national index representing educational quality at the school,

[7] We provide details to enable replication in Appendix C

[8] Our main focus is on the 2012 data because that survey wave contains a richer set of questions, particularly relating to people management. See Appendix C for a mapping of the 2015 PISA data.

[9] The set of WMS topics that had matching PISA questions is detailed in Appendix C.

[10] We also built the indices using alternative methods (straightforward standardization, factor analysis, and factor analysis with Bartlett correction) which yielded similar results.

municipality, and state levels.

We followed the same steps to create a Prova Brasil-based management index: we classified 33 questions (14 from the principal questionnaire and 19 from the teacher questionnaire) into 8 WMS topics, coded responses following the same rubric, and used the Anderson [2008] method to build a school management index.

Potential concerns. One of the key differences between the WMS survey and PISA or school census surveys is that the WMS is administered and analyzed by an independent interviewer, while the latter surveys are self-reported. There are a number of issues with self-reported data: for example, problems with translation and interpretation, and/or measurement equivalence. To address measurement error of cross-cultural understandings and norms on answering questions in our PISA index, 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) correlation between management and other variables for a far wider set of countries than was previously possible.[11] This is not a concern for country-specific national surveys.

Another concern with self-reported data is that it is difficult to assess whether respondents are being accurate and truthful. In the WMS there are several 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. We address this issue by focusing on the topics that have a direct equivalent in the WMS to allow for a clear benchmark for our new index. If principals are reporting "good" information in these surveys that allow us to capture similar signals as the WMS scores, we should see similar distributions of scores across the common countries and a similar overall relationship between management and student test scores across countries. For PISA, we compare the distribution of scores and the performance correlations for the common 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

[11] In the 2012 PISA the 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]).

the index standardized values.

Validation of new indices. As a first validation exercise, we compare the distribution of our PISA-based management index with the distribution of school management as measured by the WMS data in Figure 1 for all countries that the WMS has collected data.[12] 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.[13]

As a second validation exercise, and to ensure we are picking up important variation with our management index, we conduct a basic check of the correlation between our measure and student performance. For each country we separate schools into quartiles of the management measure, and in Figure 2 we 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 simple relationship suggests that students in schools in the bottom quartile of management within their country score are, on average, about 6 points lower than the PISA global mean, while students in schools in the top quartile of management within their country score, on average, about 5.5 points higher than the PISA global mean. To put this into context, 41 PISA points in math are the equivalent of a year of learning. 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).

Unlike PISA, the data in Prova Brasil includes school identifiers that allow for a one-to-one match with the schools surveyed in the 2013 WMS wave.[14] In total, we have 262 matched schools in the public sector. We use this matched sample in Figure 3 where we show a school-level binned scatter plot of WMS management score against the Prova Brasil-based management score. There is a positive and significant correlation of 0.19, suggesting reasonable internal validation of the Prova Brasil index. As with the PISA index, we repeat the exercise of correlating the new index with student performance in secondary schools and find the same pattern (see Figure 4).

[12] Independent researchers conducted the WMS in Colombia and Mexico during 2015, with guidance and supervision from the original WMS team. These data were not available to Bloom et al. [2015a]. India is not included in Figure 1 because it did not participate in PISA in 2012.

[13] We show comparisons between the WMS and PISA sub-indices for operations management in Figure B.1 and people management in in Figure B.2 in Appendix B and confirm that the distributions are consistent for both sub-indices.

[14] Prova Brasil was also administered in 2013.

In Table 1 we formalize these relationships by reporting the average correlations between student learning and our management indices. For the student-level PISA dataset, we run OLS regressions via the OECD's repest Stata command, which uses the five available test score plausible values for each student and subject. 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.[15] In the PISA specifications we include country fixed effects, and successively introduce school controls (dummies for school location, student-teacher ratio, log of the number of students, share of government funding relative to total funding the school receives, and ratio of computers connected to the web used as a proxy for school resources) and then student controls (gender, grade, socio-economic status and immigration status). All panels use the same sample but have different subject outcome variables. The R-squared for each set of regressions is reported within each panel, while the common sample characteristics and controls included are reported at the bottom of the table. Column (1) shows the raw relationship between the PISA-based school management index and student performance, only controlling for country fixed effects. The raw relationship ranges from just over 4 to almost 5 points on the PISA scale.[16] Recall that 41 points on the PISA scale for math is equivalent to about one year of learning, and thus the raw correlation is equivalent to about one month of learning for math (similar for the other subjects). Column (2) includes school controls, which absorb little of the variation, and Column (3) shows the fully-specified regression including student controls. These controls account for a further point in the student performance. While we refrain from ranking management indices across countries, Figure 5 plots the coefficients of country-level regressions of management on PISA math test scores using the specification of Column (1). The estimation loses precision once we restrict to individual country samples but still broadly supports the positive relationship found in Table 1.

For the Prova Brasil student-level dataset, we run standard OLS regressions, also clustering the standard errors at the school level. Results are reported in standard deviations. In these Prova Brasil specifications, we include state fixed effects, and successively introduce school controls (student-teacher ratio, log of the number of students, dummy variables indicating the presence of an IT lab, science lab, and library, a dummy for male principals, dummies for educational attainment, and dummies for experience as principal), and then student controls (gender, race, socio-economic status, and mothers' educational attain-

[15] See Jerrim et al. [2017] for a thorough review of how to best use PISA scores and survey weights.
[16] PISA is standardized across years and countries such that the mean is 500 and the standard deviation is 100.

ment). Column (4) shows the raw relationship between the Prova Brasil-based school management index and student performance, only controlling for state fixed effects. One standard deviation higher score in the management index is strongly correlated with 0.068 standard deviations higher Portuguese scores and 0.078 standard deviations higher math scores. Column (5) shows that including school characteristics absorbs very little of the variation, while Column (6) shows that including student characteristics absorbs only slightly more. The fully specified regression supports the general positive relationship between the school management index and student performance.

3 Why does management matter in schools?

There are myriad uses of our new indices. In this paper, we push the frontier of understanding the mechanisms behind the management and performance relationship by focusing on teachers. Our aim is not to provide a theoretical contribution per se, but rather to formalize a policy discussion 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, and in particular the dynamics of the public and private sector — and the type of private sector offerings — are different across countries. In some contexts, private schools target affluent households, and jobs in private schools are often seen as more attractive than public sector jobs, 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 focus our model and empirical test on one particular regional system: Latin America. We choose Latin America because its education systems are reasonably homogeneous across countries in terms of the character of public and private schools. Specifically, the private school system caters to the middle (and upper) classes and accounts for about one-fifth of high school students. Private schools tend to be better funded (via costly school fees) and in turn pay higher teacher salaries and offer

better facilities. Public schools, on the other hand, are often poorly funded and operate in highly centralized environments. Teacher pay is set on a rigid scale dictated by strong unions. Focusing on a region that has such systems makes the applied theory exercise substantially less complex, and the prevalence of large-scale national surveys in the region opens many possibilities for future empirical work.

Table 2 reports the correlation exercise in Columns (1) to (3) of Table 1 for Latin American countries only, and confirms that the relationship between management and student performance is strong in the region. Further, the coefficient on private schools indicates that students in private schools achieve higher scores, by about 55 points, than students in public schools. This affords a suitable empirical environment to study the channels that we are interested in this section.

3.1 Overview of the theoretical framework

The analysis is built around a student-level education production function. A common, general formulation is $y = A(L, K) + \varepsilon$ where y is a measure of student learning, L and K are respectively labour and physical capital inputs into the student's education, A is a (school-specific) productivity parameter, and ε is an error term. Here, we specialize to $y = \theta\ e + a + \varepsilon$, where θ is teacher ability, e is teacher effort, and a is household (student and/or parent) effort. That is, we enrich the specification of labour to allow for (additively separable) teacher and household inputs but abstract from the role of physical capital and school-level productivity.[17] Using a theoretical framework built around this education production function, we show that school management structures can impact student learning outcomes via the following three channels:

1. Teacher selection: schools with high management scores offer compensation packages that select in more able (higher θ) and more intrinsically motivated (lower effort cost) teacher types.

2. Teacher incentives: schools with high management scores offer compensation packages that extrinsically incentivize, and adopt practices that intrinsically motivate, more effort from any given teacher type that selects in.

[17] In principle, parents could play a further role by selecting between schools. Since our PISA data cannot speak to this issue, we leave the analysis of management-induced household selection for future work. Note that we assume management practices change effective labour inputs. In their study of the IT industry, Schivardi and Schmitz [2019] assume that management is an additional input, alongside capital and labour, in an approach that they term "management as a production technology".

3. Household incentives: schools with higher management scores institutionalize a strong work ethic and culture of high achievement among students and encourage greater parental involvement within the school (higher a).

In Section 3.2, we present a simple model that suffices to make the points above. In Section 3.3 and Section 3.4 we explain, intuitively, how the above selection and incentive effects are driven by people management and operations management. Then, in Section 3.5 we draw together these results and discuss implications for policy. We also briefly comment on how predictions would change in an alternative model featuring 'low-cost private schools'.

3.2 The model

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.

Preferences. 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 with density function f. 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 people 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 differences within classes 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.

Performance metrics. 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 be thought of as the realization of a random variable with density function g, and which is drawn independently 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 $U\left[\underline{\varepsilon}, \overline{\varepsilon}\right]$. At times, for the purposes of illustration, we also assume a specific (uniform) distribution for θ, as part of a numerical example that we discuss at the end of this section.[18]

Compensation schemes. Schools offer either a performance-pay contract or a fixed wage contract. Under the former, the teacher receives a base wage of W plus a bonus B if her performance exceeds a threshold $\bar{y}$. Under the latter, the teacher simply receives a base wage of G. The outside sector offers a performance-pay contract with a low base wage (normalized to zero) and a bonus β if performance exceeds a threshold $\bar{z}$.

The impact of management practices. We assume that people management has two effects. The first relates to the structure of compensation: good people management practices enable managers to observe, and contract on, the performance of their employees—i.e. to offer a performance-pay contract. The second relates to teacher motivation: good people management practices enable managers to cultivate the intrinsic motivation of their staff—i.e. to increase Δ. We assume that operations management also has two effects. The first relates to the level of compensation: good operations management practices free up resources and enable managers to offer a higher level of base pay. The second relates to household effort: good operations management practices help to create a stimulating environment for students and parents —i.e. to increase γ.

We classify schools into three management types: high (strong people and strong operations management), intermediate (weak people but strong operations management), and low (weak people and weak operations management). Performance metrics are indexed accordingly by $i = H, I, L$. We assume that high management schools are found exclusively in the private sector, while the public sector consists of a

[18] Note that the basic production function is the same across schools; management practices matter by affecting which θ-types are hired, the teacher's choice of e (which depends on which τ-types are hired), and the household's choice of a.

mix of intermediate and low management schools. This implies that performance-pay contracts are only offered by private schools (and the outside sector). Figure 6 provides evidence that this key assumption is well-supported in our PISA data. Here, we plot empirical cumulative distribution functions (CDFs) of the PISA-based people management score by sector and find that the private sector CDF (dashed blue plot) clearly first order stochastically dominates the public sector CDF (solid red plot).[19]

Timing. The timing of the game is as follows.

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 structures 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.[20]
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.

Numerical example. At times in the analysis below, we will invoke specific distributional and parameter assumptions. In this numerical example, teacher intrinsic motivation is distributed $\tau \sim U[0, 10]$, and teacher ability is distributed $\theta \sim U[1, 5]$. These random variables are independent of each other and the error term in the production functions. In a high management private school: teacher pay is $W + B = 55$ if $y_1^H \geq 4.5$ and $W = 15$ otherwise, and the motivational increments are $\Delta = 0.5$ and $\gamma = 2$. In an intermediate management public school teacher pay is $G = 35$, and the motivational increments are $\Delta = 0$ and $\gamma = 2$. And in a low management public school: teacher pay is $G = 30$, and the motivational increments are $\Delta = 0$ and $\gamma = 1$. Pay in the outside sector is $\beta = 50$ if $z \geq 1$ and 0 otherwise.

[19] We show empirical CDFs by country in Latin America in Figure B.4 in Appendix B. The private sector CDF first order stochastically dominates the public sector CDF in Colombia, Peru, Costa Rica and Mexico.

[20] In assuming this timing, we abstract from applicant choice between schools in the public sector. As Table B.4 and B.5 in Appendix B, the degree to which teachers can choose among public schools varies across Latin America, yet our model generally fits the reality in these countries.

Our interest lies in establishing the impact of management practices on student learning via teacher occupational choice and effort level, and household effort level. We do not model the government's assignment rule, or the school principal's choice of management structure, simply treating these as exogenous parameters. The model is straightforward to solve (see Appendix A for details) and yields the insights summarized in the next two sections.

3.3 The impact of good people management

In this subsection, we use the theoretical framework to give a possible explanation for why schools with good people management may produce better student outcomes. In Section 3.3.1, we decompose the test score gain from people management into two effects: teacher selection and teacher incentives. If this decomposition is correct, then we should see evidence of these mechanisms in intermediate school outcomes. We develop this argument, and present corroborative evidence from our PISA dataset, in Section 3.3.2.

3.3.1 Decomposing the test score gain into teacher selection and incentives

A school of management type i hires the teacher if, given her (τ, θ) type, she expects to receive a higher payoff teaching in this school compared to other schools or working in the outside sector. Let the set of (τ, θ) types hired by a school of management type i be denoted by $\mathcal{T}^i$. The expected learning outcome of a representative student (i.e. ex ante, prior to occupational and effort choices) can therefore be written as

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

where $1_{\{(\tau,\theta)\in\mathcal{T}^i\}}$ and $1_{\{[(\tau,\theta)\notin\mathcal{T}^i\}}$ 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 score across high and intermediate management schools—that is, the impact of people management holding operations management constant—can be written as

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

where the equality follows from the fact that people management only impacts test scores when the teacher is hired (the effect of household effort and the error term difference out). It is helpful to decompose this difference as follows

$$\begin{aligned}&\mathrm{E}\left[y^H\right]-\mathrm{E}\left[y^I\right]= \\ &\qquad\underbrace{\mathrm{E}\left[(y_1^H-y_1^I)\cdot 1_{\{(\tau,\theta)\in\mathcal{T}^H\}}\right]}_{\text{teacher incentives}}+\underbrace{\mathrm{E}\left[y_1^I\cdot\left(1_{\{(\tau,\theta)\in\mathcal{T}^H\}}-1_{\{(\tau,\theta)\in\mathcal{T}^I\}}\right)\right]}_{\text{teacher selection}}.\end{aligned} \tag{1}$$

The first term on the RHS of equation (1) captures what we will term the teacher incentive effect of good people management practices. Here, we compare the expected test score outcome in a high management private school with a teacher in the event that the teacher is hired to such a school against the expected test score outcome in an intermediate management public school with a teacher in the counterfactual event that the teacher is hired to a high management private school. In this way, we hold the set of (τ,θ) types fixed and just consider how the incentive environment produces test scores.

In Lemma 1 in Appendix A, we derive teacher effort in high and intermediate management schools. Respectively, these are $e^H=\frac{\theta\, B}{2(\overline{\varepsilon}-\underline{\varepsilon})}+\frac{\tau+\Delta}{2}$ and $e^I=\frac{\tau}{2}$. Substituting, we can write the first incentive term in (1) as

$$\begin{aligned}&\mathrm{E}\left[(y_1^H-y_1^I)\cdot 1_{\{(\tau,\theta)\in\mathcal{T}^H\}}\right]= \\ &\int\int\theta\left(\frac{\theta\overbrace{B}^{\text{extrinsic}}}{2(\overline{\varepsilon}-\underline{\varepsilon})}+\frac{\overbrace{\Delta}^{\text{intrinsic}}}{2}\right)\cdot 1_{\{(\tau,\theta)\in\mathcal{T}^H\}}\;\; f(\theta)g(\tau)d\theta d\tau.\end{aligned} \tag{2}$$

We see from this expression that there are two teacher incentive channels. Part of the reason that test scores are higher in schools with good people management practices is because any given (τ,θ) type exerts more effort due to: (i) an extrinsic incentive from the bonus B, and (ii) additional intrinsic motivation arising via the shift term Δ.

The second term in equation (1) captures what we will term the teacher selection effect of good people management practices. Here, we compare the expected test score outcome in an intermediate management public school with a teacher in the event that the teacher is hired to such a school against the expected test score outcome in an intermediate management school with a teacher in the counterfactual

event that the teacher is hired to a high management school. In this way, we hold the incentive environment fixed and just consider how the selection of (τ, θ) types produces test scores. Substituting for e^I, we can write this second selection term as

$$\mathrm{E}\left[y^I \cdot \left(1_{\{(\tau,\theta)\in\mathcal{T}^H\}} - 1_{\{(\tau,\theta)\in\mathcal{T}^I\}}\right)\right] =$$
$$\int\int \overbrace{\theta}^{\text{ability}} \left(\frac{\overbrace{\tau}^{\text{effort}}}{2}\right) \cdot \left(1_{\{(\tau,\theta)\in\mathcal{T}^H\}} - 1_{\{(\tau,\theta)\in\mathcal{T}^I\}}\right) \quad f(\theta)g(\tau)d\theta d\tau. \tag{3}$$

We see from this expression that there are also two selection channels. A further part of the reason that test scores are higher in schools with good people management practices is because: (i) the τ-types selected in are intrinsically motivated to exert more effort, and (ii) the θ-types selected in are of greater ability.

To see this, consider the numerical example illustrated in Figure 7. In the top panel, the grey shaded area depicts the set of (τ, θ) types that are hired by a high management private school. The unshaded area depicts the set of (τ, θ) types that are hired by an intermediate management public school. It is clear that the intermediate management public school experiences negative selection on both dimensions. More able teachers prefer the performance-contingent compensation schemes available either in private schools or the outside sector. And more intrinsically motivated teachers prefer private schools because they anticipate exerting higher effort (and hence higher pay).

3.3.2 Predictions for intermediate school outcomes and evidence from PISA

Our theoretical framework suggests two mechanisms, teacher selection and teacher incentives, that could explain the positive correlation between people 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 intermediate school outcomes. In this section, we set out these predictions and then explore empirically whether they hold in our PISA data for Latin America.[21]

[21] These predictions are based on the numerical example illustrated in Figure 7 and are derived (via numerical integration) in Remarks 1 and 2 in Appendix A. We present the main results with our preferred specification, but include additional variations of the main explanatory variable in Table B.3 in Appendix B. The results are robust to alternative specifications.

Teacher shortages. The probability of hiring the teacher in a high management private school is higher than the probability of hiring the teacher in an intermediate management public school (via teacher selection). In the numerical example shown in the top panel of Figure 7, the area of the grey region is bigger than the area of the unshaded region.

The PISA dataset does not contain objective information on school-level vacancies, so we use a series of 4 questions in the school principal questionnaire that ask the principal whether he/she feels that the school's capacity is hindered by a lack of qualified teachers in each of math, science, language and 'other subjects'.[22] It is worth emphasising that these questions are open to considerable interpretation. For instance, a principal might answer 'a lot' because he/she feels that the school needs more new posts even if there are few vacancies for existing posts. Conversely, he/she might answer 'not all' because of a belief (or desire to say) that the school is coping despite there being vacancies.[23]

With this caveat in mind, it can still be instructive to examine the data. Column (1) of Table 3 shows that, consistent with the theory, the teacher shortage index is 0.535 standard deviations lower among private schools than public schools, significant at the 1 percent level. Column (4) repeats the specification but with the people management index instead of the private school dummy. The relationship is consistently negative, suggesting that a one standard deviation increase in the people management index is correlated with 0.062 lower teacher shortage in schools, marginally significant at the 10 percent level.

Teacher motivation. The expected intrinsic motivation of a teacher hired to a high management private school is higher than the expected intrinsic motivation of a teacher hired to an intermediate management public school (via teacher selection and augmentation of teacher intrinsic motivation). In the numerical example in the top panel of Figure 7, the vertical height of the black point is greater than the vertical height of the blue point.

We explore this prediction by using the school climate section of the school principal questionnaire (questions relating to the perception of teachers' expectations of their students and meeting student needs, as well as the morale, enthusiasm, pride and valuation of academic achievement) to construct an index of

[22] We describe how this teacher shortage index, and the other intermediate outcome indices for teacher motivation, teacher effort, and household involvement, are constructed in Appendix C. All indices are standardized.

[23] Consistent with this, by far the most common answer given by principals in both sectors is 'not at all', as reflected in the density of the standardized score in Figure B.5 in Appendix B.

teacher motivation. Column (2) of Table 3 shows that, consistent with the theory, the teacher motivation index is 0.591 standard deviations higher among private schools than public schools, significant at the 1 percent level. Using the people management index also yields a consistent relationship, shown in Column (5). The coefficient suggests a one standard deviation higher people management score is associated with 0.238 higher teacher motivation score, also significant at the 1 percent level.

Teacher effort. The expected effort level of a teacher hired to a high management private school is higher than the expected effort level of a teacher hired to an intermediate management public school (via teacher selection, extrinsic teacher incentives, and augmentation of teacher intrinsic motivation on-the-job)

$$\mathrm{E}\left[\frac{\theta B}{2(\bar{\varepsilon}-\underline{\varepsilon})}+\frac{\tau+\Delta}{2}\middle|(\tau,\theta)\in\mathcal{T}^{H}\right]>\mathrm{E}\left[\frac{\tau}{2}\middle|(\tau,\theta)\in\mathcal{T}^{I}\right].$$

We explore this prediction by using the school climate section of the school principal questionnaire (questions relating to how often teachers are absent, late and/or unprepared) to construct an index of teacher effort. Column (3) of Table 3 shows that, consistent with the theory, the teacher effort index is 0.792 standard deviations higher among private schools than public schools, significant at the 1 percent level. Column (6) reports the same specification for the people management index, suggesting that a one standard deviation increase in the management score is associated with 0.074 higher teacher effort, significant at the 5 percent level.. For completeness, Figure 8 plots the coefficients for country-level regressions using the same specifications reported in Columns (4) to (6) of Table 3. While there is some variation across countries, the results broadly hold.

3.4 The impact of good operations management

In this subsection, we use the theoretical framework to give a possible explanation for why schools with good operations management may produce better student outcomes. In Section 3.4.1 we decompose the test score gain from operations management into three effects: teacher selection, teacher incentives and household incentives. If this decomposition is correct, then we should see evidence of these mechanisms in intermediate school outcomes. We develop this argument, and present corroborative evidence from our PISA dataset, in Section 3.4.2.

3.4.1 Decomposing the test score gain into teacher selection, teacher incentives, and household incentives

The difference in expected test scores across intermediate and low management public schools—that is, the impact of operations management holding people management constant—is

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

Letting a^I and a^L respectively denote household effort in these schools, and using the same decomposition as before, we can rewrite this difference as

$$\mathrm{E}\left[y^I\right] - \mathrm{E}\left[y^L\right] = \underbrace{\mathrm{E}\left[y_1^L \cdot \left(1_{\{(\tau,\theta)\in\mathcal{T}^I\}} - 1_{\{(\tau,\theta)\in\mathcal{T}^L\}}\right)\right]}_{\text{teacher selection}} + \underbrace{a^I - a^L}_{\text{household incentives}}. \tag{4}$$

There is no teacher incentive term because both extrinsic teacher incentives and augmentation of teacher intrinsic motivation depend on people management and this is assumed to be constant across these schools. We can write the teacher selection term as:

$$\begin{aligned}&\mathrm{E}\left[y^L \cdot \left(1_{\{(\tau,\theta)\in\mathcal{T}^I\}} - 1_{\{(\tau,\theta)\in\mathcal{T}^L\}}\right)\right] = \\ &\int\int \overbrace{\theta}^{\text{ability}} \left(\frac{\overbrace{\tau}^{\text{effort}}}{2}\right) \cdot \left(1_{\{(\tau,\theta)\in\mathcal{T}^I\}} - 1_{\{(\tau,\theta)\in\mathcal{T}^L\}}\right) \quad f(\theta)g(\tau)d\theta d\tau.\end{aligned} \tag{5}$$

Again, there are two teacher selection channels. Part of the reason that test scores are higher in schools with good operations management practices is because: (i) the τ-types selected in are intrinsically motivated to exert more effort, and (ii) the θ-types selected in are of greater ability.

To see this, consider the numerical example illustrated in Figure 7. The unshaded area in the top panel depicts the set of (τ, θ) types that are hired by an intermediate management public school, while the unshaded area in the bottom panel depicts the set of (τ, θ) types that are hired by a low management public school. It is clear that the intermediate management public school hires both more and better types.

In contrast to the people management case, there is a channel operating via household incentives. A fur-

ther part of the reason that test scores are higher in schools with good operations management practices is because households (students plus parents) exert more effort due to additional intrinsic motivation arising via the shift term γ.

3.4.2 Predictions for intermediate school outcomes and evidence from PISA

Again, we set out predictions relating to intermediate school outcomes (see Remark 2 in Appendix A), and then explore empirically whether they hold in our PISA data.[24]

Teacher shortages. The probability of hiring the teacher in an intermediate management public school is higher than the probability of hiring the teacher in a low management public school (via teacher selection). In the numerical example shown in Figure 7, the unshaded area is larger in the top panel relative to the bottom panel.

We take this prediction to the data using the 4 questions in the PISA school principal questionnaire that ask the principal whether they feel that the school's capacity is hindered by a lack of qualified teachers (see Appendix C). Column (1) of Table 4 shows a negative and statistically significant correlation between the operations management index and the teacher shortage index. A one standard deviation increase in operation score is associated with a 0.076 standard deviation decrease in the teacher shortage index, significant at the 10 percent level.

Teacher motivation. The expected intrinsic motivation of a teacher hired to an intermediate management public school is higher than the expected intrinsic motivation of a teacher hired to a low management public school (via teacher selection). In the numerical example shown in Figure 7, the vertical height of the blue point in the top panel is greater than the vertical height of the orange point in the bottom panel.

Column (2) of Table 4 shows that, consistent with the theory, the partial effect of operations score on the teacher motivation index is positive and significant at 1 percent; a one standard deviation increase in op-

[24] We present the main results with our preferred specification, but include additional variations of the main explanatory variable in Tables B.2 in Appendix B. The results are robust to alternative specifications.

eration score is associated with a 0.238 standard deviation increase in the teacher motivation index, significant at the 1 percent level.

Teacher effort. The expected effort level of a teacher hired to an intermediate management public school is higher than the expected effort level of a teacher hired to a low management public school (via teacher selection)

$$\mathrm{E}\left[\tfrac{\tau}{2}\middle|(\tau,\theta)\in\mathcal{T}^{I}\right]>\mathrm{E}\left[\tfrac{\tau}{2}\middle|(\tau,\theta)\in\mathcal{T}^{L}\right].$$

Column (3) of Table 4 shows that one standard deviation higher operations score is correlated with 0.076 standard deviations higher teacher effort, significant at the 5 percent level.

Household effort The expected level of household effort in an intermediate management public school is higher than the expected level of household effort in a low management public school (via augmentation of student intrinsic motivation): $a^{I}>a^{L}$.

We explore this prediction by using the school climate section of the school principal questionnaire to construct an index of household effort, combining student behavior questions (relating to how often students are truant, late, disrespectful and/or disruptive) and parental involvement questions (relating to the extent to which parents: are interested in, and discuss, their child's progress and behaviour; volunteer for school activities; and participate in school governance or other forms of accountability). Column (4) of Table 4 shows that, consistent with the theory, one standard deviation higher operations management score is correlated with 0.160 higher household effort, significant at the 1 percent level. For completeness, Figure 9 plots the coefficients for country-level regressions using the same specifications in Columns (1) to (4) in Table 4. Again, the results broadly hold at country-level.

3.5 Summary of theoretical prediction

We developed a simple theoretical framework, built around a student-level education production function, to explore why management practices might matter in schools. Using this framework, we showed that people management practices may be contributing to higher student test scores through two channels: teacher selection and teacher incentives. The predictions that these channels imply for intermedi-

ate school outcomes—fewer teacher shortages, higher teacher motivation, and higher teacher effort in schools with strong people management than in schools with weak people management—are all well-supported in our PISA data for Latin America.

We also showed that operations management practices may be contributing to higher student test scores via two channels: teacher selection and household incentives. The empirical support for the predictions that these channels imply for intermediate school outcomes—fewer teacher shortages, higher teacher motivation, higher teacher effort, and higher household effort in schools with strong operations management than in schools with weak operations management—is also strong.

While this does not represent definitive causal evidence, this combination of theory and descriptive empirical analysis offers an insight into why management appears to matter in schools and so we cautiously move on to policy. For example, what type of school management practices might be changed to drive improved student learning? Our analysis suggests that people management is a good place to start. While it may not be feasible (on political or budgetary grounds) for governments to introduce performance pay in public schools, it may be possible to conduct assessments to judge teacher effectiveness, and for these appraisals to lead to changes in public recognition, and to opportunities for professional development, likelihood of career advancement, and greater responsibilities and leadership. Such practices also reward and develop good performers and create a good employee proposition and could improve both teacher selection and incentives.

Beyond the difference in people management across private and public sectors, a striking feature of the PISA data is that there is substantial variation in the strength of operations management practices within the public sector. Some public schools are adopting management practices that appear to be driving student learning, while others within the same public education system are not. This suggests a role for government to encourage schools with weak operations management to follow best practice. As we observe from our mapping exercise, 'strong' operations management practices do two things, they: actively promote quality of delivery in the classroom (e.g. via personalization of learning, and encouragement to follow best educational practice); and put processes in place to review school performance and drive change (e.g. dialogue and meetings focused on continuous improvement, collection and use of student assessment data). Such practices could be adopted more widely in the public sector and, our analysis suggests, should improve both teacher selection and household incentives.

To be sure, our goal has not been to produce a global theory; given the diversity of real-world education systems, we have deliberately focused on one region, Latin America, and developed a theoretical framework for that context. One could adapt this framework to study different settings, for instance South Asia and parts of East Africa where there is a preponderance of 'low-cost private schools'. Such a model would need to allow for the possibility of 'queues' for jobs in public schools and, as a result, to explicitly model demand-side selection. To the extent that strong management practices enable public school principals to offer higher levels of compensation and then choose motivated and able teachers from the resulting queue, then qualitatively similar predictions would likely still apply. We hope that our new index will enable fertile ground for further research.

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, it has been suggested that part of this variation in learning might stem from differences in school management. 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.

This paper has responded to these observations by developing new approaches to measurement, as well as a simple theoretical framework that captures key features of education systems in Latin America. The first application of our new measurement approach used publicly available data from the school principal surveys conducted by PISA to construct a school management index spanning 65 countries. This PISA-based school management index can be well-validated against the more detailed (though also much more expensive) index based on the WMS. As such, it has clear value in settings where cross-country coverage is important, enabling researchers to study and compare the (within-country) correlation between management and student/school-level outcomes for a far wider set of countries than was previously possible.

Our second application used publicly available data from a national administrative survey to construct a school management index spanning all public schools in a single country: Brazil. This Prova Brasil-based

index was also well-validated against the WMS. This second application has value in settings where within-country coverage, and the availability to merge with other administrative data sets, is important.

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. [2015a]. A positive relationship holds for the global PISA sample, and in the census of schools in Brazil. Our theoretical framework, for the first time, formalizes the possible causal mechanisms in one of these regions: Latin America. We argued that strong people management practices may be improving student learning through a combination of teacher selection and incentive effects, and that schools could be encouraged to adopt practices that reward good performers, develop good performers, and create a good employee value proposition. Looking to operations management, we argued that strong operations practices may be improving student learning through a combination of teacher selection and household incentives, and that schools could be encouraged to adopt practices promoting quality of delivery in the classroom and adopt processes to review school performance and drive change. We also provided a suggestive set of evidence for these channels.

Improvements to management practices present an untapped opportunity for potentially 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. 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. [forthcoming] 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.

Table 1: School management and student performance

	PISA			Prova Brasil		
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A:	Reading PISA points			Portuguese scores (SDs)		
Management Index	4.904	3.947	3.019	0.068	0.066	0.059
	(1.193)	(1.172)	(0.980)	(0.003)	(0.003)	(0.002)
	[0.000]	[0.000]	[0.002]	[0.000]	[0.000]	[0.000]
Private		11.514	2.911			
		(2.889)	(2.560)			
		[0.000]	[0.255]			
R-squared	0.24	0.29	0.42	0.03	0.04	0.10
Panel B:	Math PISA points			Math scores (SDs)		
Management Index	4.689	3.937	2.800	0.078	0.075	0.068
	(1.267)	(1.272)	(1.060)	(0.003)	(0.003)	(0.002)
	[0.000]	[0.001]	[0.008]	[0.000]	[0.000]	[0.000]
Private		11.467	2.001			
		(2.874)	(2.655)			
		[0.000]	[0.451]			
R-squared	0.31	0.34	0.45	0.05	0.05	0.10
Panel C:	Science PISA points			n.a.		
Management Index	4.283	3.601	2.553			
	(1.187)	(1.217)	(0.982)			
	[0.000]	[0.003]	[0.009]			
Private		10.215	1.245			
		(2.751)	(2.377)			
		[0.000]	[0.600]			
R-squared	0.30	0.33	0.43			
# Observations	410701	410701	410701	9890704	9890704	9890704
# Schools	15196	15196	15196	33148	33148	33148
Location FE*	Y	Y	Y	Y	Y	Y
School controls		Y	Y		Y	Y
Student controls			Y			Y

Notes: Standard errors in parentheses, p-values in square brackets. OLS regressions for PISA were run with the student-level PISA dataset using the OECD's repest Stata command. Standard errors clustered at the school level and use all 5 plausible values for each subject and student final weights. Prova Brasil regressions run with standard OLS. Standard errors clustered at the school level and dependent variables are student learning outcomes on national tests at Grade 9 (the same exercise can be done with primary schools and tests at Grade 5). All specifications include location fixed effects (countries for PISA and states for Prova Brasil). PISA controls: School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, and ratio of computers connected to the web as a proxy for school resources. Student controls include gender, grade, socio-economic status and immigration status. Prova Brasil controls: School controls include student-teacher ratio, log of the number of students, dummies indicating the presence of an IT lab, science lab, and library as proxies for school resources. Given availability of principal characteristics, school controls also include a dummy for male principals, dummies for educational attainment, and dummies for experience as principal. Student controls include a dummy for male students, a dummy for white students, student households' consumption index, 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. All panels use the same sample but have different subject outcome variables. Summary statistics for PISA dependent variables and controls are presented in Table B.1.

Table 2: PISA management index and student performance: Latin America

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Reading PISA points			Math PISA points			Science PISA points		
Management Index	8.255	2.681	2.212	7.442	2.432	1.764	7.859	3.092	2.509
	(1.610)	(1.252)	(1.008)	(1.576)	(1.230)	(1.039)	(1.421)	(1.144)	(0.973)
	[0.000]	[0.032]	[0.028]	[0.000]	[0.048]	[0.089]	[0.000]	[0.006]	[0.009]
Private		56.807	31.921		55.695	32.589	0.000	55.428	33.077
		(3.301)	(2.956)		(3.713)	(3.121)		(3.735)	(3.327)
		[0.000]	[0.000]		[0.000]	[0.000]		[8.161]	[2.736]
R-squared	0.032	0.173	0.342	0.041	0.185	0.350	0.040	0.172	0.312
# Observations	78144	78144	78144	78144	78144	78144	78144	78144	78144
# Schools	3075	3075	3075	3075	3075	3075	3075	3075	3075
# Countries	8	8	8	8	8	8	8	8	8
Country FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
School controls		Y	Y		Y	Y		Y	Y
Student controls			Y			Y			Y

Notes: Standard errors in parentheses, p-values in square brackets. OLS regressions for PISA were run with the student-level PISA dataset for 8 Latin American countries using the OECD's repest Stata command. Standard errors clustered at the school level and use all 5 plausible values for each subject and student final weights. All specifications include country fixed effects. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, and ratio of computers connected to the web as a proxy for school resources. Student controls include gender, grade, socio-economic status and immigration status. 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, for each variable with imputed values.

Table 3: People management and intermediate outcomes, public and private schools in Latin America

	(1) z-teacher shortage	(2) z-teacher motivation	(3) z-teacher effort	(4) z-teacher shortage	(5) z-teacher motivation	(6) z-teacher effort
Private School	-0.535	0.591	0.792			
	(0.122)	(0.139)	(0.128)			
	[0.000]	[0.000]	[0.000]			
People Index				-0.062	0.238	0.074
				(0.035)	(0.040)	(0.033)
				[0.077]	[0.000]	[0.026]
R-squared	0.152	0.142	0.154	0.139	0.169	0.123
Observations	3035	3043	3043	3035	3043	3043
School controls	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y

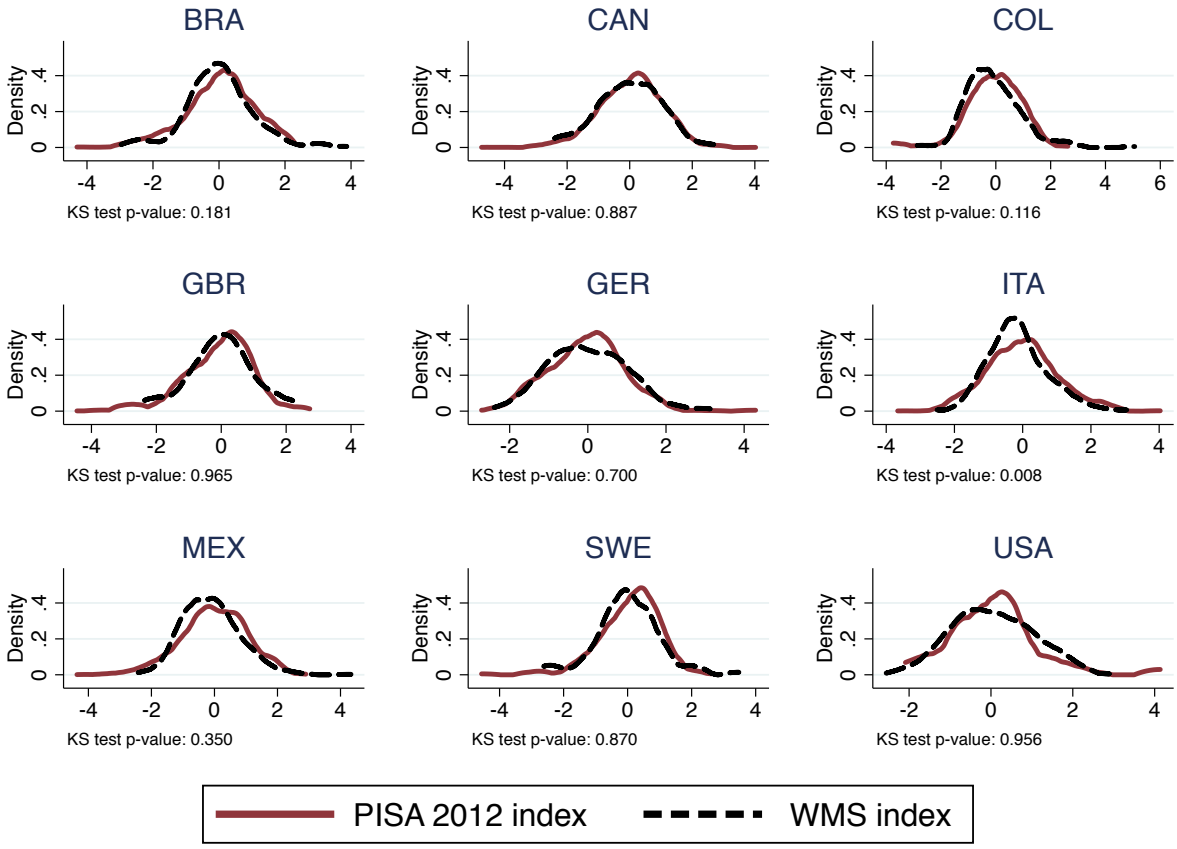
Notes: The first row reports the coefficients from regressions of a binary indicator (coded to 1 if the school is a private school, 0 otherwise) on the standardized index of three intermediate school outcomes: teacher shortage, teacher motivation and teacher effort. The second row reports coefficients from regressions of the standardized people management index on each of the intermediate school outcomes. The people management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include PISA school final weights and country fixed effects. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

Table 4: Operations management and intermediate outcomes, public schools in Latin America

	(1) z-teacher shortage	(2) z-teacher motivation	(3) z-teacher effort	(4) z-household effort
Operations Management Index	-0.080	0.238	0.076	0.160
	(0.043)	(0.041)	(0.038)	(0.054)
	[0.061]	[0.000]	[0.044]	[0.003]
R-squared	0.0787	0.171	0.154	0.242
Observations	2407	2414	2414	2414
School controls	Y	Y	Y	Y
Country FE	Y	Y	Y	Y

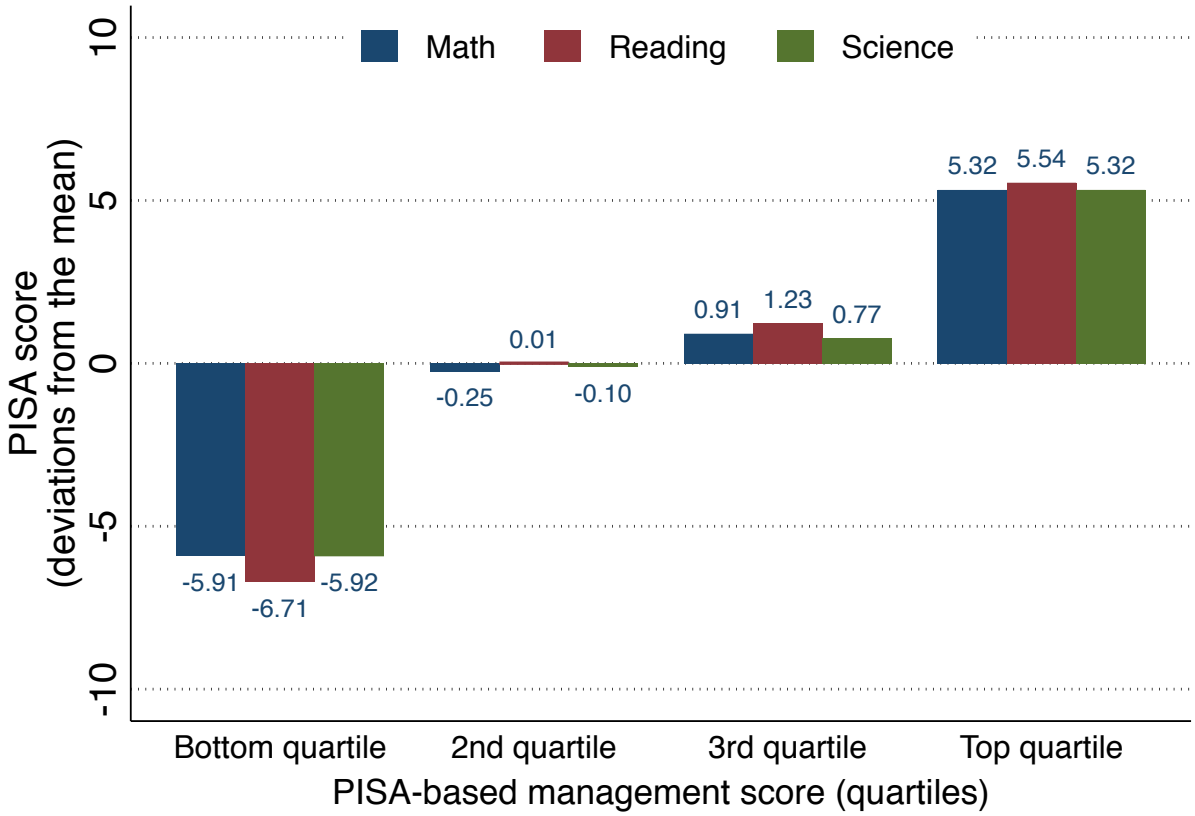
Notes: All regressions use data from public schools only. The table reports coefficients from regressions of the standardized operations management index on each of the intermediate school outcome. The operations management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include PISA school final weights and country fixed effects. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

Figure 1: Distribution of overall management scores, PISA vs WMS



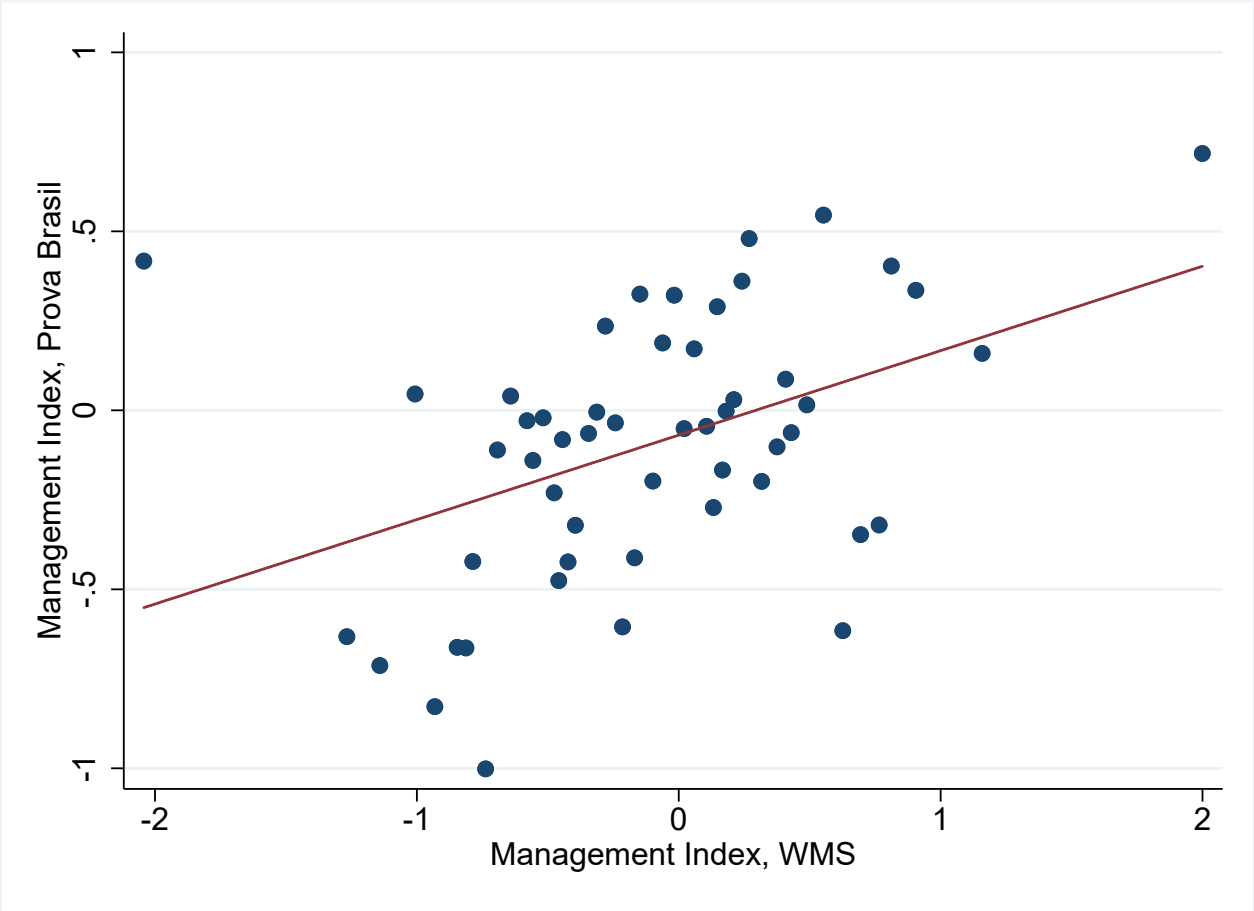
Note: Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at `www.worldmanagementsurvey.org`. Distribution of overall management indices standardized within countries. Kernel density curves estimated using WMS sampling weights (calculated as the inverse 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 to public primary schools. Number of WMS/PISA observations are as follow (WMS/PISA): Brazil = 510/561, Canada = 129/770, Colombia = 468/268, Great Britain = 89/422, Germany = 102/158, Italy = 284/926, Mexico = 157/1327, Sweden = 85/179, United States = 263/136.

Figure 2: PISA-based management index by quartile x PISA student outcomes



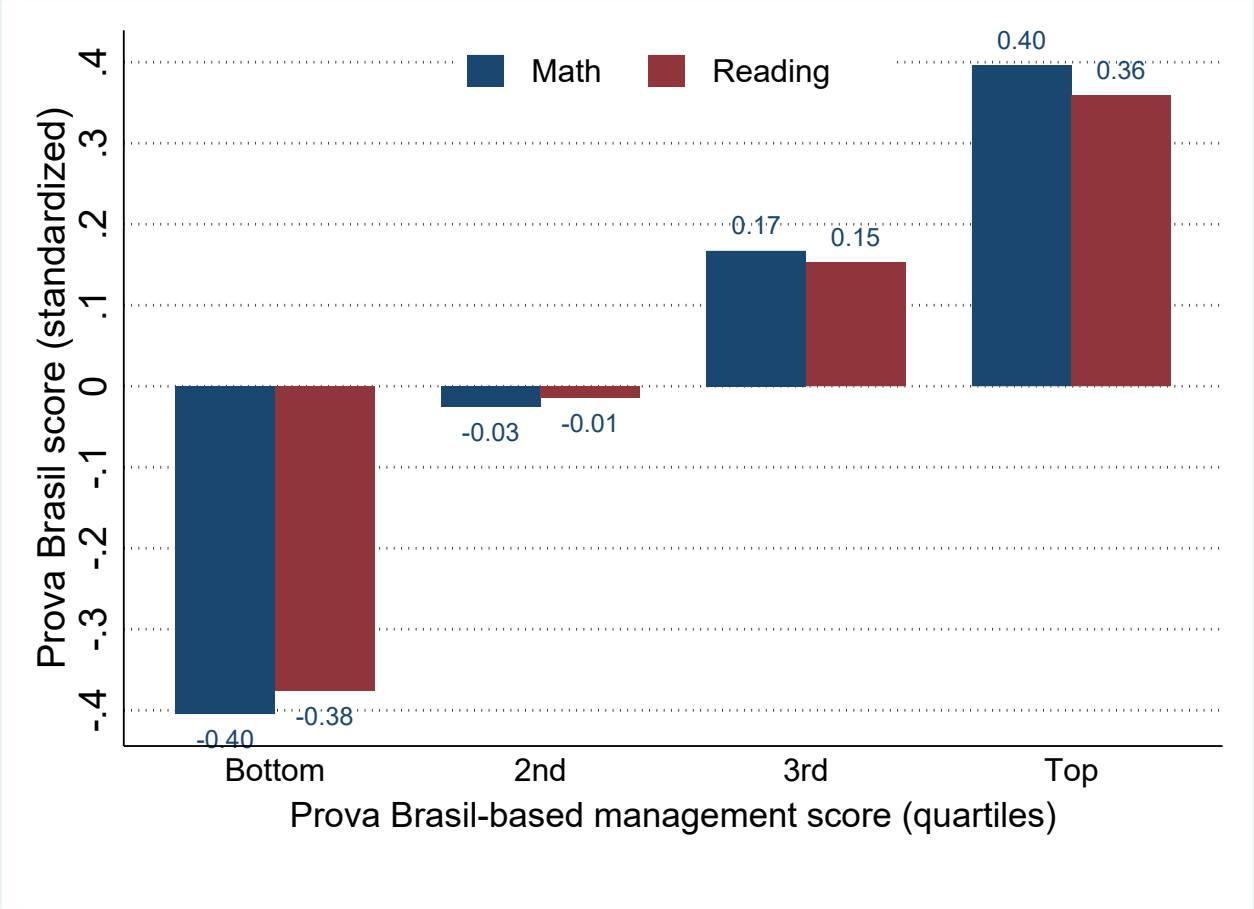
Note: Number of observations: 15,196 schools from 65 countries available in PISA 2012 data. Student outcomes are estimated using five plausible values and collapsed at the school level using PISA's senate weights. Quartiles of management are built at the country level. Test scores are presented as deviations from the global mean.

Figure 3: Prova Brasil-based management index x WMS management index



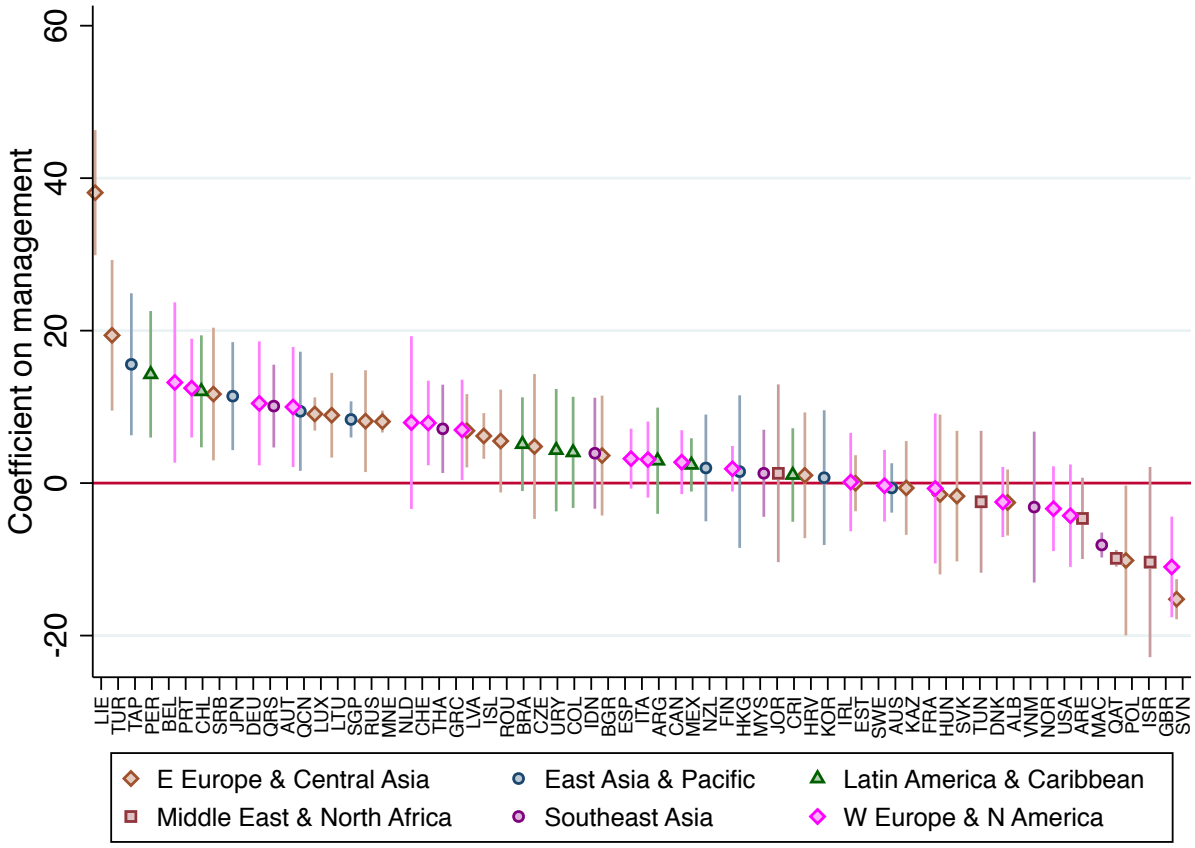
Note: This graph is a binned scatter plot. Each circle represents the average of 5 schools. The sample contains 262 schools which have data for both Prova Brasil and WMS in 2013. Correlation of 0.19 (p-level:0.00).

Figure 4: Prova Brasil-based management index by quartile x student outcomes



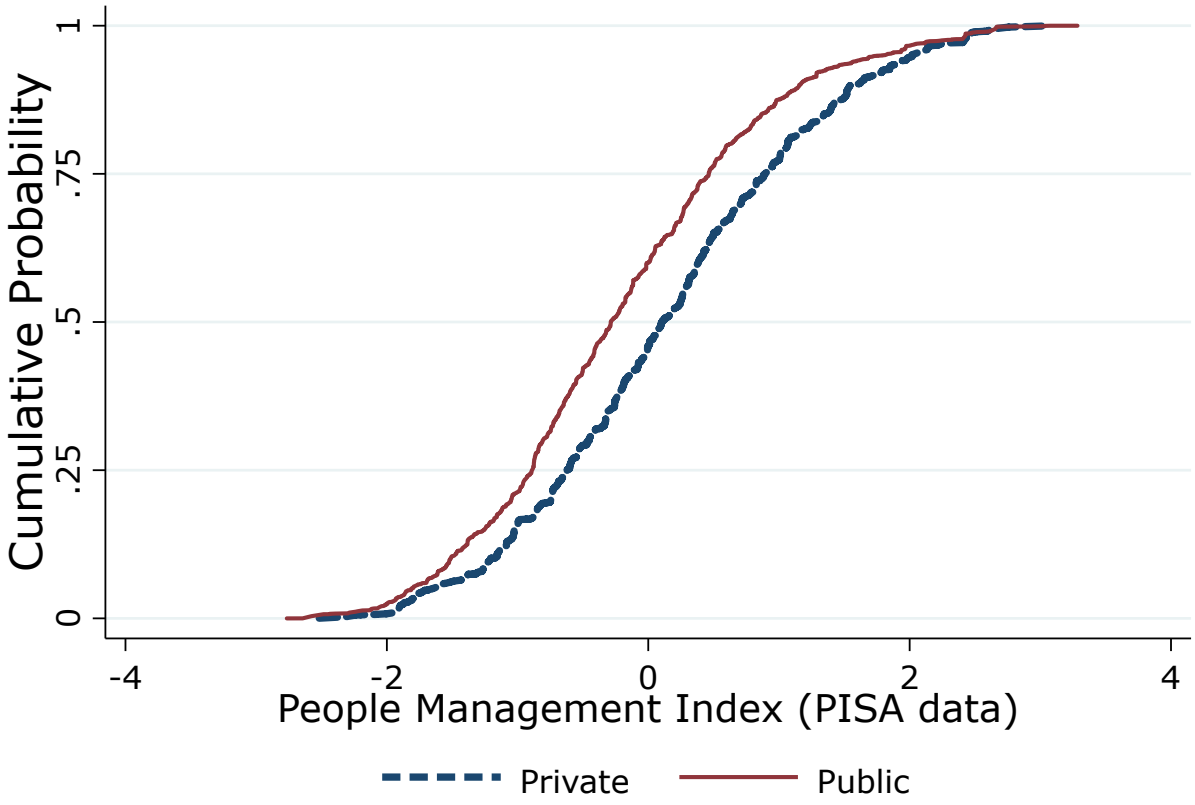
Note: The sample contains 33,148 public secondary schools of Prova Brasil in 2013 for which have available data. For simplicity and to compare the results to the results of PISA and the WMS, we use student learning outcomes on national tests in Portuguese and Math at Grade 9. The same exercise can be repeated with primary schools and national tests in Portuguese and Math at Grade 5.

Figure 5: Coefficient plot of PISA-based management index x math PISA points, by country



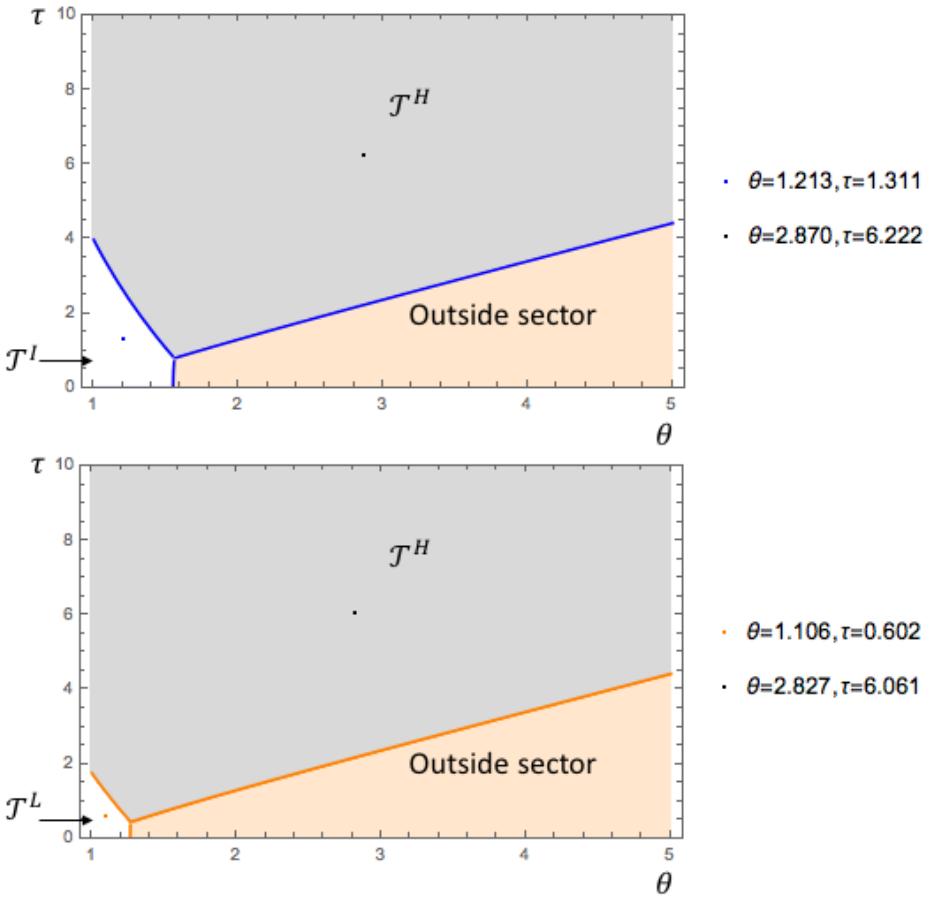
Note: PISA 2012 data. Regressions are estimated using OECD's `repest` command in Stata, by country. The specification includes all five plausible values for PISA 2012 and student final weights. Each marker represents the coefficient (and vertical spike represents associated 95% confidence intervals) of the management index on math scores.

Figure 6: Cumulative distribution of people management, Latin America



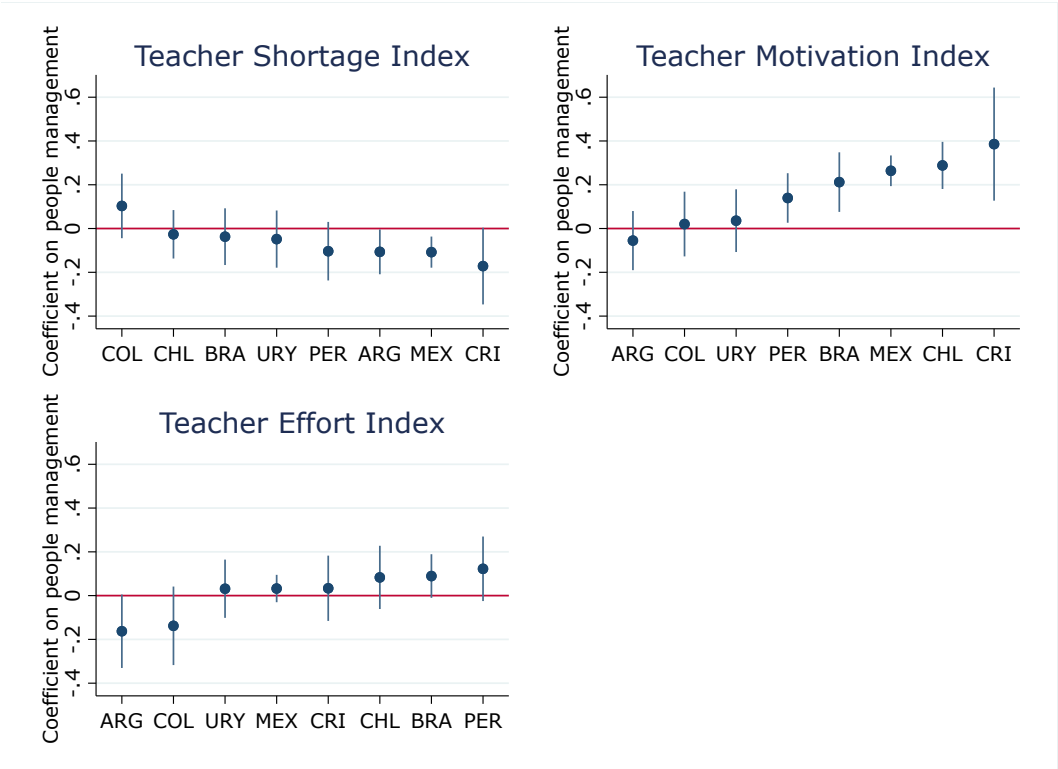
Notes: Cumulative distribution of the PISA-based people management index for private and public schools for 8 Latin American countries. The people management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. Sample consists of 3075 schools: 2432 in the public sector and 637 in the private sector.

Figure 7: Teacher selection



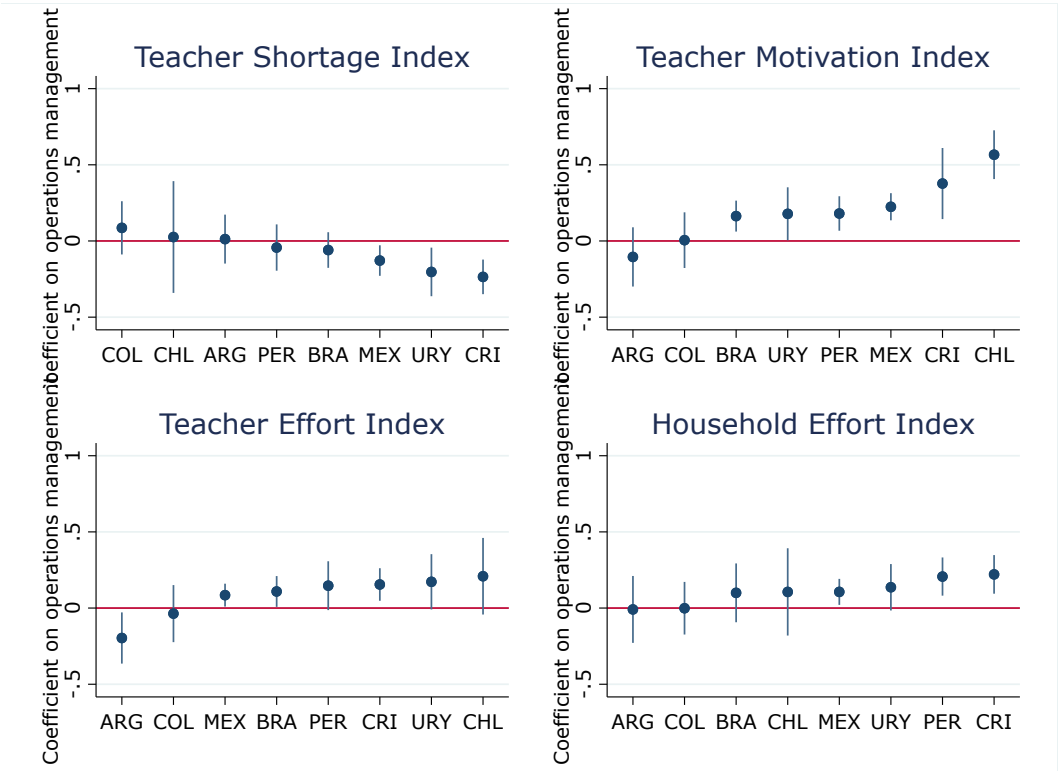
Note: The blue point in the top panel shows average teacher ability θ and baseline intrinsic motivation τ among teacher types who select into an intermediate management public school; the black point in the same panel shows average θ and τ among teacher types who select into a competing high management private school. The orange point in the bottom panel shows average θ and τ among teacher types who select into a low management public school; the black point in the same panel shows average θ and τ among teacher types who select into a competing high management private school. Both panels are plotted for the numerical example set out in Section 3.2.

Figure 8: Coefficient plot of PISA-based people management index x intermediate outcomes, by country



Notes: Each marker represents the coefficient (and vertical spike represents the associated 95% confidence intervals) from regressions of the people management index on the intermediate school outcome indices for each country in Latin America. The people management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include country fixed effects, school controls and PISA school final weights. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

Figure 9: Coefficient plot of PISA-based operations management index x intermediate outcomes, by country



Notes: Each marker represents the coefficient (and vertical spike represents the associated 95% confidence intervals) from regressions of the operations management index on the intermediate school outcome indices for each country in Latin America. The operations management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include country fixed effects, school controls and PISA school final weights. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

References

M. Adelman, R. Lemos, and T. Teodorovicz. Appointing versus locally electing school directors: Evidence from Brazil. Mimeo, World Bank, 2019.

M. Akmal and L. Pritchett. Learning equity requires more than equality: Learning goals and achievement gaps between the rich and the poor in five developing countries. Working Paper 19/028, RISE, 2019.

M. L. Anderson. Multiple inference and gender differences in the effects of early intervention: A reevaluation of the abecedarian, perry preschool, and early training projects. Journal of the American Statistical Association, 103(484):1481–1495, 2008.

G. P. Baker, M. C. Jensen, and K. J. Murphy. Compensation and incentives: Practice vs. theory. The Journal of Finance, 43(3):593–616, 1988.

S. Bender, N. Bloom, D. Card, J. Van Reenen, and S. Wolter. Management practices, workforce selection, and productivity. Journal of Labor Economics, 36(S1):S371–S409, 2018.

T. Besley. Paying politicians - theory and evidence. Journal of the European Economic Association, 2(2-3): 193–215, 2004.

T. Besley. Principled agents? The political economy of good government. Oxford University Press, Oxford, 2006.

B. Biasi. The labour market for teachers under different pay schemes. Working Paper 24813, NBER, 2019.

N. Bloom and J. Van Reenen. Measuring and explaining management practices across firms and countries. The Quarterly Journal of Economics, 122:1351–1408, 2007.

N. Bloom, R. Lemos, R. Sadun, and J. Van Reenen. Does management matter in schools? The Economic Journal, 125:647–674, May 2015a.

N. Bloom, C. Propper, S. Seiler, and J. V. Reenen. The impact of competition on management quality: Evidence from public hospitals. Review of Economic Studies, 82(2):457–489, 2015b.

N. Bloom, R. Lemos, R. Sadun, D. Scur, and J. Van Reenen. International data on measuring management practices. American Economic Review: Papers & Proceedings, 106(5):152–156, 2016.

N. Bloom, E. Brynjolfsson, L. Foster, R. Jarmin, M. Patnaik, I. Saporta-Eksten, and J. Van Reenen. What drives differences in management practices? American Economic Review, 109(5):1648–83, May 2019a.

N. Bloom, R. Sadun, R. Lemos, and J. V. Reenen. Healthy business? Managerial education and management in healthcare. The Review of Economics and Statistics, 0(ja):1–45, 2019b.

C. Cornwell, I. M. Schmutte, and D. Scur. Building a productive workforce: The role of structured management practices. CEP discussion papers, Centre for Economic Performance, LSE, 2019.

J. Delfgaauw, R. Dur, C. Propper, and S. Smith. Management practices: Are not for profits different? SSRN Electronic Journal, 07 2011.

T. Dohmen and A. Falk. You get what you pay for: Incentives and selection in the education system. The Economic Journal, 120:1–27, May 2010.

F. Finan, B. A. Olken, and R. Pande. The personnel economics of the developing state. In A. V. Banerjee and E. Duflo, editors, Handbook of Economic Field Experiments, volume 2 of Handbook of Economic Field Experiments, pages 467 – 514. North-Holland, 2017.

R. Fryer. Injecting charter school best practices into traditional public schools: Evidence from field experiments. The Quarterly Journal of Economics, 129(3):1355–1407, 2014.

R. Fryer. Management and student achievement: Evidence from a randomized field experiment. Working Paper Series 23437, NBER, May 2017.

S. Gagliarducci and T. Nannicini. Do better paid politicians perform better? Disentangling incentives from selection. Journal of the European Economic Association, 11(2):369–398, 2013.

E. A. Hanushek and L. Wössmann. Does educational tracking affect performance and inequality? Differences- in-differences evidence across countries. The Economic Journal, 116(510):63–76, March 2006.

E. A. Hanushek, S. Link, and L. Wössmann. Does school autonomy make sense everywhere? Panel estimates from PISA. Journal of Development Economics, 104(C):212–232, 2013.

J. Jerrim, L. A. Lopez-Agudo, O. D. Marcenaro-Gutierrez, and N. Shure. What happens when econometrics

and psychometrics collide? An example using the PISA data. Economics of Education Review, 61(C): 51–58, 2017.

V. Lavy. Do differences in schools' instruction time explain international achievement gaps? Evidence from developed and developing countries. The Economic Journal, 125(588):F397–F424, 2015.

E. P. Lazear. Performance pay and productivity. American Economic Review, 90(5):1346–1361, December 2000.

E. P. Lazear. Teacher incentives. Swedish Economic Policy Review, 10(3):179–214, 2003.

R. Lemos and D. Scur. Developing management: An expanded evaluation tool for developing countries. Working Paper 16/07, RISE, 2016.

A. D. Liberto, F. Schivardi, and G. Sulis. Managerial practices and student performance. Economic Policy, 30(84):683–728, 2015.

M. Martinez-Bravo. The role of local officials in new democracies: Evidence from Indonesia. American Economic Review, 104(4):1244–87, April 2014.

K. J. McConnell, K. A. Hoffman, A. Quanbeck, and D. McCarty. Management practices in substance abuse treatment programs. Journal of Substance Abuse Treatment, 37(1):79–89, 2009. doi: 10.2139/ssrn.1886387.

J. McCormack, C. Propper, and S. Smith. Herding cats? Management and university performance. The Economic Journal, 124(578):F534–F564, 2014.

C. Prendergast. The motivation and bias of bureaucrats. American Economic Review, 97(1):180–196, 2007.

I. Rasul and D. Rogger. Management of bureaucrats and public service delivery: Evidence from the Nigerian civil service. The Economic Journal, 128(608):413–446, 2016.

M. Romero, J. Sandefur, and W. Sandholtz. Outsourcing education: Experimental evidence from Liberia. American Economic Review, forthcoming.

J. Rothstein. Teacher quality policy when supply matters. American Economic Review, 105(1):100–130, 2015.

J. Ruhose and G. Schwerdt. Does early educational tracking increase migrant-native achievement gaps?

Differences-in-differences evidence across countries. Economics of Education Review, 52(C):134–154, 2016.

F. Schivardi and T. Schmitz. The IT revolution and southern Europe's two lost decades. Working Paper 18/05, EIEF, 2019.

M. R. West and L. Wössmann. 'Every catholic child in a catholic school': Historical resistance to state schooling, contemporary private competition and student achievement across countries. The Economic Journal, 120(546):F229–F255, 2010.

World Bank. World Development Report 2018: Learning to Realize Education's Promise. World Bank, Washington, DC, 2018.

L. Wössmann. The effect heterogeneity of central examinations: Evidence from TIMSS, TIMSS-Repeat and PISA. Education Economics, 13(2):143–169, 2005.

L. Wössmann. The importance of school systems: Evidence from international differences in student achievement. Journal of Economic Perspectives, 30(3):3–32, September 2016.

L. Wössmann, E. Lüdemann, G. Schütz, and M. R. West. School accountability, autonomy, choice, and the level of student achievement. OECD Publishing, Paris, (13), 2007.

A Appendix: Theoretical derivations

Lemma 1. Assume that the government assigns the teacher to an intermediate management public school.

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

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

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

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

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

where P is the probability that y_1^H exceeds the threshold $\bar{y}$ given e (and student attention a). Given the uniform distribution for ε, we can rewrite this probability as

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

The first order condition for this optimization problem is

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

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 e. 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. □

Lemma 2. Assume that the government assigns the teacher to an intermediate management public school. There exist functions

$$\tau^G = \frac{56}{8\theta + 1} - 2\theta - \tfrac{1}{4}, \quad \tau^O = \sqrt{25\theta^2 - 60}, \quad \text{and} \quad \tau^P = \sqrt{25\theta^2 - 4} - 4\theta - \tfrac{1}{2}$$

such that:

1. The teacher accepts the government's offer with probability $\Pr\left[(\tau, \theta) \in \mathcal{T}^I\right]$, where $\mathcal{T}^I \equiv (\tau, \theta) : \tau^O(\theta) \leq \tau \leq \tau^G(\theta)$.
2. The teacher declines the government's offer and accepts an offer from a private school with probability $\Pr\left[(\tau, \theta) \in \mathcal{T}^H\right]$, where $\mathcal{T}^H \equiv (\tau, \theta) : \tau \geq \max\left\{\tau^G(\theta), \tau^P(\theta)\right\}$.

Proof. Part 1. The function τ^G traces out the loci of (τ, θ)-types who, anticipating subsequent teacher effort and household effort levels, are indifferent between accepting their government job offer and declining it in favour of a job in a high management private school, i.e. types for whom

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

Substituting for e^L and e^H from Lemma 1, together with the parameters in our numerical example (imply-

ing $a^H = 1$), and rearranging yields

$$\tau^G = \frac{56}{8\theta + 1} - 2\theta - \tfrac{1}{4}.$$

Fixing θ, for any $\tau < \tau^G(\theta)$, 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 traces out the loci of (τ, θ)-types who, anticipating subsequent teacher effort levels, are indifferent between accepting their government job offer and declining it in favour of a job in the outside sector, i.e. types for whom

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

Substituting for e^L and e^O from Lemma 1, together with the parameters in our numerical example, and rearranging for τ yields

$$\tau^O = \sqrt{25\theta^2 - 60}.$$

Fixing θ, for any $\tau > \tau^O(\theta)$, 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.

All that remains, is to confirm that there exist values of θ such that $\tau^O \leq \tau^G$. Clearly, τ^G is decreasing and τ^O is increasing. Straightforward calculations show that $\tau^G - \tau^O$ is positive and decreasing on $[1, 1.56]$ which establishes that there exists a set $\mathcal{T}^I \equiv (\tau, \theta) : \tau^O \leq \tau \leq \tau^G$. For any pair (τ, θ) in this set, the payoff from accepting the government job (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.

Part 2. The function τ^P traces out the loci of (τ, θ)-types who, anticipating subsequent teacher effort and household effort levels, and having declined their government job offer, are indifferent between a job in a high management private school and a job in the outside sector, i.e. types for whom

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

Substituting for e^H and e^O from Lemma 1, together with the parameters in our numerical example, and

rearranging for τ yields

$$\tau^P = \sqrt{25\theta^2 - 4} - 4\theta - \tfrac{1}{2}.$$

Fixing θ, for any $\tau > \tau^P(\theta)$, the teacher's expected payoff from declining the government's offer and accepting a job in a high management private school is higher than her expected payoff from declining the government's offer and accepting a job in the outside sector.

Straightforward calculations show that $\tau^P - \tau^G$ is positive and increasing on $[1.56, 5]$ which establishes that there exists a set $\mathcal{T}^H \equiv (\tau, \theta) : \tau \geq \max\left\{\tau^G, \tau^P\right\}$. For any (τ, θ) in this set, the expected payoff from declining the government offer and accepting a job in a high management private school exceeds both the payoff of accepting the government job and the expected payoff of declining and accepting a job in the outside sector. □

Lemma 3. Assume that the government assigns the teacher to a low management public school. There exist functions

$$\tau^{G'} = \tfrac{36}{8\theta+1} - 2\theta - \tfrac{1}{4}, \quad \tau^{O'} = \sqrt{25\theta^2 - 40}, \quad \text{and} \quad \tau^P = \sqrt{25\theta^2 - 4} - 4\theta - \tfrac{1}{2}$$

such that:

1. The teacher accepts the government's offer with probability $\Pr\left[(\tau, \theta) \in \mathcal{T}^L\right]$, where $\mathcal{T}^L \equiv (\tau, \theta) : \tau^{O'}(\theta) \leq \tau \leq \tau^{G'}(\theta)$.
2. The teacher declines the government's offer and accepts an offer from a private school with probability $\Pr\left[(\tau, \theta) \in \mathcal{T}^{H'}\right]$, where $\mathcal{T}^{H'} \equiv (\tau, \theta) : \tau \geq \max\left\{\tau^{G'}(\theta), \tau^P(\theta)\right\}$.

Proof. Analogous to Lemma 2. □

Remark 1. Assume that the government assigns the teacher to an intermediate management public school. In the numerical example:

1. $\Pr\left[(\tau, \theta) \in \mathcal{T}^H\right] = 0.741 > \Pr\left[(\tau, \theta) \in \mathcal{T}^L\right] = 0.031.$
2. $\mathrm{E}\left[\tau + \Delta \middle| (\tau, \theta) \in \mathcal{T}^H\right] = 6.722 > \mathrm{E}\left[\tau \middle| (\tau, \theta) \in \mathcal{T}^I\right] = 1.311.$
3. $\mathrm{E}\left[\frac{\theta\, B}{2(\bar{\varepsilon} - \underline{\varepsilon})} + \frac{\tau + \Delta}{2} \middle| (\tau, \theta) \in \mathcal{T}^H\right] = 8.851 > \mathrm{E}\left[\frac{\tau}{2} \middle| (\tau, \theta) \in \mathcal{T}^I\right] = 0.655.$

Proof. Calculated via numerical integration, using Lemmas 1 and 2. The Mathematica notebook file is available upon request. □

Remark 2. Compare an intermediate management public school and a low management public school. In the numerical example

1. $\Pr\left[(\tau,\theta)\in\mathcal{T}^I\right]=0.031>\Pr\left[(\tau,\theta)\in\mathcal{T}^L\right]=0.007.$
2. $\mathrm{E}\left[\tau\middle|(\tau,\theta)\in\mathcal{T}^I\right]=1.311>\mathrm{E}\left[\tau\middle|(\tau,\theta)\in\mathcal{T}^L\right]=0.545.$
3. $\mathrm{E}\left[\frac{\tau}{2}\middle|(\tau,\theta)\in\mathcal{T}^I\right]=0.655>\mathrm{E}\left[\frac{\tau}{2}\middle|(\tau,\theta)\in\mathcal{T}^L\right]=0.301.$
4. $a^I=1>a^L=\frac{1}{2}.$

Proof. Calculated by numerical integration, using Lemmas 1 and 3. The Mathematica notebook file is available upon request. □

ONLINE APPENDIX

NOT INTENDED FOR PUBLICATION

for Leaver, Lemos and Scur "Measuring and explaining management in schools: new approaches using public data," October 17, 2019

B Additional tables and figures

Table B.1: Summary statistics

	Mean	Standard Deviation	10th pct	25th pct	50th pct	75th pct	90th pct	N
School								
Private school	0.19	(0.39)	0.00	0.00	0.00	0.00	1.00	410200
Rural	0.32	(0.46)	0.00	0.00	0.00	1.00	1.00	410209
Student-teacher ratio	17.47	(12.20)	8.70	11.94	15.57	20.17	28.00	380244
Enrolment total	983.89	(789.31)	222.00	439.00	813.00	1317.00	1861.00	394664
Share of govt funding	0.78	(0.32)	0.14	0.68	0.95	1.00	1.00	377927
Location: village	0.13	(0.33)	0.00	0.00	0.00	0.00	1.00	410209
Location: small town	0.19	(0.39)	0.00	0.00	0.00	0.00	1.00	410209
Location: town	0.28	(0.45)	0.00	0.00	0.00	1.00	1.00	410209
Location: city	0.26	(0.44)	0.00	0.00	0.00	1.00	1.00	410209
Location: large city	0.15	(0.35)	0.00	0.00	0.00	0.00	1.00	410209
Computers with internet	0.87	(0.29)	0.35	1.00	1.00	1.00	1.00	389971
Student grade	0.11	(0.32)	0.00	0.00	0.00	0.00	1.00	330163
Students								
Math score (PV1)	457.47	(103.02)	329.42	381.84	450.47	528.28	598.15	410701
Reading score (PV1)	465.67	(100.83)	335.44	395.65	465.71	536.32	596.87	410701
Science score (PV1)	466.83	(100.85)	339.18	394.01	463.20	537.52	602.14	410701
Female student	0.51	(0.50)	0.00	0.00	1.00	1.00	1.00	410701
Student age	15.41	(0.53)	14.33	15.25	15.58	15.83	15.92	410586
Student: non-immigrant	0.93	(0.26)	1.00	1.00	1.00	1.00	1.00	399606
Student: second-gen	0.04	(0.21)	0.00	0.00	0.00	0.00	0.00	399606
Student: first-gen	0.03	(0.16)	0.00	0.00	0.00	0.00	0.00	399606
Socio-economic status index	0.71	(0.48)	0.12	0.31	0.65	1.02	1.36	175060

Table B.2: Above median people management and intermediate outcomes, public and private schools in Latin America

	(1) z-teacher shortage	(2) z-teacher motivation	(3) z-teacher effort
Above median people	-0.186	0.403	0.060
	(0.077)	(0.073)	(0.072)
	[0.015]	[0.000]	[0.406]
R-squared	0.148	0.151	0.132
Above 75th pct people	-0.245	0.482	0.065
	(0.088)	(0.098)	(0.086)
	[0.005]	[0.000]	[0.451]
R-squared	0.150	0.152	0.132
Observations	3067	3074	3044
School controls	Y	Y	Y
Country FE	Y	Y	Y

Notes: The first row reports the coefficient from regressions of a binary indicator Above median people (coded to 1 if the school's PISA-based people management score is above the median, 0 otherwise) on the standardized index of three intermediate school outcomes: teacher shortage, teacher motivation and teacher effort. The second row reports coefficients from regressions of a binary indicator Above 75th pct people (coded to 1 if the school's PISA-based people management score is above 75th percentile, 0 otherwise) on each of the intermediate school outcomes. The people management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include PISA school final weights and country fixed effects. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

Table B.3: Above median operations management and intermediate outcomes, public schools in Latin America

	(1) z-teacher shortage	(2) z-teacher motivation	(3) z-teacher effort	(4) z-household effort
Above median ops	-0.165	0.323	0.130	0.197
	(0.082)	(0.083)	(0.075)	(0.088)
	[0.044]	[0.000]	[0.083]	[0.025]
R-squared	0.0790	0.151	0.153	0.234
Above 75pct ops	-0.121	0.498	0.221	0.348
	(0.101)	(0.103)	(0.092)	(0.121)
	[0.233]	[0.000]	[0.016]	[0.004]
R-squared	0.0759	0.164	0.156	0.240
Observations	2407	2414	2414	2414
School controls	Y	Y	Y	Y
Country FE	Y	Y	Y	Y

Notes: The row reports the coefficient from regressions of a binary indicator Above median ops (coded to 1 if the school's PISA-based people management score is above the median, 0 otherwise) on the standardized index of three intermediate school outcomes: teacher shortage, teacher motivation and teacher effort. The second row reports coefficients from regressions of a binary indicator Above 75th pct ops (coded to 1 if the school's PISA-based people management score is above 75th percentile, 0 otherwise) on each of the intermediate school outcomes. The operations management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. All specifications include PISA school final weights and country fixed effects. School controls include school location, student-teacher ratio, log of the number of students, share of government funding relative to total school funding, ratio of computers connected to the web as a proxy for school resources, and average student socio-economic status. 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, for each variable with imputed values dummies are added to the specifications.

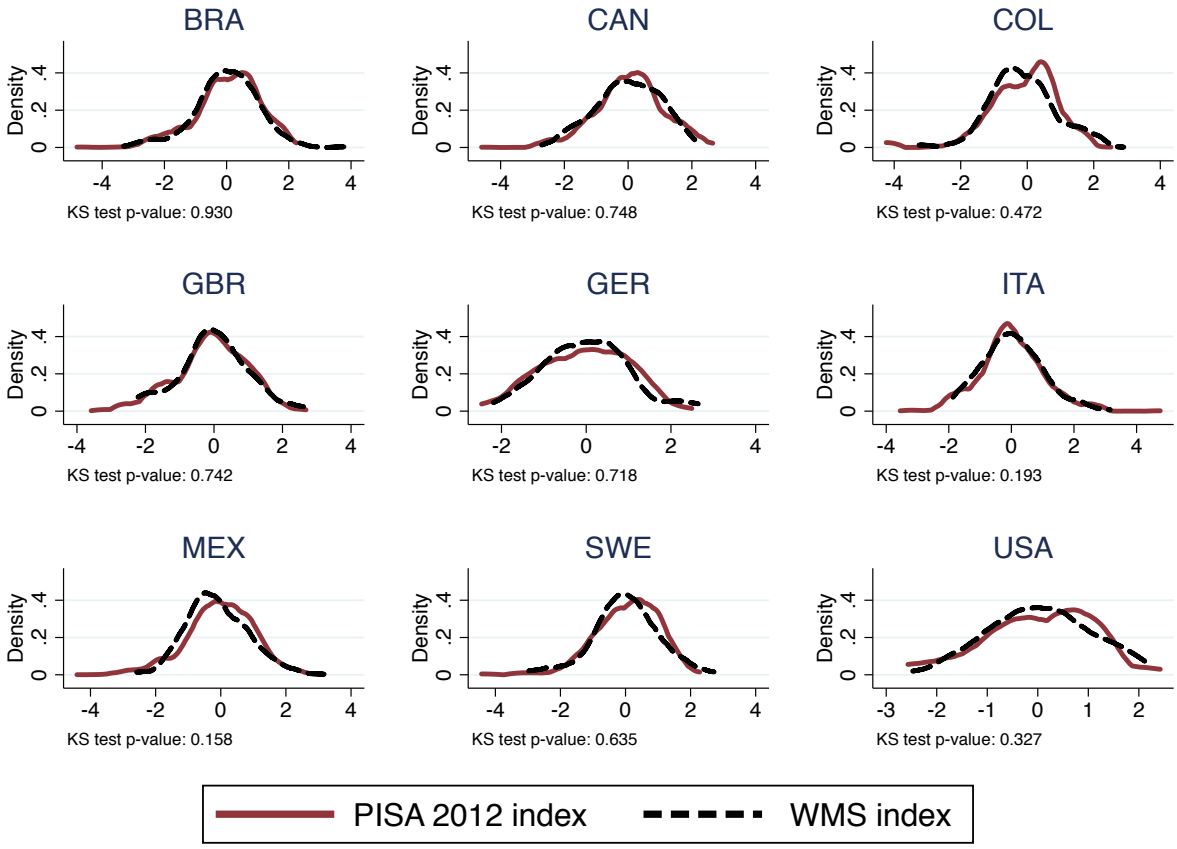
Table B.4: Process of entering the public basic education teaching career in Latin American countries in 2012

Country	Relevant Legislation in 2011-2012	Eligibility to Apply	Process for Job offer and Allocation
Argentina **(Buenos Aires)**	Law 10.579, Estatuto del Docente	Professional degree or equivalent in Teaching or Education in accordance to educational stage. Candidates cannot be older than 50 years old. Foreign applicants must have at least 5 years of residency in the country.	1) District government within Province announces vacancies. 2) Candidate submits application along with supporting documentation. Candidate may choose a maximum of 3 districts per application (with no limit on the number of applications submitted). 3) Decentralized classification tribunal (*Tribunales de Clasificación Descentralizados)* scores and ranks candidates based on supporting documentation (candidates applying to district of residency receive bonus points), following guidance and supervision of centralized classification tribunal at the provincial level. 4) District government makes an offer to suitable candidates based on ranking, and offers permanent assignment after the candidate passes an assessment carried out during the first year of work.
Brazil **(Rio de Janeiro)**	Municipal Law 2391/1995 **Subsequent legislation was approved in 2013 (Plano de Cargos, Carreira e Remuneração-PCCR, Municipal Law Nº 5623/2013)	Professional degree in Teaching or Education.	1) State government announces vacancies. 2) Candidate registers in a specific district, pays an enrollment fee, takes state examination, and submits supporting documentation. 3) State Office of Examination, Statistics and Public Service scores candidate's supporting documentation, conditional on passing state examination. 4) State government publishes candidates' final score. 5) Regional office under the state government (*Coordenadoria Regional de Educação*) makes an offer based on candidate's score, and offers permanent assignment after no more than 3 years of probationary period.
Chile	Law 19.070 passed in 1991. Subsequent reform was carried in 2011 (Law 20.501) with focus on school principals.	Professional degree in Teaching or Education in accordance to educational stage**.**	1) Municipal government announces vacancies. 2) Candidate submits individual applications for each vacancy (with no limit on the number applications) along with supporting documentation. 3) Municipal evaluation committee selects 2 to 5 candidates for each vacancy. 4) Candidate presents a school work proposal to the committee. The proposal is ranked by the municipal evaluation committee (additional assessments may be requested). 5) Municipal evaluation committee recommends candidates suitable for its vacancies, based on its ranking. 6) Mayor makes an offer to suitable candidates, according to the recommendation received from the municipal evaluation committee.
Colombia	Law Decree 1278, 2002, Estatuto de Profesionalización Docente	Professional degree or equivalent. Non-educators are required to hold a specialization program on Pedagogy or similar field.	1) Local government (*Entidad Territorial*) announces vacancies. 2) Candidate registers, submits supporting documentation, and takes national examination. 3) Local government committee evaluates the candidate based on a psycho-technical assessment, conditional on passing the national examination. 4) Public Service National Authority decentralized committees (*Comisión Nacional del Servicio Civil*) score candidate's supporting documentation and carry out interviews. 5) Public Service National Authority decentralized committees ranks candidates in each locality by educational stages and school modalities. Ranking is valid for 2 years. 6) Local government makes an offer to suitable candidates based on ranking. 7) Local government offers candidates permanent assignment after 1 year of probationary period, based on the school principal's evaluation.

Table B.5: Process of entering the public basic education teaching career in Latin American countries in 2012

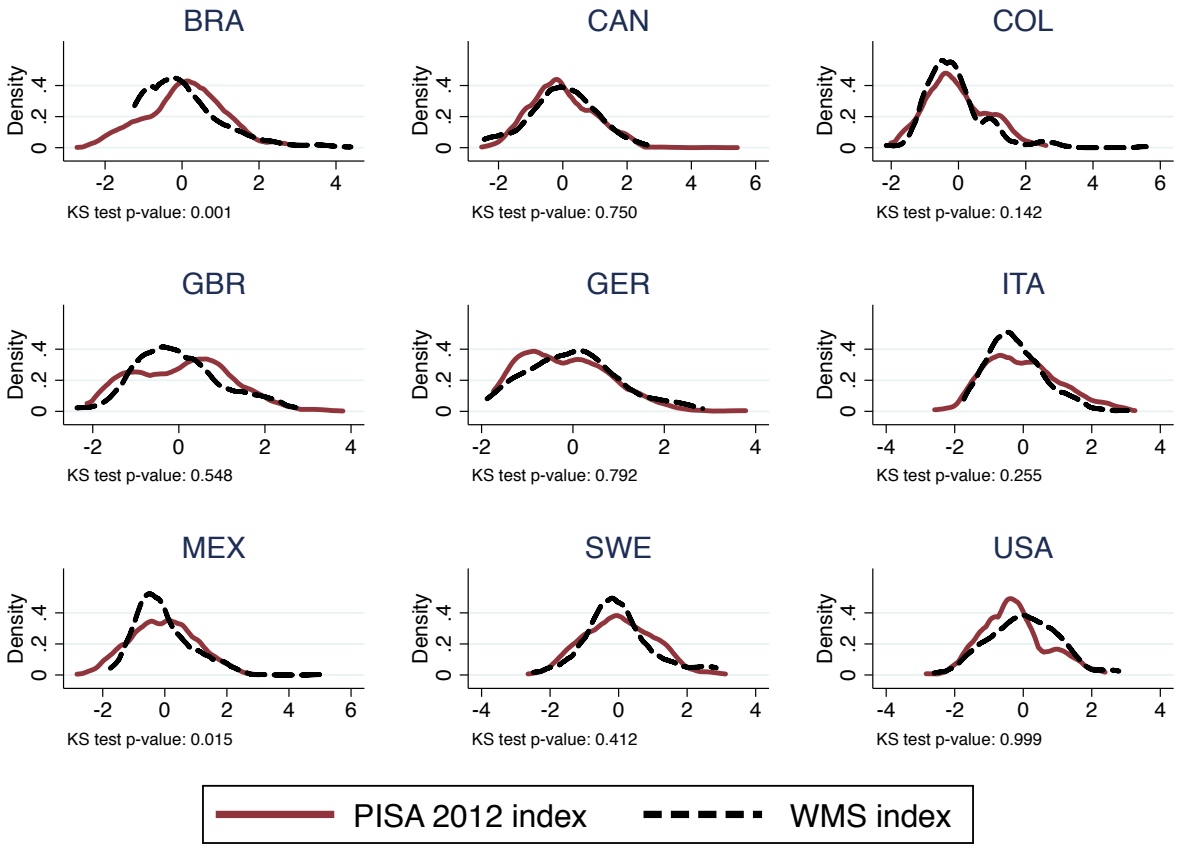
Country	Relevant Legislation in 2011-2012	Eligibility to Apply	Process for Job offer and Allocation
Costa Rica	2005 Nueva Carrera Profesional Docente	Professional degree or equivalent in Teaching or Education.	1) National government announces vacancies. 2) Candidate submits application along with supporting documentation, and indicates region(s) of preference. 3) Public Service National Authority (*Autoridad Nacional de Servicio Civil*) ranks each candidate, allocates vacancies to suitable candidates, according to ranking and candidates' preferred region. 4) National government offers candidate a permanent assignment after 3 months of probationary period, based on the school principal's evaluation.
Mexico	2008, Alianza por la Calidad de la Educación. **An education reform took place in 2013: *Ley General del Servicio Profesional Docente*	Professional degree or equivalent in Teaching or Education in accordance to educational stage. States have discretion to only accept candidates from specific teacher-training institutes or with a minimum time of residency in the State.	1) State government announces vacancies. 2) Candidate register, submits supporting documentation, and takes national examination. 3) National government grades examinations and sorts candidates into "Accepted", "Eligible" and "Not accepted" based on score. Cut-off points are determined by the Independent National Evaluation Body (*Órgano de Evaluación Independiente con Carácter Federalista*) and might differ across States. 4) National government ranks "Accepted" and "Eligible" candidates based on their scores and publishes ranking. "Eligible" candidates will require additional training if accepted. 5) State government makes an offer for a permanent assignment based on its ranking.
Peru	Law 29062, Ley de la Carrera Pública Magisterial. **An education reform took place in Nov2012, and its regulation was later issued in Mar2013.	Professional degree in Teaching or Education in accordance to educational stage. Years of experience might be a requirement for candidates to vacancies in special or alternative education schools.	1) National government announces vacancies. 2) Candidate registers and takes national examination. 3) Candidate applies to a single school vacancy, conditional on meeting eligibility criteria and passing the national examination, and submits supporting documentation. 4) Evaluation committee (set up at school, municipality, local or regional level) scores candidate based on supporting documentation, school interview and classroom teaching practices. 5) Evaluation committee publishes a ranking of candidates per vacancy. 6) School makes an offer for a permanent assignment based on ranking provided by evaluation committee.
Uruguay	Estatuto Docente Regulation N° 45, approved by Act N° 68, Resolution N° 9, 1993; modified in 2008	Professional degree in Teaching or Education in accordance to educational stage.	1) National council announces vacancies. 2) Candidate registers and submits supporting documentation. Candidate may apply to multiple vacancies in up to two municipalities but must submit individual applications. 3) Council sets up 3 Evaluation Committees per every 50 to 100 applicants. Committees scores candidates based on national level examination, classroom teaching practices, and supporting documentation. 4) Evaluation Committees rank candidates based on their total score. 5) Nacional Council makes an offer for a permanent assignment based on ranking for each vacancy.

Figure B.1: Distribution of management scores, PISA 2012 vs WMS: operations



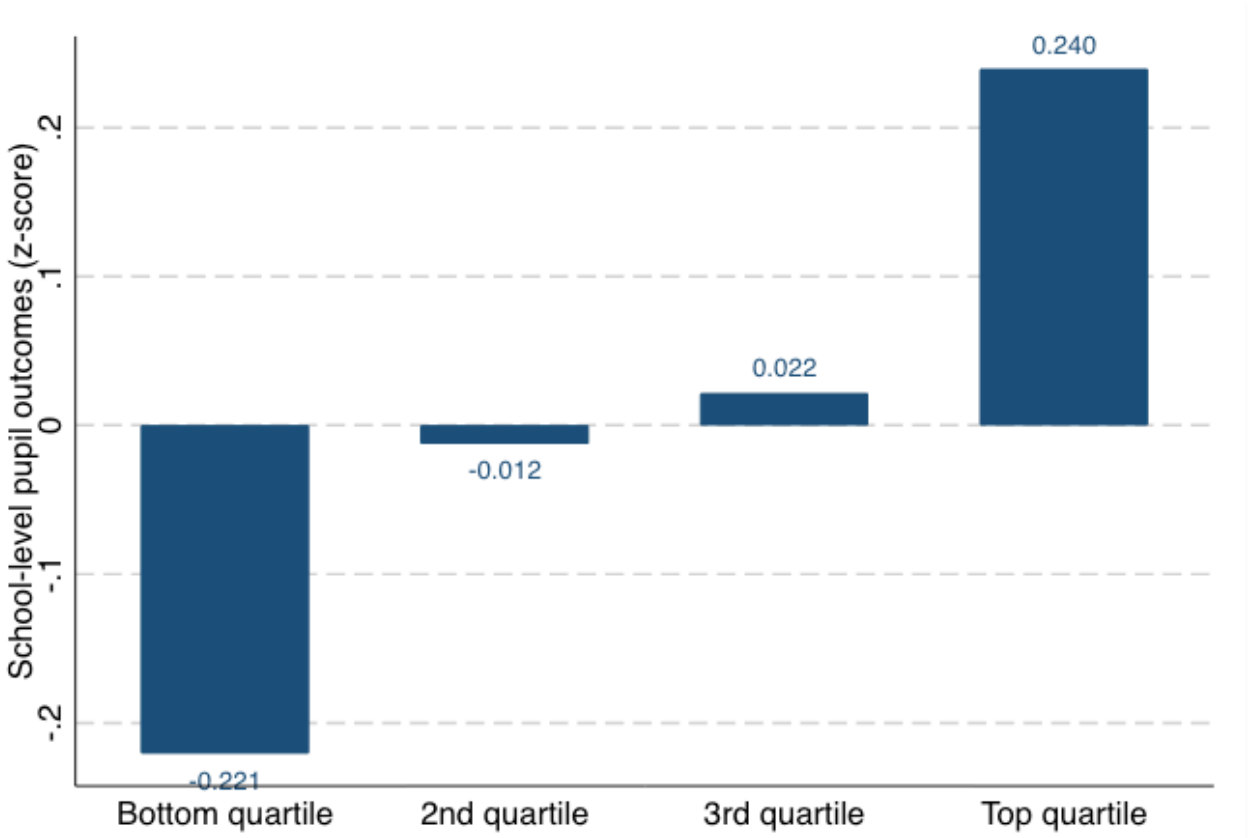
Note: Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at `www.worldmanagementsurvey.org`. Distribution of operations management indices standardized within countries. Kernel density curves estimated using WMS sampling weights (calculated as the 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 to public primary schools. Number of WMS/PISA observations are as follow (WMS/PISA): Brazil = 510/561, Canada = 129/770, Colombia = 468/268, Great Britain = 89/422, Germany = 102/158, Italy = 284/926, Mexico = 157/1327, Sweden = 85/179, United States = 263/136.

Figure B.2: Distribution of management scores, PISA 2012 vs WMS: operations



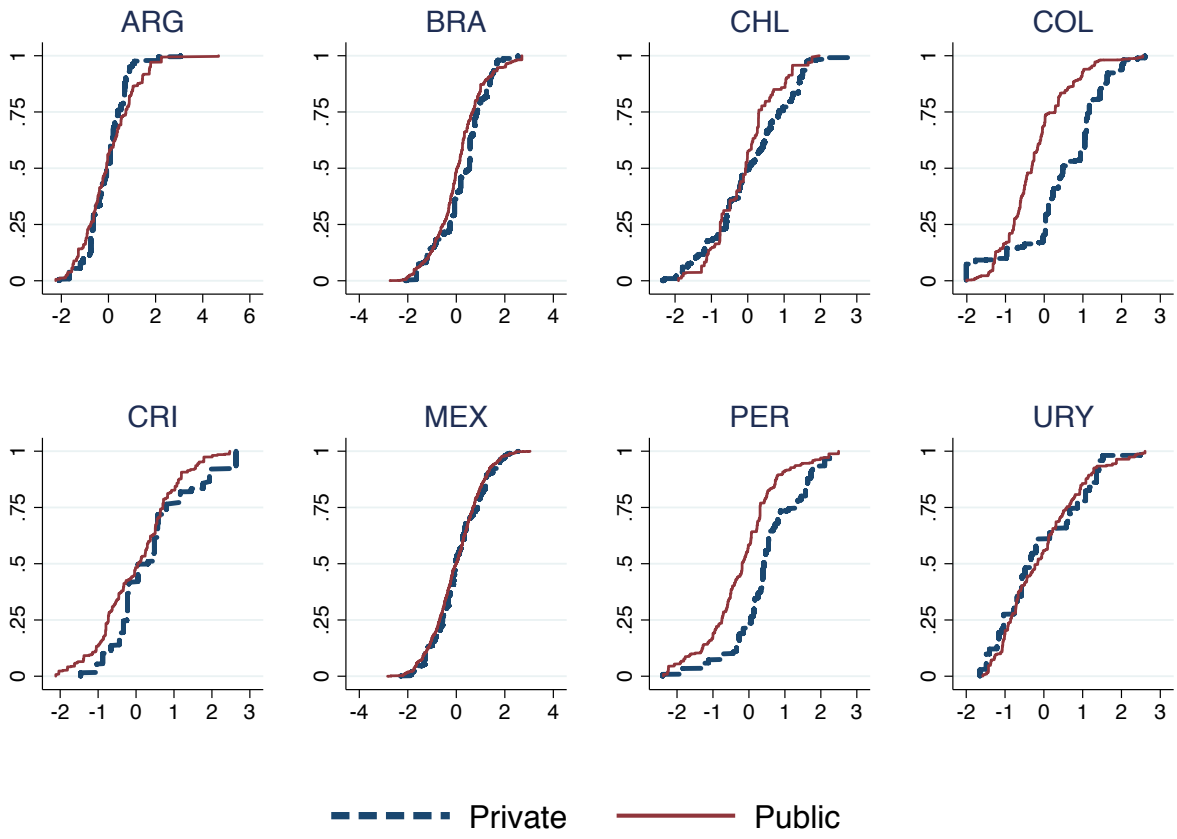
Note: Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at `www.worldmanagementsurvey.org`. Distribution of people management indices standardized within countries. Kernel density curves estimated using WMS sampling weights (calculated as the inverse 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 to public primary schools. Number of WMS/PISA observations are as follow (WMS/PISA): Brazil = 510/561, Canada = 129/770, Colombia = 468/268, Great Britain = 89/422, Germany = 102/158, Italy = 284/926, Mexico = 157/1327, Sweden = 85/179, United States = 263/136.

Figure B.3: WMS score by quartile x country-specific student outcomes



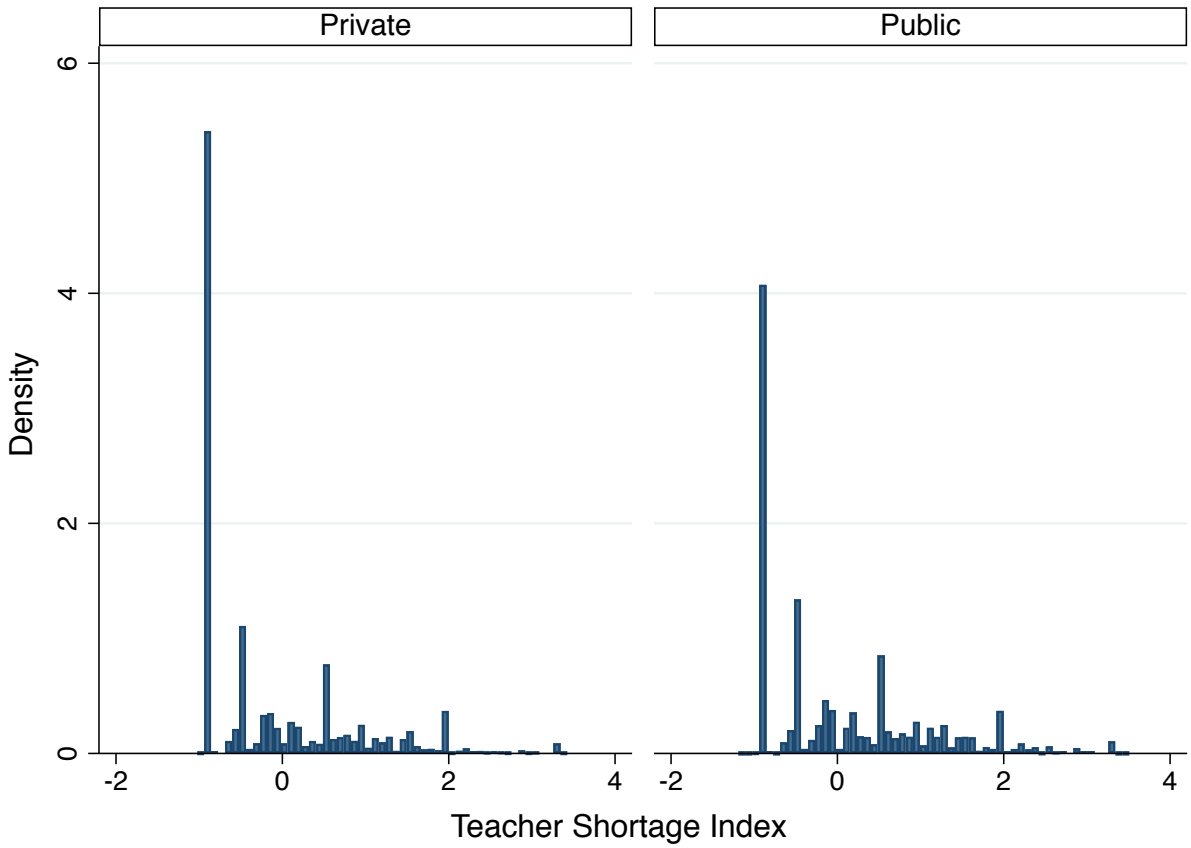
Note: Reproduced from Bloom et al. [2015a]. Performance measures for 1002 observations: 472 for Brazil, 77 for Canada, 152 for India, 82 for Sweden, 86 for the UK and 133 for the US. At the time of writing, the authors of Bloom et al. [2015a] had conducted the WMS in 8 countries, the listed 6 plus Germany and Italy. The latter two countries are not included in this figure because data on student learning outcomes was not available to the authors.

Figure B.4: Cumulative distribution of people management: by country in Latin America



Notes: Cumulative distribution of the PISA-based people management index for private and public schools for each one of the 8 Latin American countries in the PISA 2012 dataset. The people management index is built out of the school questionnaire from PISA 2012 using the methodology from Anderson [2008]. Sample sizes are as follows: Argentina: 183 schools (63 private, 120 public). Brazil: 561 schools (79 private, 482 public). Chile: 201 schools (137 private, 64 public). Colombia: 268 schools (62 private, 106 public). Costa Rica: 158 schools (22 private 136 public). Mexico: 1327 schools (196 private, 1131 public). Peru: 207 schools (50 private, 157 public). Uruguay: 164 schools (28 private, 136 public).

Figure B.5: Standardized teacher shortage scores, by sector



Notes: Teacher Shortage index is built out of four PISA 2012 questions: "is your school's capacity to provide instruction hindered by any of the following issues? a lack of qualified [science, math, language, other subjects] teachers". The responses are scored as 1 = not at all, 2 = very little, 3 = to some extent and 4 = a lot. The index is built using the methodology in Anderson [2008]. Measures are standardized.

C Data

C.1 Construction of the PISA-based indices

To construct a PISA-based school management index, we followed a three-step approach. First, we classified each of the PISA questions either under one of the WMS topics or under "not management". We were able to classify 53 2012 PISA questions into 14 WMS topics and using this mapping as a starting point, we further classified 32 2015 PISA questions into 12 WMS topics. For operations management, we classified 40 2012 PISA questions into 11 WMS topics and using this mapping as a starting point, we further classified 30 2015 PISA questions into 11 WMS topics. For people management, we classified 13 questions into 3 WMS topics using the 2012 questionnaire, and 2 questions into 1 WMS topic using the 2015 questionnaire. Table C.6 provides a summary of the mapping for PISA 2012 and Prova Brasil 2013 used in this paper as well as a mapping for PISA 2015.

Table C.6: Mapping of Management Practices in Publicly Available Survey Data

WMS Management Practice	WMS Description	# of Questions Mapped		
		PISA 2012	PISA 2015	Prova Brasil 2013
Operations Management				
1) Standardization of Instructional Processes	School uses meaningful processes that allow students to learn over time.	7	1	9
2) Personalization of Instruction and Learning	School incorporates teaching methods that ensure all pupils can master the learning objectives.	3	3	9
3) Data-Driven Planning and Student Transitions	School uses assessment and easily available data to verify learning outcomes at critical stages.	3	3	
4) Adopting Educational Best Practices	School incorporates and shares teaching best practices and pupil strategies across classrooms accordingly.	5	3	3
5) Continuous Improvement	School implements processes towards continuous improvement and encourages lessons to be captured and documented.	8	7	
6) Performance Tracking	School performance is regularly tracked with useful metrics.			
7) Performance Review	School performance is reviewed with appropriate metrics.	5	4	2
8) Performance Dialogue	School performance is discussed with appropriate content, depth and communicated to teachers.	3	2	
9) Consequence Management	School has mechanisms in place to follow-up on performance issues.			
10) Target Balance	School covers a sufficiently broad set of targets at the school, department and individual levels.	4	4	
11) Target Inter-Connection	School establishes well-aligned targets across all levels.	1	1	
12) Time Horizon of Targets	School takes a rational approach to planning and setting targets.			
13) Target Stretch	School sets targets with the appropriate level of difficulty.	1	1	
14) Clarity and Comparability of Targets	School sets understandable targets and openly communicates and compares school, department and individual performance.	7	6	
People Management				
15) Rewarding High Performers	School implements a systematic approach to identifying good and bad performance, rewarding teachers proportionately.	5	2	
16) Removing Poor Performers	School deals with underperformers promptly.			
17) Promoting High Performers	School promotes employees based on job performance.	4		2
18) Managing Talent	School nurtures and develops teaching and leadership talent.			1
19) Retaining Talent	School attempts to retain employees with high performance.			
20) Attracting Talent/ Creating a Distinctive Employee Value Proposition	School has a thought-through approach to attract employees.	3		5

Second, we manually assigned scores following the conceptual guidelines of the scoring grid of the World Management Survey, similar to the exercise conducted in the census-based management surveys such as the US Census Management and Organizational Practices Survey (MOPS), where values indicating best

practices receive higher scores than values indicating poor practices. Values are normalized from 0 to 1.[25]

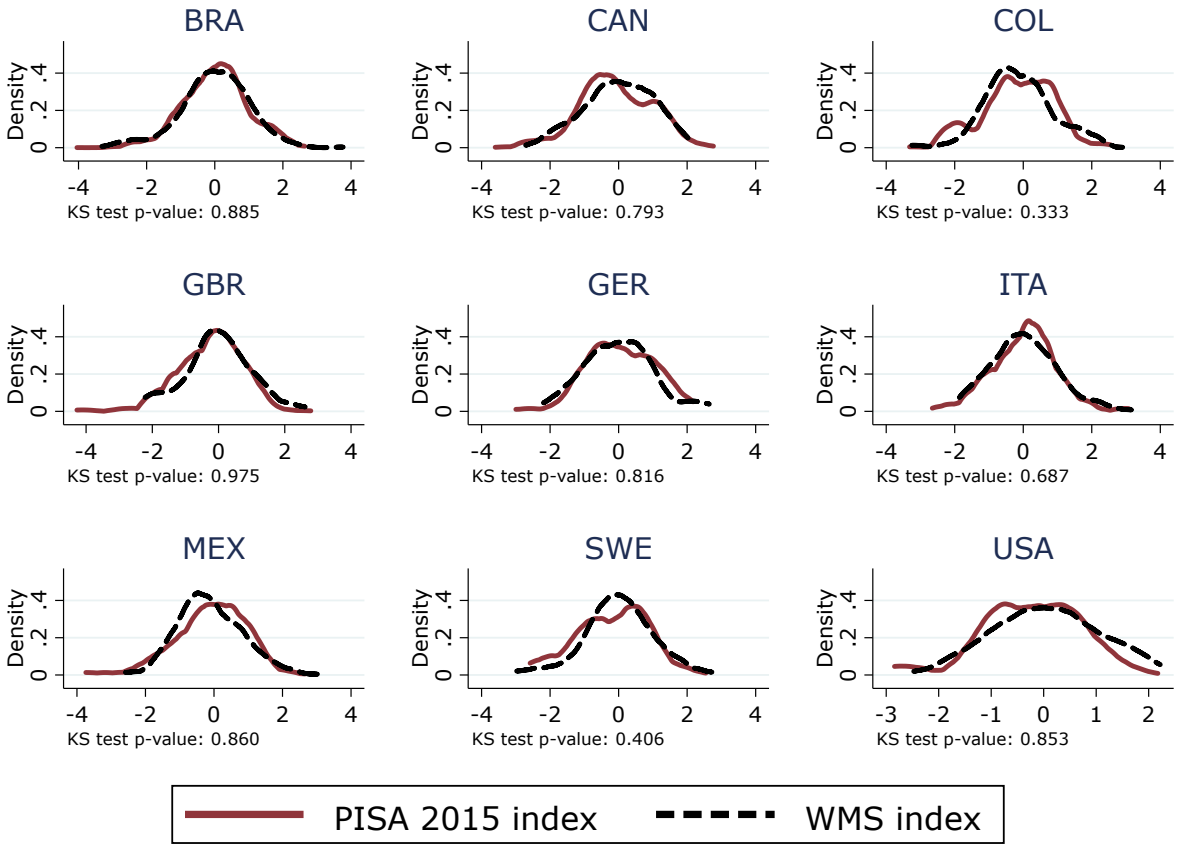
Third, to build the overall management index, and the operations and people management sub-indices, we follow Anderson [2008]. This methodology weights the impact of the included variables by the sum of their row in the inverse variance-covariance matrix, thereby assigning greater weight to questions that carry more "new information". Given that the importance (weight) of one questions is relative to the important of all others, we conservatily drop schools missing more than one management question (approximately 15% of schools are dropped, yet all countries are still included in the final sample). We also built the indices using alternative methods (straightforward standardization, factor analysis, including the Bartlett correction) which yielded similar results.

PISA 2015 has a reduced number of questions relative to the 2012 questions we used to measure people management. Several questions were moved to the new teacher questionnaire which was not mandatory for countries in 2015, preventing us from building an identically rich index across both years. For this reason, we focus on the richer 2012 data. A visual inspection of the distributions for the 2015 PISA-based management index for operations and people management shown in Figures C.6 and C.7 when compared to the distributions for 2012 indices in Figures B.1 and B.2 confirm that the 2012 indices, especially the people management index, are a better fit for this exercise.

We run two additional exercises to validate our index. First, we test whether the results are being driven by one specific question in the management index. To do this, we estimate the partial correlation of each of the 53 management questions on student performance, controlling for a partial index which takes into account all remaining management questions, standardized using Anderson [2008]. We find that the partial indices are positive and statistically significant throughout all individual regressions, suggesting that no single question is driving our results. Second, we test the importance of having both operations and people management questions in the index. This is to validate whether it is feasible to use the 2015 PISA data. To do this we run a regression where we include both operations and people management indices to the specification. This specification indicates whether each of the indices contain additively separable relevant information to explain student performance. We find that the coefficients remain positive and statistically significant across all subjects when including country fixed effects (same specification as Column (1) of Ta-

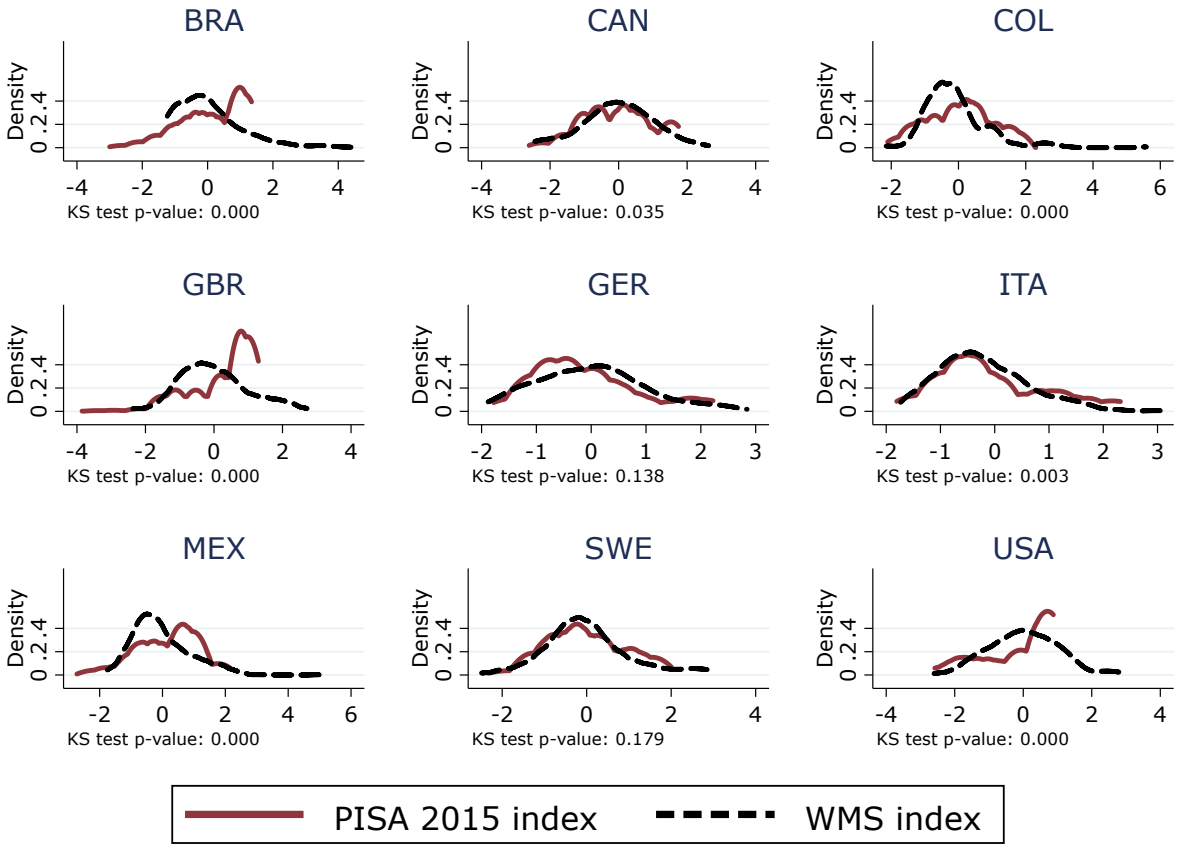
[25] MOPS has since been replicated in a number of other countries. Its questions follow the WMS topics and look to measure similar practices, but with self-reported answers.

Figure C.6: Distribution of management scores, PISA 2015 vs WMS: operations



Note: Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at `www.worldmanagementsurvey.org`. Distribution of operations management indices 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 to public primary schools. Number of WMS/PISA observations are as follow (WMS/PISA): Brazil = 510/421, Canada = 129/562, Colombia = 468/258, Great Britain = 89/381, Germany = 102/156, Italy = 284/291, Mexico = 157/138, Sweden = 85/192, United States = 263/158.

Figure C.7: Distribution of management scores, PISA 2015 vs WMS: people



Note: Data for the World Management Survey index for all countries except for Mexico and Colombia can be found at `www.worldmanagementsurvey.org`. Distribution of people management indices 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 to public primary schools. Number of WMS/PISA observations are as follow (WMS/PISA): Brazil = 510/421, Canada = 129/562, Colombia = 468/258, Great Britain = 89/381, Germany = 102/156, Italy = 284/291, Mexico = 157/138, Sweden = 85/192, United States = 263/158.

ble 1), and remain positive and statistically significant in reading, marginally non-significant in math and science when fully specified (same specification as Column (3) of Table 1). Overall, these results suggest that both measures are still meaningful (tables are available upon request).

The list of questions included in the PISA 2012 management index and its mapping to the individual questions is described below.

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
1) Standardisation of Instructional Processes					
a) How structured or standardised are the instructional planning processes across the school?	Which of the following options describe what your school does for <national modal grade for 15-year-olds> students in mathematics classes? Answer: Mathematics classes study similar content, but at different levels of difficulty.	SC15Q01	All classes	1	0.00
			Some classes	2	0.50
			Not for any class	3	1.00
	Which of the following options describe what your school does for <national modal grade for 15-year-olds> students in mathematics classes? Answer: Different classes study different content or sets of mathematics topics that have different levels of difficulty.	SC15Q02	All classes	1	0.00
			Some classes	2	0.50
			Not for any class	3	1.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Implementation of a standardised policy for mathematics (i.e. school curriculum with shared instructional materials accompanied by staff development and training).	SC39Q10	Yes	1	1.00
			No	2	0.00
b) What tools and resources are provided to teachers (e.g. standards-based lesson plans and textbooks) to ensure consistent level of quality in delivery across classrooms?	Which of the following statements apply in your school? Answer: The school has a policy on how to use computers in mathematics instruction (e.g. amount of computer use in mathematics lessons, use of specific mathematics computer programs).	SC40Q01	Yes	1	1.00
			No	2	0.00
	Which of the following statements apply in your school? Answer: All <national modal grade for 15-year-olds> mathematics classes in the school use the same textbook.	SC40Q02	Yes	1	1.00
			No	2	0.00
	Which of the following statements apply in your school? Answer: Mathematics teachers in the school follow a standardised curriculum that specifies content at least on a monthly basis.	SC40Q03	Yes	1	1.00
			No	2	0.00
2) Personalization of Instruction and Learning					
b) How do you as a school leader ensure that teachers are effective in personalising instruction in each classroom across the school?	Which of the following options describe what your school does for <national modal grade for 15-year-olds> students in mathematics classes? Answer: In mathematics classes, teachers use pedagogy suitable for students with heterogeneous abilities (i.e. students are not grouped by ability).	SC15Q04	All classes	1	1.00
			Some classes	2	0.50
			Not for any class	3	0.00
3) Data-Driven Planning and Student Transitions					
a) Is data used to inform planning and strategies? If so how is it used – especially in regards to student transitions through grades/ levels?	Are assessments of students in <national modal grade for 15-year-olds> used to inform parents about their child's progress?	SC18Q01	Yes	1	1.00
			No	2	0.00
	Are assessments of students in <national modal grade for 15-year-olds> used to make decisions about students' retention or promotion?	SC18Q02	Yes	1	1.00
			No	2	0.00
b) What drove the move towards more data-driven planning/ tracking?	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Systematic recording of data including teacher and student attendance and graduation rates, test results and professional development of teachers.	SC39Q03	Yes	1	1.00
			No	2	0.00
4) Adopting Educational Best Practices					
a) How does the school encourage incorporating new teaching practices into the classroom?	Are assessments of students in <national modal grade for 15-year-olds> used to identify aspects of instruction or the curriculum that could be improved?	SC18Q07	Yes	1	1.00
			No	2	0.00

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
4) Adopting Educational Best Practices					
a) How does the school encourage incorporating new teaching practices into the classroom?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I promote teaching practices based on recent educational research.	SC34Q05	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
b) How are these learning or new teaching practices shared across teachers? What about across grades or subjects? How does sharing happen across schools (community, state-wide etc), if at all?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I set aside time at faculty meetings for teachers to share ideas or information from in-service activities.	SC34Q18	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Teacher mentoring.	SC39Q08	Yes	1	1.00
			No	2	0.00
	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I lead or attend in-service activities concerned with instruction.	SC34Q17	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
5) Continuous Improvement					
a) When problems (e.g. within school/ teaching tactics/ etc.) do occur, how do they typically get exposed and fixed?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: When a teacher has problems in his/her classroom, I take the initiative to discuss matters.	SC34Q07	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
c) Who within the school gets involved in changing or improving process? How do the different staff groups get involved in this?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I engage teachers to help build a school culture of continuous improvement.	SC34Q11	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
5) Continuous Improvement					
c) Who within the school gets involved in changing or improving process? How do the different staff groups get involved in this?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I conduct informal observations in classrooms on a regular basis (informal observations are unscheduled, last at least 5 minutes, and may or may not involve written feedback or a formal conference).	SC34Q19	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Internal evaluation/self-evaluation.	SC39Q05	Yes	1	1.00
			No	2	0.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: External evaluation.	SC39Q06	Yes	1	1.00
			No	2	0.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Seeking written feed-back from students (e.g. regarding lessons, teachers or resources).	SC39Q07	Yes	1	1.00
			No	2	0.00
7) Performance Review					
a) How often do you review (school) performance -- formally or informally-- with teachers and staff?	During the last year, have any of the following methods been used to monitor the practice of mathematics teachers at your school? Answer: Tests or assessments of student achievement.	SC30Q01	Yes	1	1.00
			No	2	0.00
	During the last year, have any of the following methods been used to monitor the practice of mathematics teachers at your school? Answer: Teacher peer review (of lesson plans, assessment instruments, lessons).	SC30Q02	Yes	1	1.00
			No	2	0.00
	During the last year, have any of the following methods been used to monitor the practice of mathematics teachers at your school? Answer: Principal or senior staff observations of lessons.	SC30Q03	Yes	1	1.00
			No	2	0.00
	During the last year, have any of the following methods been used to monitor the practice of mathematics teachers at your school? Answer: Observation of classes by inspectors or other persons external to the school.	SC30Q04	Yes	1	1.00
			No	2	0.00
	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I evaluate the performance of staff.	SC34Q22	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
8) Performance Dialogue					
a) How are these review meetings structured?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I ask teachers to participate in reviewing management practices.	SC34Q12	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
8) Performance Dialogue					
a) How are these review meetings structured?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: When a teacher brings up a classroom problem, we solve the problem together.	SC34Q13	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I discuss academic performance results with the faculty to identify curricular strengths and weaknesses.	SC34Q16	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
10) Target Balance					
a) What types of targets are set for the school to improve student outcomes? Which staff levels are held accountable to achieve these stated goals?	Are assessments of students in <national modal grade for 15-year-olds> used to compare the school to <district or national> performance?	SC18Q04	Yes	1	1.00
			No	2	0.00
	Are assessments of students in <national modal grade for 15-year-olds> used to monitor the school's progress from year to year?	SC18Q05	Yes	1	1.00
			No	2	0.00
	Are assessments of students in <national modal grade for 15-year-olds> used to compare the school with other schools?	SC18Q08	Yes	1	1.00
			No	2	0.00
	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I make sure that the professional development activities of teachers are in accordance with the teaching goals of the school.	SC34Q03	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
11) Target Inter-Connection					
a) How are these goals cascaded down to the different staff groups or to individual staff members?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I discuss the school's academic goals with teachers at faculty meetings.	SC34Q14	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
13) Target Stretch					
a) How tough are your targets? How pushed are you by the targets?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I use student performance results to develop the school's educational goals.	SC34Q02	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
14) Clarity and Comparability of Targets					
a) If I asked one of your staff members directly about individual targets, what would they tell me?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I ensure that teachers work according to the school's educational goals.	SC34Q04	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I refer to the school's academic goals when making curricular decisions with teachers.	SC34Q15	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Written specification of the school's curricular profile and educational goals.	SC39Q01	Yes	1	1.00
			No	2	0.00
	Which of the following measures aimed at quality assurance and improvement do you have in your school? Answer: Written specification of student performance standards.	SC39Q02	Yes	1	1.00
			No	2	0.00
c) How do people know about their own performance compared to other people's performance?	In your school, are achievement data used in any of the following <accountability procedures>? Answer: Achievement data are posted publicly (e.g. in the medi1).	SC19Q01	Yes	1	1.00
			No	2	0.00
	In your school, are achievement data used in any of the following <accountability procedures>? Answer: Achievement data are tracked over time by an administrative authority.	SC19Q02	Yes	1	1.00
			No	2	0.00
15) Rewarding High Performers					
a) How does your evaluation system work? What proportion of your employees' pay is related to the results of this review?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I evaluate the performance of staff.	SC34Q22	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	Are assessments of students in <national modal grade for 15-year-olds> used to make judgements about teachers' effectiveness?	SC18Q06	Yes	1	1.00
			No	2	0.00
b) Are there any non-financial or financial bonuses/ rewards for the best performers across all staff groups? How does the bonus system work (for staff and teachers)?	To what extent have appraisals of and/or feedback to teachers directly led a change in salary?	SC31Q01	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
	To what extent have appraisals of and/or feedback to teachers directly led a financial bonus or another kind of monetary reward?	SC31Q02	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
	To what extent have appraisals of and/or feedback to teachers directly led a public recognition from you?	SC31Q05	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00

PISA 2012					
WMS questions	**Questions**	**Var. name in questionnaire**	**Value label**	**Value**	**MGMT score**
15) Rewarding High Performers					
b) Are there any non-financial or financial bonuses/ rewards for the best performers across all staff groups? How does the bonus system work (for staff and teachers)?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I praise teachers whose students are actively participating in learning.	SC34Q06	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
17) Promoting High Performers					
b) How do you identify and develop your star performers?	To what extent have appraisals of and/or feedback to teachers directly led to opportunities for professional development activities?	SC31Q03	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
c) What types of professional development opportunities are provided? How are these opportunities personalised to meet individual teacher needs?	To what extent have appraisals of and/or feedback to teachers directly led changes in work responsibilities that make the job more attractive?	SC31Q06	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
	To what extent have appraisals of and/or feedback to teachers directly led a role in school development initiatives (e.g. curriculum development group, development of school objectives)?	SC31Q07	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
d) How do you make decisions about promotion/ progression and additional opportunities within the school, such as performance, tenure, other? Are better performers likely to be promoted faster, or are promotions given on the basis of tenure/ seniority?	To what extent have appraisals of and/or feedback to teachers directly led a change in the likelihood of career advancement?	SC31Q04	No change	1	0.00
			Small change	2	0.33
			Moderate change	3	0.66
			Large change	4	1.00
20) Attracting Talent/ Creating a Distinctive Employee Value Proposition					
b) How do you monitor how effectively you communicate your value proposition and the following recruitment process?	Please indicate the frequency of the following activities and behaviours in your school during <the last academic year>. Answer: I work to enhance the school's reputation in the community.	SC34Q01	Did not occur	1	0.00
			1-2 times during the year	2	0.20
			3-4 times during the year	3	0.40
			Once a month	4	0.60
			Once a week	5	0.80
			More than once a week	6	1.00
	What percentage of all staff in your school has attended a programme of professional development with a focus on mathematics?	SC35Q01	Percentage	0	0.00
				1-25	0.25
				26-50	0.50
				51-75	0.75
				76-	1.00
	What percentage of math teachers in your school has attended a programme of professional development with a focus on mathematics?	SC35Q02	Percentage	0	0.00
				1-25	0.25
				26-50	0.50
				51-75	0.75
				76-	1.00

C.2 Construction of teacher shortage, teacher motivation, teacher effort, and household effort indices

We use the Anderson [2008] methodology to build each intermediate teacher outcomes index below.

PISA 2012			
Questions	**Var. name in questionnarie**	**Value label**	**Value**
Teacher Shortage			
Is your school's capacity to provide instruction hindered by any of the following issues? Answer: A lack of qualified science teachers.	SC14Q01	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Is your school's capacity to provide instruction hindered by any of the following issues? Answer: A lack of qualified mathematics teachers.	SC14Q02	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Is your school's capacity to provide instruction hindered by any of the following issues? Answer: A lack of qualified <test language> teachers.	SC14Q03	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Is your school's capacity to provide instruction hindered by any of the following issues? Answer: A lack of qualified teachers of other subjects.	SC14Q04	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Teacher Motivation			
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teachers' low expectations of students.	SC22Q13	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teachers not meeting individual students' needs.	SC22Q14	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Discussed their child's behaviour on the initiative of one of their child's teachers.	SC25Q02	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Discussed their child's progress on the initiative of one of their child's teachers.	SC25Q04	Percentage	
Think about the teachers in your school. How much do you agree with the following statements? Answer: The morale of teachers in this school is high.	SC26Q01	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
Think about the teachers in your school. How much do you agree with the following statements? Answer: Teachers work with enthusiasm.	SC26Q02	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
Think about the teachers in your school. How much do you agree with the following statements? Answer: Teachers take pride in this school.	SC26Q03	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
Think about the teachers in your school. How much do you agree with the following statements? Answer: Teachers value academic achievement.	SC26Q04	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
How much do you agree with these statements about teachers in your school? Answer: Mathematics teachers are interested in trying new methods and teaching practices.	SC27Q01	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
How much do you agree with these statements about teachers in your school? Answer: There is a preference among mathematics teachers to stay with well-known methods and practices.	SC27Q02	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
How much do you agree with these statements about teachers in your school? Answer: There is consensus among mathematics teachers that academic achievement must be kept as high as possible.	SC28Q01	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4

PISA 2012			
Questions	**Var. name in questionnarie**	**Value label**	**Value**
Teacher Motivation			
How much do you agree with these statements about teachers in your school? Answer: There is consensus among mathematics teachers that it is best to adapt academic standards to the students' levels and needs.	SC28Q02	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
How much do you agree with these statements about teachers in your school? Answer: There is consensus among mathematics teachers that the social and emotional development of the students is as important as their acquisition of mathematical skills and knowledge in mathematics classes.	SC29Q01	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
How much do you agree with these statements about teachers in your school? Answer: There is consensus among mathematics teachers that the development of mathematical skills and knowledge in students is the most important objective in mathematics classes.	SC29Q02	Strongly agree	1
		Agree	2
		Disagree	3
		Strongly disagree	4
Teacher Effort			
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teachers having to teach students of heterogeneous ability levels within the same class.	SC22Q11	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teacher absenteeism.	SC22Q15	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teachers being too strict with students.	SC22Q17	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Teachers being late for classes.	SC22Q18	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Household Effort			
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Student truancy.	SC22Q01	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Students skipping classes.	SC22Q02	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Students arriving late for school.	SC22Q03	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Students not attending compulsory school events (e.g. sports day) or excursions.	SC22Q04	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Students lacking respect for teachers.	SC22Q05	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Disruption of classes by students.	SC22Q06	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Students intimidating or bullying other students.	SC22Q08	Not at all	1
		Very little	2
		To some extent	3
		A lot	4

PISA 2012			
Questions	**Var. name in questionnarie**	**Value label**	**Value**
Household Effort			
In your school, to what extent is the learning of students hindered by the following phenomena? Answer: Poor student-teacher relations.	SC22Q10	Not at all	1
		Very little	2
		To some extent	3
		A lot	4
Which statement below best characterises parental expectations towards your school?	SC24Q01	There is constant pressure from many parents, who expect our school to set very high academic standards and to have our students achieve them.	1
		Pressure on the school to achieve higher academic standards among students comes from a minority of parents.	2
		Pressure from parents on the school to achieve higher academic standards among students is largely absent.	3
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Discussed their child's behaviour with a teacher on their own initiative.	SC25Q01	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Discussed their child's progress with a teacher on their own initiative.	SC25Q03	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Volunteered in physical activities, e.g. building maintenance, carpentry, gardening or yard work.	SC25Q05	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Volunteered in extra-curricular activities, e.g. book club, school play, sports, field trip.	SC25Q06	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Volunteered in the school library or media centre.	SC25Q07	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Assisted a teacher in the school.	SC25Q08	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Appeared as a guest speaker.	SC25Q09	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Participated in local school <government>, e.g. parent council or school management committee.	SC25Q10	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Assisted in fundraising for the school.	SC25Q11	Percentage	
During <the last academic year>, what proportion of students' parents participated in the following school-related activities? Answer: Volunteered in the school <canteen>.	SC25Q12	Percentage	

C.3 Construction of the Prova Brasil-based school management index

To construct the Prova Brasil-based school management index, we followed the three steps as detailed in the construction of the PISA-based index. However, as we map variables from both the school director and teacher questionnaires, we take one further step: we collapse the teacher dataset at the school level, taking the average of all teacher responses by school, combine the school principal responses, and compute the school level index. The WMS-Prova Brasil 2013 mapping is detailed below. For a harmonized version of the Prova Brasil mapping across 2007 to 2017, see Adelman et al. [2019].

					2013
WMS questions	**Questions**	***Questionnaire:*** Var. name	**Option**	**Value label**	**MGMT score**
1) Standardisation of Instructional Processes			**Operations Management**		
a) How structured or standardised are the instructional planning processes across the school?	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Não cumprimento dos conteúdos curriculares ao longo da trajetória escolar do aluno.	***Teacher:*** TX_RESP_Q73	A	Sim	0.00
			B	Não	1.00
	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Sobrecarga de trabalho dos professores, dificultando o planejamento e o preparo das aulas.	***Teacher:*** TX_RESP_Q74	A	Sim	0.00
			B	Não	1.00
	Quanto do conteúdo previsto você conseguiu desenvolver com os alunos desta turma neste ano?	***Teacher:*** TX_RESP_Q106	A	Menos de 20%.	0.00
			B	De 20% a menos de 40%.	0.20
			C	De 40% a menos de 60%.	0.50
			D	De 60% a menos de 80%.	0.75
			E	80% ou mais.	1.00
b) What tools and resources are provided to teachers (e.g. standards-based lesson plans and textbooks) to ensure consistent level of quality in delivery across classrooms?	Como se deu a escolha do livro didático neste ano?	***Principal:*** TX_RESP_Q086	A	Não sei.	0.00
			B	Foi escolhido de forma participativa pelos professores.	1.00
			C	Foi escolhido por somente alguns membros da equipe escolar.	0.50
			D	Foi escolhido por órgãos externos à escola.	0.50
			E	Foi escolhido de outra maneira.	missing
	Os alunos desta turma têm livros didáticos?	***Teacher:*** TX_RESP_Q99	A	Não, esta turma não recebeu o livro didático.	0.00
			B	Sim, menos da metade da turma tem.	0.25
			C	Sim, metade da turma tem.	0.50
			D	Sim, a maioria tem.	0.75
			E	Sim, todos têm.	1.00
	Gostaríamos de saber quais os recursos que você utiliza para fins pedagógicos, nesta turma: Jornais e revistas informativas.	***Teacher:*** TX_RESP_Q44	A	Não utilizo porque a escola não tem.	0.00
			B	Nunca.	0.00
			C	De vez em quando.	0.50
			D	Sempre ou quase sempre.	1.00
	Gostaríamos de saber quais os recursos que você utiliza para fins pedagógicos, nesta turma: livros de literatura em geral.	***Teacher:*** TX_RESP_Q45	A	Não utilizo porque a escola não tem.	0.00
			B	Nunca.	0.00
			C	De vez em quando.	0.50
			D	Sempre ou quase sempre.	1.00
	Gostaríamos de saber quais os recursos que você utiliza para fins pedagógicos, nesta turma: máquina copiadora (xerox).	***Teacher:*** TX_RESP_Q48	A	Não utilizo porque a escola não tem.	0.00
			B	Nunca.	0.00
			C	De vez em quando.	0.50
			D	Sempre ou quase sempre.	1.00
d) How does the school leader monitor and ensure consistency in quality across classrooms?	Nesta escola e neste ano, indique a frequência com que: O(A) diretor(a) dá atenção especial a aspectos relacionados com a aprendizagem dos alunos.	***Teacher:*** TX_RESP_Q61	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00

					2013
WMS questions	**Questions**	***Questionnaire:*** Var. name	**Option**	**Value label**	**MGMT score**
2) Personalization of Instruction and Learning				**Operations Management**	
a) How much does the school attempt to identify individual student needs? How are these needs accommodated for within the classroom?	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Conteúdos curriculares inadequados às necessidades dos alunos.	***Teacher:*** TX_RESP_Q72	A	Sim	0.00
			B	Não	1.00
c) What about students, how does the school ensure they are engaged in their own learning? How are parents incorporated in this process?	Indique com qual frequência são desenvolvidas as seguintes atividades para minimizar as faltas dos alunos neste ano e nesta escola: Os professores conversam com os alunos para tentar solucionar o problema.	***Principal:*** TX_RESP_Q045	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
	Indique com qual frequência são desenvolvidas as seguintes atividades para minimizar as faltas dos alunos neste ano e nesta escola: Os pais/responsáveis são avisados por comunicação da escola.	***Principal:*** TX_RESP_Q046	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
	Indique com qual frequência são desenvolvidas as seguintes atividades para minimizar as faltas dos alunos neste ano e nesta escola: Os pais/responsáveis são chamados à escola para conversar sobre o assunto em reunião de pais.	***Principal:*** TX_RESP_Q047	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
	Indique com qual frequência são desenvolvidas as seguintes atividades para minimizar as faltas dos alunos neste ano e nesta escola: Os pais/responsáveis são chamados à escola para conversar sobre o assunto individualmente.	***Principal:*** TX_RESP_Q048	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
	Indique com qual frequência são desenvolvidas as seguintes atividades para minimizar as faltas dos alunos neste ano e nesta escola: A escola envia alguém à casa do aluno.	***Principal:*** TX_RESP_Q049	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Falta de assistência e acompanhamento dos pais na vida escolar do aluno.	***Teacher:*** TX_RESP_Q78	A	Sim	0.00
			B	Não	1.00
	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Desinteresse e falta de esforço do aluno.	***Teacher:*** TX_RESP_Q80	A	Sim	0.00
			B	Não	1.00
	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Alto índice de faltas por parte dos alunos.	***Teacher:*** TX_RESP_Q82	A	Sim	0.00
			B	Não	1.00
4) Adopting Educational Best Practices				**Operations Management**	
a) How does the school encourage incorporating new teaching practices into the classroom?	Qual foi a quantidade de docentes desta escola que participou das atividades de formação continuada que você organizou nos últimos dois anos?	***Principal:*** TX_RESP_Q027	A	Não foram organizadas atividades de formação	0.00
			B	Poucos professores.	0.25
			C	Um pouco menos da metade dos professores.	0.50
			D	Um pouco mais da metade dos professores.	0.75
			E	Quase todos ou todos os professores.	1.00
	Nesta escola e neste ano, indique a frequência com que: O(A) diretor(a) estimula atividades inovadoras.	***Teacher:*** TX_RESP_Q65	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00

			2013		
WMS questions	**Questions**	***Questionnaire:*** Var. name	**Option**	**Value label**	**MGMT score**
4) Adopting Educational Best Practices			**Operations Management**		
c) How does the school ensure that teachers are utilising these new practices in the classroom? How often does this happen?	Nesta escola e neste ano, indique a frequência com que: O(a) diretor(a) dá atenção especial a aspectos relacionados com a aprendizagem dos alunos.	***Teacher:*** TX_RESP_Q61	A	Nunca.	0.00
			B	Algumas vezes.	0.33
			C	Frequentemente.	0.66
			D	Sempre ou quase sempre.	1.00
7) Performance Review			**Operations Management**		
a) How often do you review (school) performance -- formally or informally-- with teachers and staff?	Conselho de classe é um órgão formado por todos os professores que lecionam em cada turma/série. Neste ano, quantas vezes se reuniram os conselhos de classe desta escola?	***Principal:*** TX_RESP_Q031	A	Não existe Conselho de Classe nesta escola.	0.00
			B	Nenhuma vez.	0.25
			C	Uma vez.	0.50
			D	Duas vezes.	0.75
			E	Três vezes ou mais.	1.00
	O Conselho de Classe é um órgão formado por todos os professores que lecionam em cada turma/série. Neste ano e nesta escola, quantas vezes se reuniu o Conselho de Classe?	***Teacher:*** TX_RESP_Q52	A	Não existe Conselho de Classe nesta escola.	0.00
			B	Nenhuma vez.	0.00
			C	Uma vez.	0.33
			D	Duas vezes.	0.66
			E	Três vezes ou mais.	1.00
17) Promoting High Performers			**People Management**		
b) How do you identify and develop your star performers?	Na sua percepção, os possíveis problemas de aprendizagem dos alunos das série(s) ou ano(s) avaliado(s) ocorrem, nesta escola, devido à/ao(s): Insatisfação e desestímulo do professor com a carreira docente.	***Teacher:*** TX_RESP_Q75	A	Sim	0.00
			B	Não	1.00
	Nos últimos dois anos, você organizou alguma atividade de formação continuada (atualização, treinamento, capacitação etc.) nesta escola?	***Principal:*** TX_RESP_Q026	A	Não	0.00
			B	Sim	1.00
18) Managing Talent			**People Management**		
b) How do you ensure you have enough teachers of the right type in the school?	Neste ano, qual foi o principal critério para a atribuição das turmas aos professores?	***Principal:*** TX_RESP_Q040	A	Preferência dos professores.	0.00
			B	Escolha dos professores, de acordo com a pontuação por tempo de serviço e formação.	0.50
			C	Professores experientes com turmas de aprendizagem mais rápida.	1.00
	Neste ano, qual foi o principal critério para a atribuição das turmas aos professores?	***Principal:*** TX_RESP_Q040	D	Professores experientes com turmas de aprendizagem mais lenta.	1.00
			E	Manutenção do professor com a mesma turma.	0.50
			F	Revezamento dos professores entre as séries.	0.50
			G	Sorteio das turmas entre os professores.	0.50
			H	Atribuição pela direção da escola.	0.50
			I	Outro critério.	missing
			J	Não houve critério.	0.00

				2013	
WMS questions	**Questions**	***Questionnaire:*** Var. name	**Optio n**	**Value label**	**MGMT score**
20) Attracting Talent/ Creating a Distinctive Employee Value Proposition				**People Management**	
a) What makes it distinctive to teach at your school, as opposed to other similar schools? If you were to ask the last three candidates would they agree? Why?	Nesta escola e neste ano, indique seu grau de concordancia: O(A) diretor(a) me anima e me motiva para o trabalho	***Teacher:*** TX_RESP_Q64		Nunca.	0.00
				Algumas vezes.	0.33
				Frequentemente.	0.66
				Sempre ou quase sempre.	1.00
	Nesta escola e neste ano, indique a frequência com que: sinto-me respeitado(a) pelo(a) diretor(a)	***Teacher:*** TX_RESP_Q66		Nunca.	0.00
				Algumas vezes.	0.33
				Frequentemente.	0.66
				Sempre ou quase sempre.	1.00
	Nesta escola e neste ano, indique a frequência com que: tenho confiança no(a) director(a) como professional	***Teacher:*** TX_RESP_Q67		Nunca.	0.00
				Algumas vezes.	0.33
				Frequentemente.	0.66
				Sempre ou quase sempre.	1.00
	Nesta escola e neste ano, indique a frequência com que: participo nas decisões relacionadas com o meu trabalho	***Teacher:*** TX_RESP_Q68		Nunca.	0.00
				Algumas vezes.	0.33
				Frequentemente.	0.66
				Sempre ou quase sempre.	1.00
	Nesta escola e neste ano, indique a frequência com que: a equipe de professores leva em consideração as minhas idéias	***Teacher:*** TX_RESP_Q69		Nunca.	0.00
				Algumas vezes.	0.33
				Frequentemente.	0.66
				Sempre ou quase sempre.	1.00