Treating schools to a new administration: Evidence from South Africa of the impact of better practices in the system-level administration of schools

(A substantial elaboration of WP28/13)

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MARTIN GUSTAFSSON AND STEPHEN TAYLOR[1]

ABSTRACT

School examination results are far from ideal measures of progress in schooling systems, yet if analysed with sufficient care these data, which are common in education systems, can serve this purpose. The paper partly deals with how various student selection and year-on-year comparability issues in examinations data can be dealt with. This is demonstrated using South African student-level results, aggregated to the school level, for Grade 12 mathematics in the years 2005 to 2013. This was a period during which provincial boundaries changed, creating a quasi-experiment which is amenable to impact evaluation techniques. Value-added school production functions and fixed effects models are used to establish that movement into a better performing province was associated with large student performance improvements, equal in magnitude to around a year's worth of progress in a fast improving country. Improvements were not always immediate, however, and the data seem to confirm that substantial gains are only achieved after several years, after students have been exposed to many grades of better teaching. The institutional factors which might explain the improvements are discussed. Spending per student was clearly not a significant explanatory variable. What did seem to matter was more efficient use of non-personnel funds by the authorities, with a special focus on educational materials, the brokering of pacts between stakeholders, including teacher unions, schools and communities, and better monitoring and support by the district office. Moreover, the education department in one province in question, Gauteng, has for many years pursued an approach which is unusual in the South African context, of hiring a substantial number of senior managers within the bureaucracy on fixed term contracts, as opposed to on a permanent basis, the aim being to improve accountability and flexibility at the senior management level.

Keywords: South Africa, school improvement, mathematics education, impact evaluation

JEL codes: C21, H11, I21

[1] Both authors are researchers based at the Department of Basic Education (DBE), and are members of Research on Socio-Economic Policy (ReSEP), a group within in the Department of Economics at the University of Stellenbosch. The current paper emerged from work undertaken for the Department of Basic Education to support the development of a new national mathematics, science and technology (MST) strategy. Advice on the interpretation of the data by Rufus Poliah, Willie Venter, Mathanzima Mweli, Jennifer Kinnear and other colleagues in the DBE was much appreciated. Thanks also go to Servaas van der Berg and Nic Spaull at the University of Stellenbosch and Lisa Laun and her team at IFAU in Uppsala, Sweden, for their methodological advice.

1 Introduction

Understanding how to improve not only individual schools, but entire schooling systems, in sustainable and cost effective manners, is fraught with problems. Identifying cause and effect in education systems is inherently difficult, even when good data are available, and often such data are not available. Moreover, ideology often clouds reason in education research and policymaking. Psacharopoulos (1996: 343), a key figure in the emergence of economics of education as a discipline, has argued: '[i]n the field of education, perhaps more than in any other sector of the economy, politics are substituted for analysis'. This paper contributes to the growing stock of literature which makes use of impact evaluation techniques to throw light on the complex matter of which factors contribute towards better education.

Even before cause and effect are considered, there needs to be sufficient certainty that one is able to measure positive or negative change in educational outcomes. The economists Hanushek and Woessman (2009) have played an important role in shifting the emphasis towards more reliable measures of educational improvement, which in effect has meant focussing more on standardised tests covering a few basic subjects, with anchor items spanning years to establish sufficient comparability, and focussing less on traditional examinations. Yet examination results continue to be widely used to gauge educational progress, often in inappropriate ways. The current paper demonstrates that despite their limitations, examinations results can be used to examine improvement and, in certain contexts, cause and effect. The specific context which this paper takes advantage of is the limited redrawing of South Africa's provincial boundaries in 2005.

Section 2 explains the institutional background, including specifics of the South African Grade 12 examinations, how educational improvement is viewed in South Africa, and the 2005 provincial boundary changes. Section 3 explains the economics of education framework used in the paper, and what past empirical work informs this. It also deals with the question of how one measures impact. Section 4 discusses the Grade 12 examinations data used for the analysis, including the derivation of eight indicators of improvement. Section 5 examines overall national and provincial trends emerging from the data. Section 6 presents results from simple value-added school production functions and a fixed effects panel data analysis aimed at exploring what the impact of the provincial boundary changes were on schools, and what this says about the value-addition of the provincial administrations. Section 6 also presents an spatial analysis exploring the possible impacts of the boundary changes on which schools students attend. Section 7 discusses institutional factors at the provincial level which might explain why certain province-switching schools benefited from the boundary changes. Section 8 concludes.

The current paper elaborates on an earlier working paper by the authors (Gustafsson and Taylor, 2013). Key differences include the use of data from more years and more sources, and improved methods for quantifying the 'treatment' of schools.

2 Institutional background

South Africa's Grade 12 examinations offered for many decades the only more or less reliable measure of school performance in South Africa and much behaviour has understandably been oriented towards Grade 12 indicators, in particular 'pass rates', the percentage of students successfully obtaining a certificate or surpassing minimum thresholds in individual subjects. Around 40% of youths have obtained the Grade 12 certificate in recent years. Roughly a further 20% of youths participate in Grade 12 but do not obtain the certificate, whilst the bulk of the remaining 40% of youths do not reach Grade 12 or any equivalent level of education outside a school (South Africa: Department of Basic Education, 2013b; Gustafsson, 2011). Both public and some private schools participate in the national public examinations. Around 90% of candidates in recent years writing the examinations have been full-time school students and it is these students that this paper focuses on. This analysis therefore excludes part-time students, who are nearly all Grade 12 repeaters and take fewer than the full set of seven subjects.

In 2013, the end of the period studied in this paper, the full menu of subjects in the Grade 12 examinations included 27 non-language subjects. The system was changed rather fundamentally between 2007 and 2008. Subjects were redesigned, a distinction between standard grade and higher grade examination papers across all subjects was removed and it became compulsory for all students not taking mathematics to take mathematical literacy, a relatively easy subject. This paper focuses on improvements in mathematics, a subject that is widely taken and is of special importance for economic development. In 2005, 58% of examination candidates took mathematics and 8% of all candidates took mathematics at the higher grade. In 2011, 45% of candidates took mathematics (as explained below, 2005 and 2011 serve as anchor years in the analysis). The percentage of schools with mathematics candidates was 99% in 2005 and 97% in 2011. In 2005, 59% of schools had students taking mathematics on the higher grade. Simkins (2010) provides an important account of the 2007 to 2008 transition with respect to mathematics. Van der Berg (2004) describes the legacy of race-based inequality in South Africa that continues to influence performance in mathematics.

Poor student performance, in particular in mathematics, is widely acknowledged as being a key hurdle to economic and social development in South Africa. The low numbers of black African students achieving sufficiently high scores in mathematics to enter university studies requiring minimum levels of mathematics competencies continues to worry policymakers. Problems are rooted in low levels of performance and stark inequalities, across provinces and socio-economic groups, well below Grade 12 (Spaull, 2011). The data used for this paper, which include the race of students, and population data, indicate that in 2011 only 0.5% of black African youths were obtaining 70 or more out of 100 in Grade 12 mathematics, against a figure of 3.5% for youths of other races[2]. Typically, a mark of at least 70 out of 100 in mathematics is a requirement for entry into under-graduate university programmes requiring strong mathematical competencies, for instance engineering programmes. The importance of increasing high-end mathematics performance influences the focus of the data analysis presented below.

It is often useful to think of interventions aimed at improving schools in terms of whether they follow a more school-specific interventionist approach, or a more system-wide structural approach. Both are clearly important and receive much attention in South Africa. The former would include interventions such as the Dinaledi programme, designed to provide capacity building to a set of 500 secondary schools in the areas of mathematics and physical science (World Bank, 2010; Blum, Krishnan, Legovini, 2010). The latter would include the Annual National Assessments programme, introduced in 2011 and aimed at improving accountability against national standards below the Grade 12 level (South Africa: Department of Basic Education, 2011).

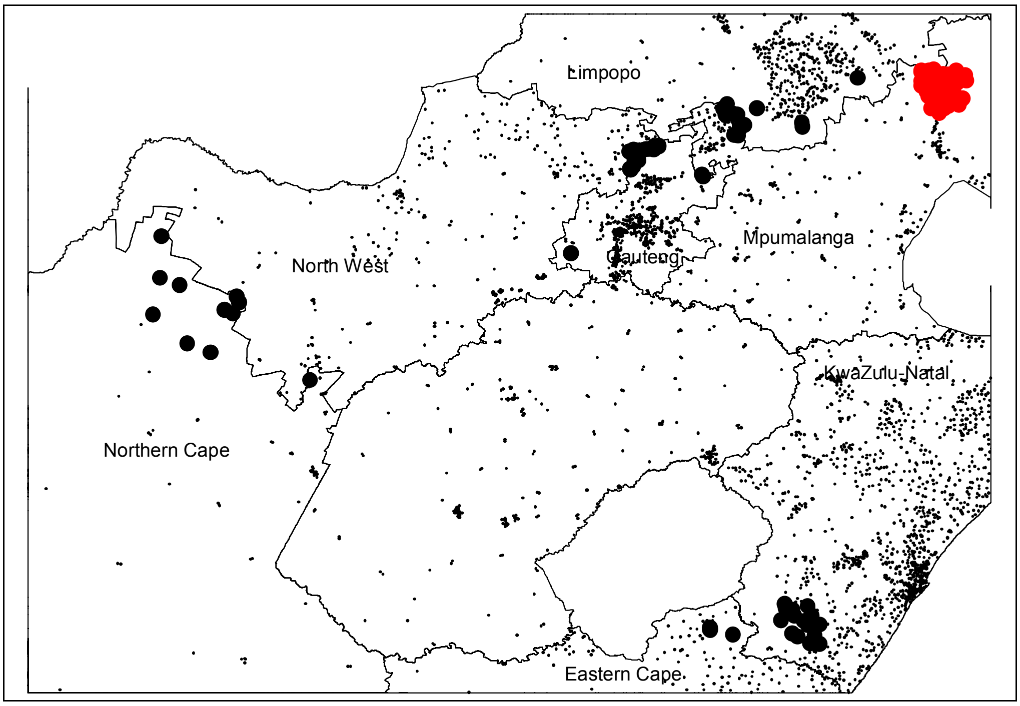
An event not aimed at improving school quality, but which nonetheless can assist in understanding school improvement, and in particular system-wide structural solutions, were relatively minor changes to the boundaries of South Africa's nine provinces occurring after 2005. Most of the provinces were completely new entities established in 1994 as part of the dismantling of the apartheid system. Seven provinces saw their boundaries change in 2005, all except for Western Cape and Free State. A total of 710 schools, 158 of which offer Grade 12, experienced a change in provincial administration. The distribution of the 158 schools is shown in Figure 1. All except for two of the 151 schools involved in the five largest province-to-province school 'migrations' had Grade 12 groups that were between 90% and 100% black African (the two exception schools were in the Mpumalanga to Limpopo migration). The

[2] The other races would be coloureds, whites and Indians, using the official South African terms.

schools in question are thus interesting in terms of understanding educational improvements for the most historically disadvantaged segments of the South African population

The boundary changes occurred largely to ensure that all municipalities fell into just one province and did not span two provinces. It must be noted that municipalities do not play a role in the administration of schools in South Africa. Instead, provincial governments are responsible for administering schools. Reporting directly to the provincial authorities are a number of 'education districts' (current there are 86 of these), whose boundaries often coincide with those of the municipalities, though institutionally they are independent of each other. Provincial education departments, of which the education districts are essentially branch offices, thus determine to a large degree how schools are resourced, the type of in-service training offered to teachers and the manner in which schools are accountable for their educational achievements. Crucially, provincial education departments are funded by the provincial department of finance, and not the national education authorities. Responsibilities left in the hands of the national authorities include maintenance of the national curriculum, the setting of the Grade 12 examination papers and quality control in the marking process, the Annual National Assessments programme and central bargaining with teacher unions around teacher salaries.

Figure 1: Schools experiencing a province change in 2005



Source: Produced in Stata using dataset analysed in this paper. The points refer only to schools offering Grade 12.
Note: Provincial boundaries are those created by the 2005 boundary changes. Schools which moved from a neighbouring province are marked by large points. Schools which moved from Limpopo to Mpumalanga are represented by large red points, to make them distinct from schools which moved in the opposite direction, from Mpumalanga to Limpopo.

A key question for this paper is exactly when the change to a new province could be expected to change the dynamics within the affected schools. Though legislation changing the provincial boundaries was passed in December 2005, after the 2005 examinations had been written, the transfer of schools to their new provincial administrations was not immediate. The official transfer for all affected provinces appears to have occurred in April 2007, at the start of the financial year, which would have been a few months into the 2007 academic year, starting in January 2007. The 2008 academic year would therefore have been the first such year in which a new province would have been in full administrative control of the transferred school. The fact that schools knew that the transfer was imminent could have influenced behaviour in the schools from as early as the 2006 school year. For instance, school principals may have felt invigorated or dejected by the fact that they were being transferred to what was perceived as a better or worse province. These kinds of concerns lay behind serious political protests during this period. In particular, there was a perception that Gauteng was a relatively good province to be in from a service delivery angle. To illustrate, the township of Khutsong, which was moved from Gauteng to North West following the 2005 boundary changes, saw protests that led to the widespread destruction of property over the dissatisfaction of residents with the move (Centre for Development and Enterprise, 2007). In 2008, further legislation moved Khutsong back to Gauteng. No other such reversals of the 2005 boundary changes occurred, but the Khutsong events provide a telling indication of how much differences in the perceived capacity of administrative units to deliver services matter to ordinary South Africans. That the quality of provincial and local governance is uneven and too often of an unacceptably low standard is a problem dealt with explicitly in South Africa's long-range national development plan (South Africa: National Planning Commission, 2012: 408).

3 Theoretical underpinnings

An education system is internally efficient when it optimises the use of available resources, including human resources in the form of teachers, in order to produce the educational outcomes it sets itself out to achieve. External efficiency is realised when the education system optimally contributes to the kind of human capital development required to advance development priorities such as raising incomes, reducing unemployment and promoting social cohesion. A key shift with regard to external efficiency has been the relative decline of manpower planning approaches, or the determination of specific vocational skills sets required in the economy, and a rising awareness of the importance of basic competencies, in language and subjects such as mathematics, for economic development. Hanushek and Woessman (2009) have been particularly influential in promoting the shift towards the prioritisation of basic competencies in policymaking circles.

How best to advance the internal efficiency of schooling systems has been a hotly debated matter, but there appears to be a convergence of opinions, partly due to more empirical research in this area. Importantly, a greater use of impact evaluations, either evaluations planned upfront or evaluations undertaken opportunistically with the available data, has underlined that things are often not what they seem. Interventions that at face value appear to be doing the right thing often produce no or very disappointing results when subjected to rigorous impact evaluation. Bruns, Filmer and Patrinos (2011) identify a few intervention types that appear promising, if interventions are carefully designed and appropriately combined: strengthening parent involvement in schools by giving parents more reliable information on the performance of their children; giving school principals more autonomy; making teacher employment conditions and pay less insensitive to student performance; and improving the in-service training of teachers. Taylor (2013) demonstrates how getting good educational materials to students in South Africa has made a positive difference to Grade 12 examination results.

As argued by Gustafsson and Mabogoane (2013) and others, the optimal bundle of interventions to improve the internal efficiency of a schooling system may differ rather fundamentally according to the level of development of that system, and society as a whole. For instance, very human capital-intensive interventions where teams of experts work with individual schools to bring about change, whilst appropriate in high income countries with limited pockets of dysfunctional schools, may be inefficient in developing countries where basic problems, such as teacher absenteeism, are widespread and school turnaround experts are scarce. In developing countries, there appears to be a stronger argument for the use of system-wide structural reforms, focussing for instance on overcoming information asymmetries and introducing better incentives for teachers and school managers. Going further, amongst economists Pritchett[3] has been a prominent advocate for fixing the fundamental problems of poor leadership and bad organisational culture in the state which seem to explain the weakness of service delivery in developing countries. Similarly, Acemoglu has underlined 'institutions as the fundamental determinant of development'. He has also noted that 'There is … ample room for developing better measures of sub-national institutions and exploiting the rich sub-national variation in institutional development paths and development outcomes'[4]. This is in fact the approach employed in the current paper.

One advantage with impact evaluations, in particular more rigorous ones which are planned upfront and make use of techniques associated with randomised control trials (RCTs), is that they help to combat publication bias, a bias that adversely affects the relationship between research and policymaking, according to Duflo, Glennester and Kremer (2006). Publication bias occurs where the finding of a zero impact results in the non-publication of some research. This easily happens where researchers rely exclusively on typical production function-type analysis of relationships between inputs and outputs. Due to inherent problems with this technique, it becomes easy to attribute a zero impact finding to problems with the data, even if the problem may be that there is no impact, the consequence being that the study is discarded as unpublishable and uninteresting. Policymakers are thus denied access to information on interventions that do not work, when such information is clearly necessary. Impact evaluations tend to come with fewer methodological problems and are more likely to be taken seriously even when no impact is found.

Yet impact evaluations need to be interpreted with care. They tend not to focus on the system as a whole, and thus do not deal with general equilibrium dynamics such as reactions of teacher unions over time to certain interventions. Important system-wide changes, such as the remarkable improvements in Brazil's PISA results between 2000 and 2009 are difficult to decipher with the available data and methods, yet they are of huge importance. Rasul and Rogger (2014) demonstrate that despite considerable methodological and data hurdles, it is sometimes possible to test the effectiveness of certain management practices followed by governments. Their study, which uses data from some 4,700 public projects in Nigeria confirms, amongst other things, that when incentive structures for senior public servants are clear and well-focussed, service delivery results improve. This specific finding seems to be supported by the analysis presented in the current paper.

Theory needs to be informed by good knowledge of institutional factors. A drawback with a 2010 impact evaluation of South Africa's Dinaledi programme, which pointed to some evidence of positive impacts on the basis of patterns seen in historical data not originally designed for impact evaluation purposes, is an insufficient acknowledgement of institutional realities. Specifically, there is a possibility that improvements seen in Dinaledi schools were at least partially the result of migration to these schools by good students from neighbouring schools, given that South African policy allows for considerable migration of this type and that evidence points to this being widespread. In impact evaluation terms, the possibility of contamination of the treatment group was not taken into account. The analysis presented below attempts to deal with this risk using spatial analysis techniques.

The following equation reflects key variables of concern for the empirical analysis that follows. We are concerned with improvements in some school-level measure of mathematics performance over time, so an improvement in indicator E in school i between periods t=1 and t=2. In a no change scenario, $E_{i,t=2}$ would be the same as $E_{i,t=1}$. Improvements in E could be brought about through resourcing or management improvements at the school level,

[3] Pritchett, Woolcock and Andrews, 2012.
[4] Acemoglu, Gallego and Robinson, 2014: 28-9.

represented by q_i, or at the level of the school region or district k, represented by Q_k. This paper is largely concerned with what can occur within Q_k to improve educational outcomes.

$$E_{i,t=2} = f\left(E_{i,t=1}, q_i, Q_k, S1_i, S2_i, S3_i\right) \quad (1)$$

The three S variables in equation (1) deal with three types of selection effects which are all potentially important if one is examining performance in a single subject at the secondary school level in the South African context, as we do. This is especially so where there is pressure for schools to improve results in terms of specific E indicators. $S1$ refers to the selection of students into the subject mathematics, given that this subject is not compulsory. By controlling the numbers entering mathematics, and having effective pre-entry assessments indicating which students are most likely to perform well, schools can improve their average scores. $S2$ refers to the effect on E of dropping out before students reach the grade with the examination, in our case Grade 12. Generally worse performing students drop out, meaning inducing dropping through various subtle and unsubtle means can be a way for the school to improve its Grade 12 results, at least with respect to indicators such as the average score. For instance, teachers can make students repeat grades before Grade 12, partly with a view to discouraging students from continuing with their schooling. Finally, $S3$ refers to a school's ability to attract the 'cream', or best performers, from neighbouring schools or, conversely a school's inability to stop the best students from moving to other schools. Gustafsson (2011: 23) finds that at the secondary school level, around 17% of students attend a school which is not the closest school to home, the largest reason for this being that the closest school is not satisfactory in terms of the quality of schooling offered. One would expect students who move to more distant schools to be better performing students, for three reasons. Firstly, they are likely to be socio-economically advantaged students from households that can afford the transport costs involved, and we know that socio-economic status is correlated with student performance. Secondly, households are likely to send better performing students to distant schools as these students are most likely to be benefit from better teaching. Thirdly, schools are likely to be more accepting of students from other areas if they are high-performing students.

4 The data

The data used for the analysis were student records of results in the Grade 12 year-end examinations, for the years 2005 to 2013. These data were obtained from the Department of Basic Education (DBE). The key challenge was to link schools across years as the system of school identifiers had changed over time and there were many inconsistencies with respect to school identifiers even in years when provincial boundaries were not changing. Essentially the examinations database was not really designed with school-level year-on-year comparison in mind. The point of departure was to link the schools from the 2005 and 2011 datasets. The final school-level panel of data included all schools for which examinations data were available in both 2005 and 2011. For the other years there were missing values for some of these schools, mostly due to school identifier problems. The extent of this is shown in Table 2[5]. Table 1 indicates the number of students covered in the 2005 and 2011 datasets, broken down by mutually exclusive categories reflecting the province of a school in 2005 and 2011. Provincial categories were determined on the basis of variables in the data referring to the school's line of administrative accountability, not on the basis of the school's geographical coordinates. There is thus no possibility that inaccurate geo-coordinates in the data led to a misclassification of schools. The decline in the average number of mathematics students per school should be seen in the context of the introduction in 2008 of mathematical literacy, a subject not considered in the analysis. Simkins (2010: 19) has estimated that if mathematical

[5] The lower total school count for 2013 in Table 2 is mainly due to the fact that virtually a whole KwaZulu-Natal district (not affected by the boundary changes) was missing in the dataset used.

literacy is considered, the 2007 to 2008 curriculum change resulted in an increase in the total amount of mathematics knowledge produced by the schooling system.

Table 1: 2005 and 2011 data coverage in terms of schools and students

			Mathematics examination takers			Average Grade 12 mathematics students per school	
	Total schools	Private schools	2005	2005 (HG)	2011	2005	2011
EC	824	24	41,989	2,390	37,482	51	45
EC>KN	15	0	756	28	741	50	49
FS	293	8	12,589	1,670	9,986	43	34
GP	585	112	47,644	8,995	28,309	81	48
KN	1,463	34	78,496	8,527	58,743	54	40
LP	1,180	29	41,039	9,901	31,914	35	27
LP>MP	83	1	2,886	897	3,362	35	41
MP>LP	13	2	578	52	356	44	27
MP	360	13	18,309	2,235	14,527	51	40
NC	95	2	3,269	502	2,454	34	26
NW>GP	29	0	2,326	191	1,297	80	45
NW>NC	11	0	426	4	302	39	27
NW	328	10	16,966	1,640	9,312	52	28
WC	342	30	21,053	4,736	13,662	62	40
Other	7	1	217	13	172	31	25
Total	5,628	266	288,543	41,781	212,619	51	38

Note: 'Other' refers to province switches involving fewer than ten schools within the switch. The 2005 student count columns refer, firstly, to all mathematics candidates and, secondly, to those from the previous column taking mathematics at the higher grade (HG). The provincial abbreviations mean the following: EC, Eastern Cape; FS, Free State; GP, Gauteng; KN, KwaZulu-Natal; MP, Mpumalanga; NC, Northern Cape; NW, North West; WC, Western Cape.

The 'LP>MP' category stands out as the only one where the average number of mathematics students per school increased. Moreover, this is the largest province-switching category in terms of the number of schools. The factors behind the unusual mathematics enrolment trend seen here will be examined below, as they are important for the conclusions arrived at towards the end of the analysis.

There are many ways in which to measure a school's improvement with respect to mathematics over the years. A fundamental question is one of breadth versus depth, or what Hanushek and Woessman (2009: 22) refer to as 'rocket scientists versus education for all'. Is improvement occurring through the extension of mathematics skills to more students, or is the number of high-end achievers increasing? Of course both may be occurring simultaneously, though it is reasonable to assume that to some degree there is a trade-off between the two. If available teachers must teach more students they may have less time to support high-end achievers.

The following table reflects eight indicators aimed at allowing a broad treatment of the question of improvements in mathematics and, by extension, in school education in general. Given that initiatives and trends influencing student performance tend to cut across the curriculum, trends seen in mathematics are likely to reflect trends in other subjects too. Clearly, values from the old examination system (2005 to 2007) and the new one (2008 to 2013) are not comparable in any simple sense. This should not cause problems for the analysis, however, as long as the analysis focuses on school-level differences in the change over time.

The percentage of mathematics candidates passing the subject is an indicator, the first in Table 2, which has been widely referred to in official reports. The percentage of Grade 12 students taking mathematics is an important indicator of the level of opportunity afforded to students, and of the extent of the selection effect $S1$ from equation (1). The number of mathematics passes per school, including or excluding standard grade passes from the old system, is one indicator of improvement, and one that is commonly used in official documents[6]. The average mathematics score out of 100 obtained by students is an indicator less commonly quoted. To obtain the 2005 to 2007 averages, the standard grade score was multiplied by 0.75 to reflect the lower value attached by educationists to this score. This factor has been used by Foxcroft (2006: 70) and is roughly in line with the correspondences between standard grade and higher grade scores identified by Simkins (2010: 8) for physical science. The scores of students taking higher grade mathematics were not adjusted upwards, though an argument for such an adjustment could be made. 'Mark at the 95th percentile' is based just on students who wrote the mathematics examination and for 2005 to 2007 again standard grade scores were multiplied by 0.75.

To obtain the number of high-level passes per school, a threshold of 70 out of 100 was used, and only higher grade mathematics in the old system was counted. The use of absolute numbers such as these, in a context where school sizes differ, leads to results that must be interpreted with caution, yet there are good reasons for looking at absolute numbers and not just means. Part of the reason for this is that numbers may increase exceptionally not just because communities around schools grow, but also because successful schools attract students from outside their regular catchment areas, as discussed below. This kind of success can pass unnoticed if only means are analysed.

The seventh indicator in Table 2 uses the values from indicator 6, but then assigns a score of zero to all Grade 12 students not taking mathematics, in order to calculate a new (and lower) score at the 95th percentile. The advantage with this indicator is that it controls for the tendency of the school to keep worse performing students out of the mathematics class.

[6] The old system also had 'lower grade' passes, passes at a very low level of performance. These low level passes are not counted as passes in the current analysis. Moreover, in the old and new systems, a student who obtains a score below the pass threshold may be counted as a pass if certain conditions are fulfilled. Such passes are not counted in the current analysis, for any year. These factors would explain why the Table 2 figures would produce lower totals to those seen in official reports. This should not be a cause for concern, as the same criteria are used in the current analysis for all schools.

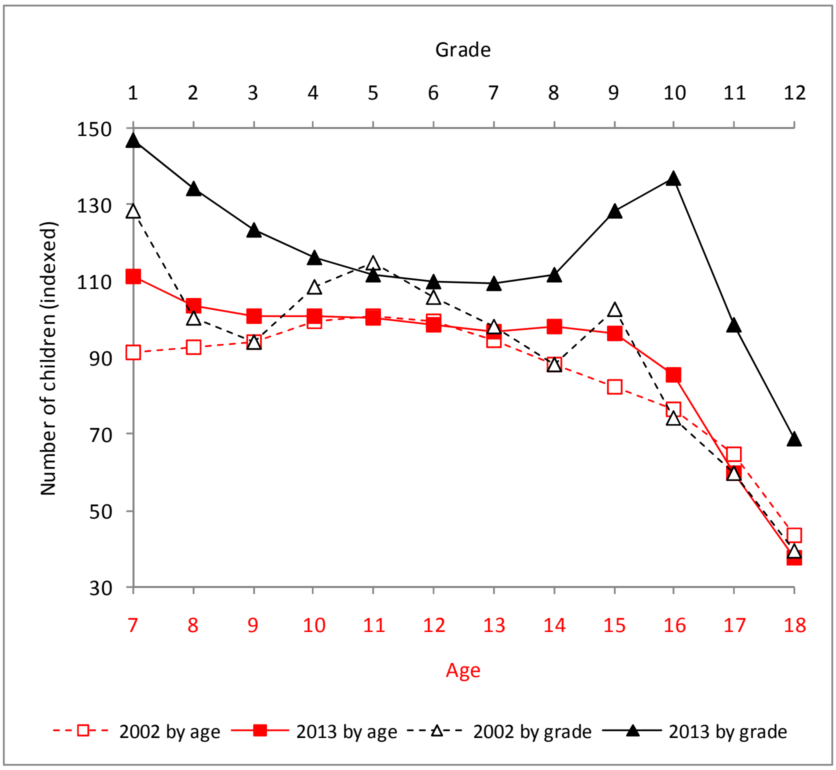
Table 2: Descriptive statistics for the eight indicators for all years

	Mean values									Std. dev.	
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2005	2013
Schools	5,628	5,609	5,579	5,600	5,585	5,616	5,628	5,602	5,456		
Switching schools	158	158	157	155	157	158	158	158	155		
1. % of mathematics-takers passing mathematics	55.6	41.3	42.8	47.1	46.3	46.4	45.3	50.1	55.5	28.8	27.3
2. % taking mathematics (SG included)	58.6	57.5	57.8	52.0	52.1	49.5	45.9	44.0	41.9	23.4	22.8
3a. Number of passes (SG included)	28.2	22.0	24.3	23.2	22.3	20.8	17.3	19.8	23.2	31.8	30.2
3b. Number of passes (SG excluded)	4.9	6.6	6.9							12.9	
4. Average mark	25.4	19.7	20.0	31.1	29.8	30.7	30.6	32.4	34.6	11.8	12.0
5. Mark at the 95th percentile	46.2	48.9	49.7	58.9	56.6	57.7	56.0	59.2	62.2	16.1	16.3
6. Number of high-level passes	1.3	2.0	2.1	4.4	3.1	3.0	2.2	2.7	3.3	5.3	9.0
7. Mark at 95th percentile relative to all Grade 12	40.5	42.6	43.4	50.4	48.5	48.7	46.7	48.8	51.0	16.0	17.7
8. Mark at 95th percentile relative to earlier Grade 10	32.2	35.3	36.7	41.9	40.1	39.9	37.1	39.5	41.9	17.5	19.3

Note: For indicator 8, which relied additionally on data other than the examinations data, data from 5,624 schools were used, of which 158 were province-switching schools. For indicator 8, 2005 was the year with the lowest number of province-switching schools. Here the school count was 148. Note that standard deviations are at the school, not the student, level.

The last indicator uses the 95th percentile in relation to all students one might expect to reach Grade 12 if there was no dropping out before this grade (so if *S*2 was zero). One might expect this indicator to be a particularly robust measure of performance because it controls for both selection into Grade 12 and selection into mathematics. The ideal would have been to use enrolment by age data and to use as one's cohort size something like the number of fifteen year olds three years before the Grade 12 group being analysed (dropping out has in the past tended to be low up to age fifteen). However, this idea was dropped due to problems in linking schools across the necessary years in the relevant tables of the DBE's Annual Survey of Schools dataset. Instead, the number of Grade 10 students two years before the Grade 12 group being analysed was used. The data source for this was the Snap Survey, the second large enrolment census conducted by the DBE each year. Even if not ideal, it will be shown in the analysis that follows that the resultant indicator is a useful one. Figure 2 below indicates why an age cohort would have been ideal. The two horizontal axes covering grade and age respectively are aligned according to official age-grade norms, so for instance age 18 is aligned to Grade 12. Clearly there is no neat correspondence between age and grade. Moreover, the gap between the age and grade curves has widened over time, evidence of both longer survival by youths in the schooling system and higher levels of grade repetition. To illustrate, the ratio of Grade 10 students to the average age 10 to 12 age cohort size (indexed to 100 in the graph) moved from 0.74 in 2002 to 1.37 in 2013. In 2002 clearly many youths did not reach Grade 10. In 2013, many more did, but there were also many grade repeaters in Grade 10. Much of this grade repetition would be the result of fears of allowing weakly performing students into Grade 12.

Figure 2: Age and grade distributions of school students



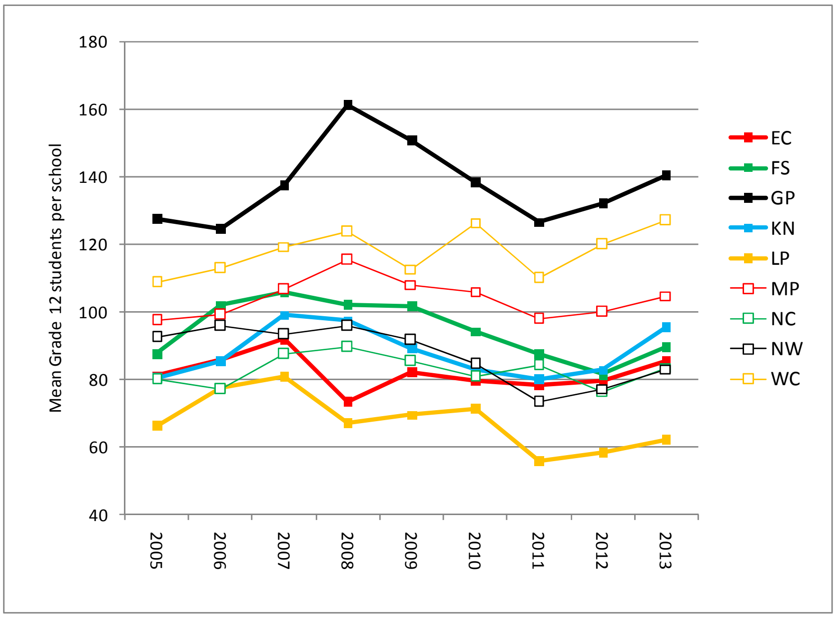
Source: Students by age is obtained from the Annual Survey of Schools data of the Department of Basic Education (DBE). Students by grade uses DBE data publicly available through the DataFirst portal at https://www.datafirst.uct.ac.za.
Note: Red curves should be read against the bottom horizontal axis, the black curves against the top axis. The two 2002 curves are each based on the same 13,979 public ordinary schools, which were the schools which could be linked across the two data sources and did not display large discrepancies across the sources. These 13,979 schools represent 61% of public school enrolment, and nothing in the data suggests they would be worryingly unrepresentative of all schools for the purposes of the current analysis. For 2013 linking of schools was better. The two 2013 curves are based on data from 23,502 public ordinary schools covering 97% of expected total enrolment. To facilitate comparison across the two years in the graph, 100 on the vertical axis means, in the case of 2002, the average age-specific enrolment across the three ages 10, 11 and 12. These are ages where high levels of enrolment, of at least 95%, can be expected. The same approach was applied separately to 2013.

5 Key provincial trends

The analysis of provincial trends presented here uses data just on schools whose province did not change. Figure 3 below illustrates Grade 12 enrolment trends. There has been an overall decline of around 0.7 students a year, or -0.7%. This is in the context of an annual growth rate of around 0.4% in the age 18 age cohort, suggesting a declining proportion of an age cohort was enrolled in Grade 12 within public schools[7]. A number of factors lie behind this trend. Enrolment in other institutions, such as vocational training colleges and independent schools has increased. Moreover, historical changes in the age of entry into Grade 1 have produced spikes and troughs in Grade 12 enrolments many years later. This factor largely explains the dip in 2011 seen in many provinces in Figure 3. Changing patterns of grade repetition in Grade 12 would also influence Grade 12 enrolment trends, though this is difficult to quantify because of data problems and some under-reporting of repetition, the latter being linked to the fact that public schools are not supposed to allow students to repeat Grade 12 on a full-time basis.

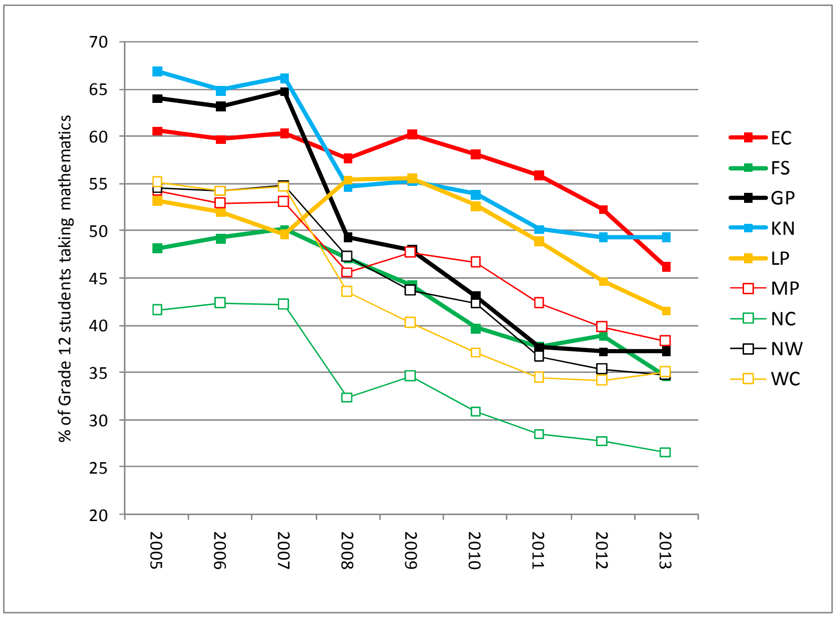
[7] South Africa: Department of Basic Education, 2013b: 4.

Figure 3: Mean Grade 12 students per school



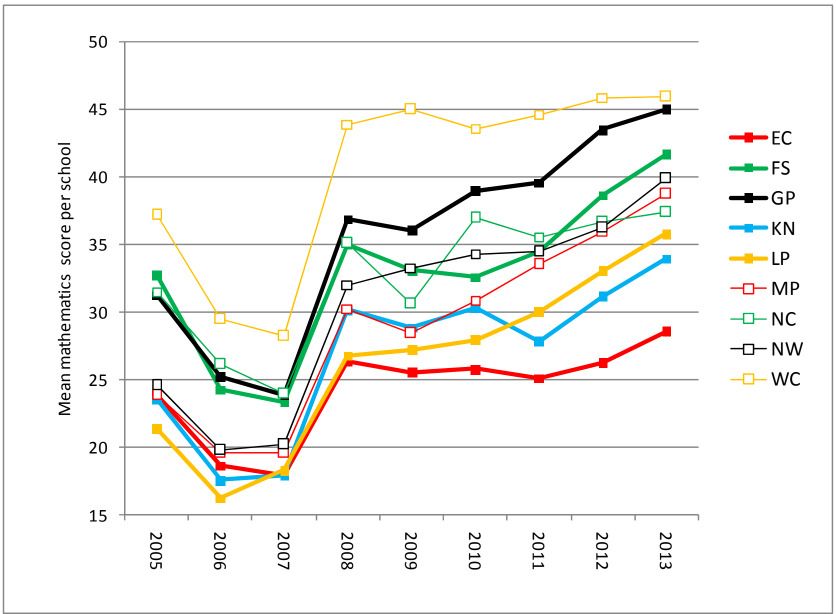
Statistics in Table 1 above pointed to a decline in the absolute number of Grade 12 mathematics student per school. Figure 4 below illustrates the declining percentage of Grade 12 students taking mathematics. This decline has continued under the new curriculum, starting in 2008. Some provinces have become more restrictive than others when it comes to allowing (or encouraging or discouraging) Grade 12 students to take mathematics. Gauteng, in particular, has been restrictive, with the percentage declining from 65% in 2007 to 37% in 2013.

Figure 4: Mean % of Grade 12s taking mathematics



Turning to more qualitative indicators, the number of mathematics passes per school has, since 2008, remained roughly flat (see Table 2). However, passes as a percentage of mathematics students would have increased as the denominator shrunk. As illustrated in Figure 5 below, the average mathematics score improved steadily since 2008. As argued previously, one cannot read too much into the trend seen when the curriculum changed (2007 to 2008) because the pre-2008 values are driven to a large extent by assumptions around how to equate pre-2008 values to the later values (though this should not affect the ranking of schools greatly). The upward trend from 2008 translates to an annual average improvement of 1.2 points (out of 100). This is around 0.06 of a standard deviation across students per year. At face value, this improvement is equivalent to the fastest improvements seen across the world in standardised tests, for instance the noteworthy improvements seen amongst Brazil's 15 year olds with respect to PISA[8] mathematics (Gustafsson, 2014: 136). In reality, there has probably been some improvement in Grade 12 mathematics over the period if one considers that South Africa's Grade 9 TIMSS mathematics score improved considerably, off a low base, between 2002 and 2011 (Reddy, Prinsloo, Arends and Visser, 2012). However, a considerable portion of the 0.06 of a standard deviation improvement would be driven by the exclusion of worse performing students. It is also possible that there are problems in the standardisation of scores across years, a process around which there is not much transparency. Worth noting is the fact that a report by a government-appointed task team of experts focussing on the Grade 12 examinations, whilst acknowledging increases in key indicator values, appears not to interpret this as a sign of fundamental change in the quality of schooling[9].

Figure 5: Mean mathematics score



Note: Schools weighted by students taking mathematics.

Arguably a school's ability to produce high-level passes is more important than its average mathematics score. At least one high-level pass in a school in most years points to important possibilities in a school. Firstly, it suggests that teaching and the school environment is such that it allows the students with the greatest mathematical aptitudes to realise their potential. Secondly, having at least one high-level performer means there is an important human resource whom others can draw from. Other students enjoy a reliable source of advice when the correctness of certain mathematical solutions is unclear. Good mathematicians in class are more likely to challenge the teacher in constructive ways. In development economics, a country's level of development is sometimes characterised by the 'frontier' technologies available within the country (see in particular Nelson and Phelps, 1966). The most advanced technologies existing in the country provide an indication of what is potentially accessible and replicable amongst a wider segment of the population. In some ways a school's level of development can also be characterised by its 'frontier', or most able, students.

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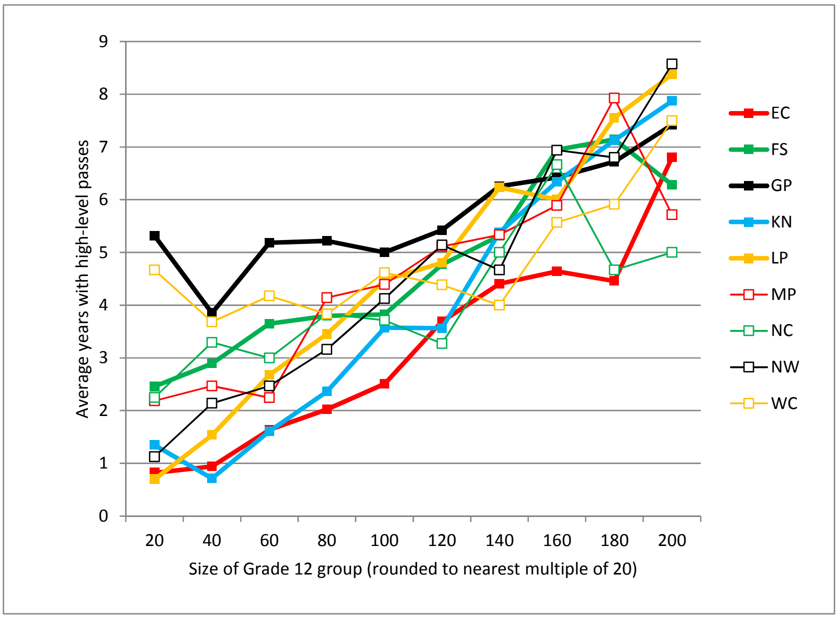
[8] Programme for International Student Assessment.
[9] South Africa: Department of Basic Education, 2014: 26.

So to what extent do schools have access to a high-level mathematics achiever within the school? Overall 12% of Grade 12 students were in schools which did not produce a single high-level pass in any year during the 2005 to 2013 period. As one would expect, this statistic is sensitive to school size. Amongst the 25% of students in the smallest schools, meaning schools with 78 or fewer students in Grade 12, 44% were in schools which never produced high-level passes, whilst the figure was virtually zero (just 0.6%) for the 25% of students in the largest schools, or schools with 164 or more in Grade 12. The following graph, Figure 6, illustrates differences across provinces, whilst controlling for school size (represented by the number of Grade 12 students). Across all provinces, students in larger schools tend to enjoy more exposure to mathematics ‘whizzkids’. Gauteng emerges as most effective in bringing about this type of exposure in relatively small schools. The curve for Limpopo is interesting. Small schools in this province are comparatively weak at producing high-level passes, yet the province’s larger schools are particularly effective in this regard, in fact better than equally large schools in Gauteng. Western Cape displays a reverse pattern of relatively outstanding performance in small schools, but rather mediocre performance in larger schools. Of course these correlations between school size and the production of high-level mathematics are basic and offer a limited view of the possible dynamics. School size is discussed further in a subsequent section.

Figure 6: High-level passes within schools



Note: The values in the vertical axis

How stable are the rankings of provinces and schools across years in terms of the eight indicators in Table 2 above? This question is important for the analysis undertaken for this paper, but also for understanding the amenability of different indicators for accountability purposes. According to the next table, the average change in a province’s ranking between one year and the next has mostly been less than 1.0, and tends to be closer to 0.5 than 1.0. This seems to be a relatively small degree of change, suggesting that one’s assessment of better and worse performing provinces is not greatly influenced by the year or indicator one chooses. For the 2008 to 2013 period, so a period when the same examination system applied, the average score and the 95th percentile relative to earlier Grade 10 enrolment can be considered particularly stable indicators of provincial performance (see the row ‘2009-13’ – the percentage of mathematics takers indicator was not mentioned because this is not really an indication of performance).

Table 3: Rank changes

year	1. % passing	2. % taking	3. Passes	4. Average	5. Maths 95^{th} p'tile	6. High-level passes	7. Grade 12 95^{th} p'tile	8. Grade 10 95^{th} p'tile	Overall mean
Mean absolute change in rank at the **province** level									
2006	0.89	0.44	1.11	0.22	0.44	0.00	0.44	0.22	0.47
2007	0.89	0.44	1.11	0.44	0.44	0.44	0.44	0.44	0.58
2008	0.67	2.00	0.44	0.67	0.89	0.89	0.67	0.89	0.89
2009	0.67	0.44	0.67	0.44	1.11	0.22	0.67	0.44	0.58
2010	0.89	0.67	0.89	0.44	1.11	1.33	1.56	1.11	1.00
2011	0.44	0.44	0.89	0.67	0.89	0.67	1.33	0.44	0.72
2012	1.11	0.00	0.67	0.67	0.44	0.89	0.67	0.67	0.64
2013	0.89	0.67	0.44	0.44	0.22	0.67	0.22	0.22	0.47
2006-13	0.81	0.64	0.78	0.50	0.69	0.64	0.75	0.56	
2009-13	0.80	0.44	0.71	0.53	0.76	0.76	0.89	0.58	
Whole	2.00	2.00	1.56	1.56	2.00	1.56	1.78	2.00	
Mean absolute change in rank at the **school** level									
2006	717	579	558	626	807	1181	761	668	747
2007	738	594	552	667	865	1167	816	694	771
2008	846	1076	638	782	916	1077	833	752	881
2009	760	730	556	692	800	884	772	674	742
2010	780	694	545	716	838	932	781	650	755
2011	821	699	572	753	864	954	793	671	779
2012	832	676	552	763	868	961	824	668	782
2013	819	652	491	734	838	877	756	628	738
2006-13	789	713	558	717	850	1004	792	675	
2009-13	802	690	543	732	842	921	785	658	
Whole	1200	1191	811	1119	1091	1169	1032	923	

Note: Values in the row 2006 reflect comparisons of rankings in 2005 against 2006. The same applies to other rows referring to single years. The row 2006-2013, for example, is simply the mean across the rows 2006 to 2013. The row 'Whole' reflects the average rank change across the whole period, comparing just 2005 to 2013. For every calculation reflected in the table, the same 4,682 schools were used, these being schools which had no values missing for any year or indicator. To obtain each per year and indicator value, schools were ranked according to the indicator, but in a manner than that ensured that 4,682 ranking values were obtained. This required assigning ranks randomly where indicator values were equal across years, for instance, where the number of high-level passes was zero. This reflects the fact that we do not actually know whether such a school has improved or not, as the indicator is too blunt an instrument. The absolute change in rank between one year and the next was found at the province or school level, and the mean of the absolute rank changes was then calculated. Provincial indicator means (not weighted by school enrolment) were used for the province analysis.

At the school level there are considerable year-on-year changes in rankings. It must be noted that for every calculation, each school was assigned a unique ranking within a year. There were 4,682 considered in total, this being the number of schools with no missing data for any year or any indicator, so for any year and any indicator, there would have been 4,682 unique rankings. Thus if two schools had the same indicator value within a year, their ranking would be partly randomly determined. For instance, if there were ten schools with two passes, and two was the lowest indicator value for all schools, then the ten schools in question would be given the rankings 1 to 10 on a random basis. This is logical if one considers that the ten schools are not truly the same in terms of educational quality, but the indicator is not able to show which schools are better than others. The indicator is simply too blunt an instrument.

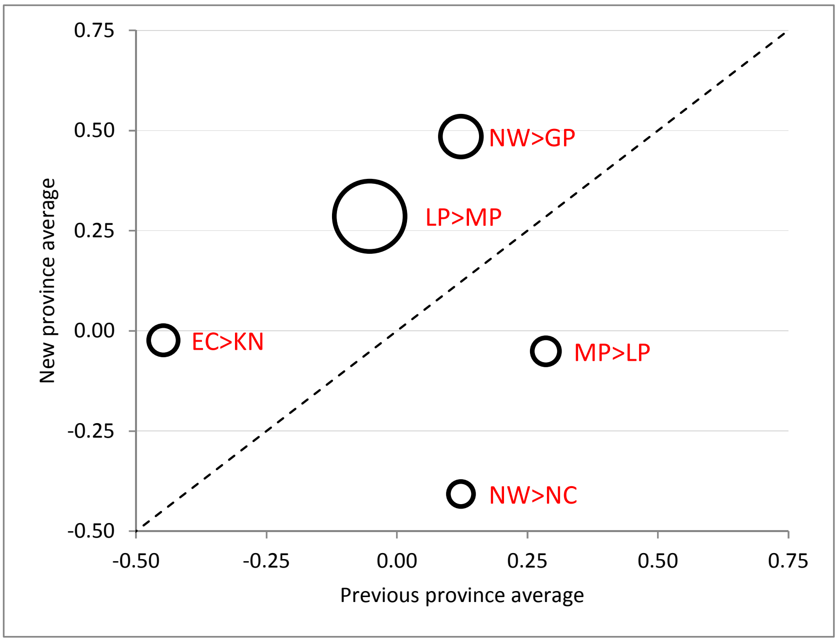
For the 2008 to 2013 period, the number of mathematics passes emerges as a particularly stable basis for ranking schools. Second in line comes the indicator using the prior Grade 10 enrolment figure as a benchmark, which confirms the utility of undertaking the data work required for an indicator with a strong selection effect control such as this one. The right-hand column in Table 3 confirms what one might expect, namely that the greatest disturbances in the rankings would have occurred between 2007 and 2008, in other words when a new examination based on a new curriculum was introduced.

6 Analysis of province-switching

6.1 Trends across two years

Figure 7 below illustrates important factors associated with the five largest switching groups, which cover 151 of the 158 switching schools. Here performance at the 95th percentile, relative to all Grade 12 students, in 2005, of the old and new province are shown (so indicator 7 of Table 2). Original values are converted to z-scores (mean of 0, standard deviation of 1.0, at the school level), using data from all schools, but with the calculation occurring separately for each year (so the mean per year across all schools is zero). A similar picture emerges if years other than 2005 are used, or any of the other indicators not driven by school size (using, for instance, high-level passes would not be appropriate here as moving to a province with larger schools could then appear as a move to a better performing province). In Figure 7 three groups move to better performing provinces, whilst two move to worse performing provinces. Clearly the larger groups, in particular 'LP>MP' and 'NW>GP' are more likely to produce statistically significant results, other things being equal, simply because of their size.

Figure 7: Provincial values before and after for switching schools



Note: Areas of circles are proportional to the number of schools. The values on the two axes are the average score values, at the school level, converted to z-scores.

The data analysis described below borrows from the methods associated with randomised control trials (RCTs), given the quasi-experimental nature of the data. Schools across the country were not treated to an education improvement intervention as they might be in a proper RCT. Instead, a 'treatment' in the sense of a shift to an alternative provincial administration occurred, with schools being somewhat randomly selected for this. This notion of boundary changes operating as treatments in a quasi-experiment, or 'natural' experiment, is used by Cogneau and Moradi (2014) in examining the impact of changes in the boundary between Ghana and Togo in 1919 on subsequent literacy levels.

In the South African 'experiment', there was randomness in the sense that schools were not placed in new provinces because there was something special about them educationally. They were moved simply because there was a need to rationalise the system of local government. Of course there was not true randomness in the selection of schools as they all fell within specific geographical areas close to provincial borders where the redrawing of these borders was deemed necessary to align the provincial and local divisions. This non-randomness problem is partially dealt with below using as controls key variables which are correlated with the status of being a moving school, such as school size. Specifically, moving schools were more likely to be from Limpopo, were slightly larger in terms of their Grade 12 enrolment and were less likely to be in quintiles 4 or 5 (less poor quintiles). Moreover, groups of schools which did not change province, but were close to schools which did, are utilised as a further control.

The following empirical model, which is an extension of the basic regression model for an RCT put forward by Duflo *et al* (2006: 6), is our point of departure.

$$E_{gi,t=2} = \hat{\beta}_0 + \hat{\beta}_1 E_{gi,t=1} + \hat{\beta}_2 \delta_g + \hat{\beta}_3 X_i ... + \hat{\beta}_n Z_i + \hat{u}_i \qquad (2)$$

Each school i is in a province-switching category g, where each category is defined by one's province in 2005, and one's province in a later year, so 'NW>GP' would be one category, and schools remaining in, say, Eastern Cape would be another. E is the performance of the school. Values for E for an initial period t=1, meaning 2005 in our case, are used and for a subsequent year t=2. δ is a measure of the degree of change embodied in the change from one province to another, which would be zero for schools which remain in the same province, and some positive (or negative) value for schools moving to a better (or worse) province. X through to Z are additional explanatory variables which might explain the value added to E between t=1 and t=2, such as the size of the school or, importantly, the inherited management culture associated with having been with the original province for around decade, up to around 2007.

Table 4 below provides regression results for three models where E is the mark at 95th percentile relative to earlier Grade 10 (indicator 8 in Table 2), and t=2 is 2013. As discussed earlier, this measure of performance is at least theoretically the most robust and comparable indicator calculated for this analysis, and as will be seen below, this measure does indeed produce particularly statistically significant patterns. To facilitate comparison across indicators in a discussion which follows, z-scores of the indicator values were used, with zero being the mean across all schools within each year. δ is an average measure of performance in the new province minus the corresponding average in the old province. δ was calculated in two different ways. The first way, which uses province-level performance from t=1 and t=2, is as follows:

$$\delta_{g,t=2} = \left(\frac{\overline{E}_{i,p=2,t=1} + \overline{E}_{i,p=2,t=2}}{2} \right) - \left(\frac{\overline{E}_{i,p=1,t=1} + \overline{E}_{i,p=1,t=2}}{2} \right) \qquad (3)$$

The first term on the right-hand side captures the performance of the new, or second, province p=2. This is found by calculating the average performance of schools across both time periods, so during t=1 and t=2 (2005 and 2013 in this instance). From this one then subtracts the corresponding value for the first province p=2. Grade 12 students were used as a weight when calculating the average of E across schools. The intention is thus to use a province's performance across more than one point in time to draw conclusions around a province's general level of performance. δ is negative for two of the five province-switching categories shown in Table 4, namely 'MP>LP' and 'NW>NC', and positive for the other three. The alternative method is discussed below.

In the column A model in Table 4, δ would carry a different value for each of the province-switching categories, so for instance δ for 'NW>GP' would be different to δ for 'LP>MP'. The coefficient on δ is positive and statistically significant. This points to a systematic impact of δ on performance change in affected schools. Moving to a better (or worse) performing province is associated, on average, with a relative performance improvement (or deterioration) of the school.

Included as explanatory variables for column A are provincial 0-1 dummies reflecting the province in which the school was before any boundary change. Six of the eight provincial dummy variables are statistically significant at least at the 5% level, confirming that the province a school finds itself in plays an important role in determining its performance trajectory. Whether the school falls into the least poor quintile of the official poverty quintiles (so quintile 5), or the second-least poor one (quintile 4), is also included in the model, to at least partially control for the socio-economic status of students. The coefficients here indicate that less poor schools have tended to see larger improvements in absolute terms, a matter which is concerning given that principles around diminishing returns to inputs would suggest that schools with worse initial levels of performance should find it easier to achieve large improvements. Finally, Grade 12 enrolment, specifically the total number of examination candidates in 2013 (divided by 100 to obtain more readable coefficients), is included in the quadratic form.

The coefficients for the enrolment variables in column A mean that an increase of ten Grade 12 students in a school is associated with an increase of 0.04 standard deviations, measured at the school level. This relationship is highly statistically significant. Larger schools have thus tended to see larger improvements over time.

For column B a simpler approach, relative to equation (3), of using only data from the starting year, 2005, was followed in calculating δ. One would not expect the different approach to impact greatly on the results, given the earlier discussion around the relative stability of provincial rankings over the years. Indeed, the coefficient on δ in column B remains essentially what is was in column A.

For the column C model province-switching is represented by dummy variables for the five main province-switching categories. Three coefficients emerge as statistically significant, namely those on ‘LP>MP’, ‘NW>GP’ and ‘MP>LP’, with the first two of these three being positive and significant at the 1% level. At least for three categories then, on average schools experience relative performance shifts which move in the same direction as the performance difference between the new and old province. This make intuitive sense, yet the fact that the trends emerge this clearly in the data seems remarkable and underscores the important role played by the province in determining the educational trajectories of schools.

Table 4: Regression outputs for models using Grade 10-adjusted 95th percentile

Dependent variable →	Mark at 95th percentile relative to earlier Grade 10			
	A	B	C	D
Constant	-0.564*** (-16.31)	-0.564*** (-16.30)	-0.494*** (-10.24)	-0.494*** (-10.24)
2005 value	0.640*** (54.30)	0.640*** (54.25)	0.642*** (54.39)	0.641*** (54.20)
Provincial diff. (δ)	0.585*** (3.09)	0.540** (2.53)		
Is EC>KN (13)			-0.244 (-1.24)	-0.245 (-1.24)
Is LP>MP (75)			0.233*** (2.75)	0.231*** (2.73)
Is MP>LP (13)			-0.504** (-2.52)	-0.516*** (-2.58)
Is NW>GP (28)			0.379*** (2.70)	0.377*** (2.69)
Is NW>NC (10)			-0.136 (-0.60)	-0.137 (-0.61)
Is near LP>MP (20)				-0.197 (-1.02)
Is near MP>LP (13)				-0.197 (-0.92)
Is near NW>GP (28)				-0.034 (-0.25)
Is EC 2005	0.066 (1.35)	0.064 (1.32)	-0.059 (-1.21)	-0.059 (-1.21)
Is GP 2005	0.156*** (3.85)	0.154*** (3.81)	0.091* (1.76)	0.093* (1.78)
Is KN 2005	0.359*** (11.22)	0.358*** (11.17)	0.293*** (6.39)	0.293*** (6.38)
Is LP 2005	0.448*** (13.46)	0.450*** (13.54)	0.374*** (7.90)	0.375*** (7.91)
Is MP 2005	0.445*** (9.79)	0.441*** (9.70)	0.396*** (6.99)	0.407*** (7.11)
Is NC 2005	-0.196** (-2.46)	-0.197** (-2.48)	-0.262*** (-3.04)	-0.261*** (-3.04)
Is NW 2005	0.192*** (4.16)	0.190*** (4.07)	0.124** (2.15)	0.125** (2.16)
Is WC 2005	-0.074 (-1.53)	-0.076 (-1.57)	-0.138** (-2.38)	-0.137** (-2.37)
Is quintile 5	0.111*** (3.08)	0.111*** (3.08)	0.106*** (2.94)	0.105*** (2.91)
Is quintile 4	-0.014 (-0.44)	-0.014 (-0.45)	-0.017 (-0.55)	-0.018 (-0.59)
Grade 12 enrolment / 100	0.367*** (8.69)	0.370*** (8.76)	0.363*** (8.59)	0.364*** (8.61)
...above squared	-0.048*** (-3.57)	-0.048*** (-3.61)	-0.047*** (-3.49)	-0.047*** (-3.51)
N	5228	5228	5228	5228
Adjusted R^2	0.498	0.498	0.499	0.499

*Note: *** indicates that the estimate is significant at the 1% level of significance, ** at the 5% level and * at the 10% level. Values in brackets next to coefficient values are t-values. Values in brackets next to switching categories are number of schools with the required data for use in the models. For the 2005 province dummies, Free State is the reference.*

Adjusted R^2 values are considerably higher for the indicator used in Table 4 than for other indicators which are also not sensitive to school size, in other words the other indicators except 3 and 6. To illustrate, had one used performance at the 95th percentile relative to all Grade 12 students, R^2 would have been 0.37, compared to the 0.50 seen above. This confirms the importance of including controls, even imperfect ones, for selection into Grade 12, or dropping out before this grade.

Finally, in column D the possibility that changes associated with the province-switching categories could instead be wider geographical trends is explored. To illustrate, in the case of the 'Is LP>MP' category, schools near these schools were selected and considered part of a new category 'Is near LP>MP'. Schools were placed in the new group starting with schools closest to any schools in 'Is LP>MP', until the number of schools in the new group was equal to the number of schools in 'Is LP>MP'. However, the constraint was applied that no school in the new group could be further than 30 kilometres away from the 'Is LP>MP' group. This explains why 'Is near LP>MP' only has 20 schools, whilst the number of schools in the other two new categories equals the number of schools in the original category. The intention was thus to create a small control group surrounding the province-switching schools, of the same size if possible, and then to see whether the statistically significant trends seen amongst the province-switching schools withstood this control. If this were not the case, one would perhaps have to conclude that changes in school performance were caused not by being under a new education administration, but rather some other dynamic. For instance, the redrawing of the provincial boundaries could change employment and income patterns, which in turn could lead to more successful schooling. But if this were the case, one might expect changes in the performance of schools to be more diffuse, and not limited to just the schools whose administration changed. In fact, column D in Table 4 shows that the coefficients on the province-switching groups remain largely unchanged and that the coefficients on the groups of nearby schools are insignificant. The conclusion that a school's improvement was closely associated with its change of province thus emerges intact.

What if a year earlier than 2013 is used for the regression analysis displayed in Table 4? The coefficient on δ in column A remains statistically significant, at least at the 10% level, if 2010, 2011 or 2012 are used as the end year. However, for 2008 or 2009 it is not statistically significant, which is consistent with the notion that it takes time for school improvement to occur, and that changes to performance in Grade 12 are dependent on what occurs in earlier grades during prior years. The matter of impact lags is dealt with in depth below.

The large number of 'control' schools in the data, or schools whose province does not change, does increase the statistical significance of the coefficients seen in Table 4, but almost imperceptibly. To demonstrate this, the models in Table 4 were rerun repeatedly, using in each instance 139 randomly selected non-switching schools, so that the number of 'treatment' and 'control' schools would be equal (there were 139 province-switching schools with the required data for the Table 4 analysis). The coefficients and their levels of significance remained virtually unchanged relative to what is seen in Table 4.

6.2 Trends using all years

Unlike data from many classical RCTs, the administrative data we were using are not from two points in time, but from a series of years. This means that cause and effect can be explored more rigorously, relative to what appears in Table 4, by means of a panel data fixed effects model. This allows us to test whether the findings seen so far are supported by trends based on data points from all the nine years in the 2005 to 2013 range. Equation (4) below illustrates a panel model with fixed effects for each individual school i, predicting the indicator value for school i in year t. The variables S in brackets refer to dummy 0-1 variables for each of the schools i, except for one. Each school, except for one, thus carries its own intercept λ. This means that unobserved phenomena influencing the general level of performance of each school, and not just observed characteristics such as the quintile of the school, are controlled for. The variable P is the period, with 1 being 2005 and 9 being 2013. D is a 0-1 dummy variable indicating whether a school is in a switching category, for instance 'NW>GP'. D would be replicated for every additional switching category. The dummy variable D is only permitted to carry the value 1 from 2008 onwards, as 2008 seems to be the earliest one can expect the new provincial administration to really make a difference (see the discussion in section 2). D and P multiplied create an interaction variable. Finally, additional variables which might predict E are used, along the lines of the models discussed previously. This is the basic model, variations of which appear in Table 5 below.

$$E_{igt} = \hat{\lambda}_0 + \left(\hat{\lambda}_2 S_{i=2,} + \ldots + \hat{\lambda}_n S_{i=n}\right) + \hat{\beta}_1 P_t + \hat{\beta}_2 D_{gt} + \hat{\beta}_3 D_{gt} P_t + \hat{\beta}_3 X_{it} + \hat{\beta}_4 Z_{it} + \hat{u}_{it} \qquad (4)$$

Column A below contains a simple model testing the existence of an overall provincial change effect through the variable δ. This variable is calculated using the first of the two methods described previously. However, it only assumes a non-zero value, in the case of province-switching schools, from 2008 onwards. A fixed effects model such as the one shown relies on variation over time, so variables cannot take on the same value in the same school and across all years. As in the previous regression analyses, an overall provincial change effect is seen. This is reflected in the coefficient for the interaction between δ and period (P). Specifically, for every standard deviation improvement in δ, keeping in mind that δ is average performance in the new province minus average performance in the old province, there is on average a 0.175 standard deviation improvement per period (or year) in the performance of the individual school.

Table 5: Regression outputs for fixed effects models

	A	B	C	D
Dependent variable →	Mark at 95th percentile relative to earlier Grade 10			
Constant	-0.223*** (-19.17)	-0.211*** (-15.32)	-0.211*** (-15.32)	-0.211*** (-15.32)
Period (*P*)	-0.002** (-2.50)	-0.017*** (-3.69)	-0.017*** (-3.68)	-0.017*** (-3.68)
Provincial diff. (*δ*)	-0.261 (-1.31)	-0.289 (-1.42)		-1.069 (-1.23)
Interaction of *δ* and *P*	0.175*** (6.27)	0.170*** (5.98)		0.022 (0.19)
Is EC>KN			-0.031 (-0.14)	0.247 (0.78)
Is LP>MP			-0.158* (-1.67)	0.094 (0.42)
Is MP>LP			-0.377 (-1.61)	-0.632** (-2.02)
Is NW>GP			-0.183 (-1.13)	0.469 (0.84)
Is NW>NC			-0.485* (-1.88)	-0.517** (-2.00)
Interaction of EC>KN and *P*			-0.015 (-0.46)	-0.020 (-0.47)
Interaction of LP>MP and *P*			0.092*** (6.94)	0.087*** (2.87)
Interaction of MP>LP and *P*			-0.002 (-0.06)	0.003 (0.07)
Interaction of NW>GP and *P*			0.079*** (3.50)	0.066 (0.89)
Interaction of NW>NC and *P*			0.075** (2.09)	0.076** (2.09)
Is EC 2005 (*EC*)		-0.225*** (-7.40)	-0.225*** (-7.36)	-0.225*** (-7.36)
Is FS 2005 (*GP*)		-0.044 (-0.89)	-0.044 (-0.89)	-0.044 (-0.89)
Is GP 2005 (*GP*)		0.036 (1.01)	0.036 (1.01)	0.036 (1.01)
Is KN 2005 (*KN*)		0.046* (1.93)	0.046* (1.95)	0.046* (1.93)
Is LP 2005 (*LP*)		-0.100*** (-3.96)	-0.095*** (-3.68)	-0.095*** (-3.67)
Is MP 2005 (*MP*)		-0.005 (-0.11)	0.010 (0.22)	0.012 (0.28)
Is NC 2005 (*NC*)		0.003 (0.03)	0.003 (0.04)	0.003 (0.04)
Is NW 2005 (*NW*)		0.131*** (2.89)	0.146*** (3.13)	0.146*** (3.13)
Is WC 2005 (*WC*)		-0.037 (-0.79)	-0.037 (-0.79)	-0.037 (-0.79)
Interaction of *EC* and *P*		0.020*** (3.22)	0.021*** (3.36)	0.021*** (3.36)
Interaction of *FS* and *P*		-0.013 (-1.54)	-0.013 (-1.54)	-0.013 (-1.54)
Interaction of *GP* and *P*		-0.004 (-0.62)	-0.004 (-0.62)	-0.004 (-0.62)
Interaction of *KN* and *P*		0.014** (2.50)	0.014** (2.48)	0.014** (2.48)
Interaction of *LP* and *P*		0.045*** (7.88)	0.042*** (7.24)	0.042*** (7.24)
Interaction of *MP* and *P*		0.048*** (6.26)	0.047*** (6.08)	0.047*** (6.07)
Interaction of *NC* and *P*		-0.037*** (-2.87)	-0.037*** (-2.88)	-0.037*** (-2.88)
Interaction of *NW* and *P*		-0.011 (-1.41)	-0.011 (-1.44)	-0.011 (-1.44)
Interaction of *WC* and *P*		-0.019** (-2.35)	-0.019** (-2.36)	-0.019** (-2.36)
Grade 12 enrolment / 100	0.332*** (20.51)	0.359*** (22.12)	0.358*** (22.10)	0.358*** (22.09)
...above squared	-0.061*** (-13.46)	-0.067*** (-14.90)	-0.067*** (-14.87)	-0.067*** (-14.87)
N	49313	49313	49313	49313
Number of schools	5624	5624	5624	5624
R^2 overall	0.041	0.026	0.024	0.025

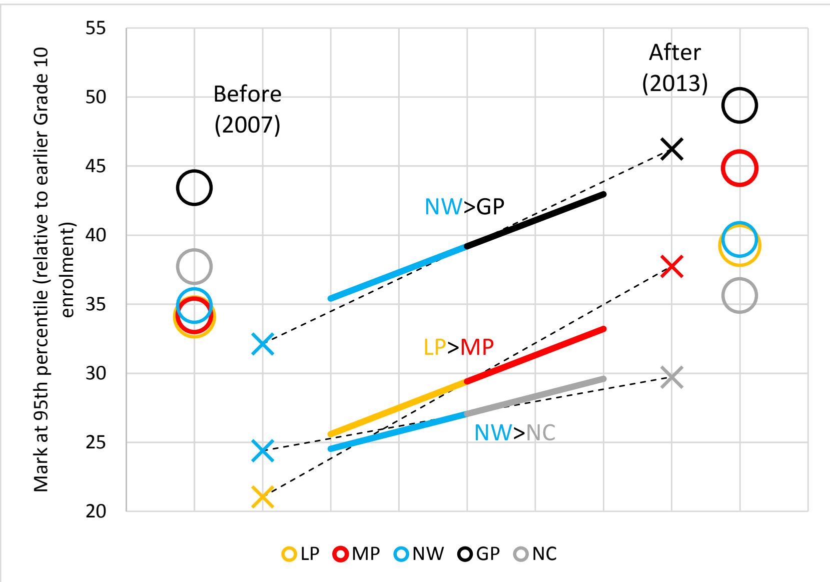
In column B the 0-1 dummy variable 'Is EC 2005 (EC)' (and other variables like it) must be explained. Like *D,* this variable is only permitted to assume the value 1 from 2008 onwards. From 2008, it would carry the value 1 for any school which was originally in Eastern Cape, whether it moved or not. The dummy variable in question can be thought of as representing the 2005 legacy of the province. Even schools which move, say, from North West to Gauteng, can be expected to display North West-like characteristics, in particular management and cultural characteristics, which they would have in common with non-switching North West schools, and which would persist for several years after the boundary change. The interaction of period (*P*) and, say, 'Was EC 2005 (EC)', reflects the annual change associated with the legacy province. The existence of statistically significant coefficients suggests that the legacy province does influence the levels and trends. For instance, schools from four provinces – Eastern Cape, KwaZulu-Natal, Limpopo and Mpumalanga – experienced average conditional improvements which were statistically significant at at least the 5% level. Importantly, the additional controls in column B do not change the coefficient on 'Interaction of *δ* and *P*'.

In column C dummy variables for the five switching groups are used. The interactions with *P* point to statistically significant (at the 1% level) annual improvements in the 'LP>MP' and 'NW>GP' categories, in line with what was seen in Table 4. In Table 5 we also see a positive and statistically significant coefficient for the 'NW>NC' group, despite the fact that the new province is a worse performer than the old province according to δ.

Finally, in column D all variables are included in the regression, the aim being to detect whether specific province-switching categories experience changes which are not captured by the overall province change variable δ, meaning the coefficients on δ and on the dummy variables, all multiplied by period, would be simultaneously significant. The fact that the coefficient on 'Interaction of δ and P' is not significant in column D appears to discard this possibility.

The column C model results are illustrated in terms of actual marks in Figure 8 below. Each dotted diagonal line represents the actual performance trend between 2007, one year before the assumed impact of the new province began, and 2013, for each of the three groups of switching schools with statistically significant coefficients. The vertical axis refers to the mathematics mark at the 95th percentile relative to the Grade 10 enrolment two years before, so indicator 8. Circular markers represent the mean indicator value per entire province (minus the switching schools), in 2007 and 2013. The slopes of the coloured diagonal lines represent the change across six years (2007 to 2013) attributable to the province switch, according to the fixed effects model. This is the change after separating out effects which would apply to all schools from the original province. Clearly, values are often very low, for instance a mark at the 95th percentile of just 21 (out of a maximum of 100) for the 'LP>MP' group of schools in 2007. The official threshold for a successful pass has been a mark of 30 since 2008. Clearly even the best mathematics performers amongst the 'LP>MP' group were unable to pass in 2007. By 2013, the mark at the 95th percentile had increased to 38. The province-switching schools were mostly below the provincial average in 2007, and still below the average of the new province in 2013, despite improvements.

Figure 8: Effects in terms of original mark values



Note: The left hand part of the graph represents 2007, the right-hand part 2013. Details for intervening years are not provided. The vertical placement of the thick diagonal lines, representing the coefficients from Table 5 multiplied by six years, is set to match that of the corresponding dotted lines.

Table 6 below illustrates key results from an analysis where all eight indicators were used for E, or as the dependent variable, in models B and C from Table 5. Thus the bottom row of Table 6 reproduces figures already seen in Table 5. The first column below demonstrates that the findings from Table 5 are confirmed if the other two indicators using performance at the

95th percentile are used. However, the coefficient is largest for the indicator which best accounts for selection effects, as one might expect. This is not because the indicator 8 models use slightly fewer observations, a result of the fact that this indicator draws from more than one data source. On the contrary, if the same observations used in Table 5 are used for the indicator 5 and 7 models, the corresponding coefficients in the first column below would shrink slightly. The first column also points to an effect on the average score associated with province-switching, though the magnitude of this is relatively small. The percentage of students taking mathematics appears to decline significantly in schools moving to better provinces. This is discussed in more depth below.

Turning to the model C coefficients on individual province-switching categories, one thing that stands out is that despite large improvements at the 95th percentile in the 'LP>MP' group, there were no discernible improvements in the average score. This is explored in a subsequent discussion. The coefficients for the 'MP>LP' group are ambiguous, perhaps suggesting that deterioration in performance is more difficult to 'achieve' than improvement, when the quality of the administration changes. As will be seen in Table 7, Limpopo is a worse performing province relative to Mpumalanga with respect to all the indicators of interest. Some statistically significant positive effects associated with moving from Eastern Cape to KwaZulu-Natal, the latter being a better performing province, emerge in Table 6. Moreover, no negative effects worth worrying about are associated with this move. The only province-switching category whose results defy the general and expected pattern is thus 'NW>NC'. As discussed below, this could be because of problems inherent in using δ as a measure of provincial effectiveness.

Table 6: Summary of several 2005-2013 fixed effects regression results

	B	C					B	C
	Inter-action of δ and P	*Inter-action of EC>KN and P*	*Inter-action of LP>MP and P*	*Inter-action of MP>LP and P*	*Inter-action of NW>GP and P*	*Inter-action of NW>NC and P*	*Over-all R^2*	*Over-all R^2*
1. % of mathematics-takers passing mathematics	-0.001	0.090**	-0.024	-0.024**	0.052*	0.074	0.000	0.000
2. % taking mathematics (SG included)	-0.347***	-0.197***	0.122***	0.122**	-0.063**	-0.024	0.009	0.009
3. Number of passes (SG included)		0.009	0.048***	0.048	-0.036**	0.004	0.343	0.343
4. Average mark	0.075*	0.064*	-0.020	-0.020**	0.085***	0.037	0.002	0.001
5. Mark at the 95th percentile	0.165***	0.094**	0.045***	0.045**	0.097***	0.006	0.013	0.012
6. Number of high-level passes		0.014	0.011	0.011	0.047***	0.007	0.119	0.119
7. Mark at 95th percentile relative to all Grade 12	0.134***	-0.031	0.081***	0.081	0.061**	0.091**	0.027	0.027
8. Mark at 95th percentile relative to earlier Grade 10	0.170***	-0.015	0.092***	-0.002	0.079***	0.075**	0.026	0.024

Note: Statistics in the first column for indicators 3 and 6, which are sensitive to school size, are left out as they do not provide meaningful information, for reasons already explained.

There is a simple explanation as to why the R^2 values for indicators 3 and 6 are so exceptionally high. There is far less variation in the values of these two indicators. The coefficient of variation for indicator 3 is 0.77 and for indicator 6 it is 0.37 (in 2013) compared to, for instance, 2.86 for indicator 4 and 2.86 for indicator 5.

Table 7 below provides the values of δ used for models A, B and D in Table 5.

Table 7: Province-switching 'treatment' magnitudes (δ)

	EC>KN	LP>MP	MP>LP	NW>GP	NW>NC
1. % of mathematics-takers passing mathematics	0.079	0.211	-0.211	0.278	-0.011
2. % taking mathematics (SG included)	0.103	-0.115	0.115	0.163	-0.503
3. Number of passes (SG included)	0.084	0.251	-0.251	0.843	-0.269
4. Average mark	0.142	0.212	-0.212	0.405	0.019
5. Mark at the 95th percentile	0.208	0.283	-0.283	0.444	-0.062
6. Number of high-level passes	0.225	0.118	-0.118	0.696	-0.110
7. Mark at 95th percentile relative to all Grade 12	0.226	0.201	-0.201	0.450	-0.239
8. Mark at 95th percentile relative to earlier Grade 10	0.296	0.216	-0.216	0.568	-0.095

The next table sums up the outcomes of a larger set of 96 fixed effect regression analyses. For each indicator, and for each of models B and C from Table 5, six regressions were run. The first used data only from the years 2005 to 2008, the second from 2005 to 2009, and so on. The aim was to examine by which year significant trends could be seen, and thus the length of the impact lags. Clearly the lag was particularly long in the case of 'NW>GP' schools, where for indicators 4, 5, 7 and 8 (average score, and the three indicators dealing with performance at the 95th percentile) there seems to have been a sudden but short-lived improvement in 2008, with a more sustained improvement only setting in from 2012. The latter would be consistent with a gradual and cumulative introduction of better teaching practices, starting with Grade 8 in 2008 and reaching Grade 12 in 2012. In contrast, the 'LP>MP' schools displayed significant Grade 12 improvements at an earlier point, specifically with the inclusion of 2010 data. Moreover, the Table 6 figures suggest that by 2013 the overall gain in 'LP>MP' was slightly larger than in 'NW>GP' (see for instance the coefficients 0.092 and 0.079).

Table 8: Summary of fixed effects regression results with different end-points

	B	C				
	Inter-action of δ and P	*Inter-action of EC>KN and P*	*Inter-action of LP>MP and P*	*Inter-action of MP>LP and P*	*Inter-action of NW>GP and P*	*Inter-action of NW>NC and P*
1. % of mathematics-takers passing mathematics	P00000	N00P0P	000000	000PPN	P000PP	N000P0
2. % taking mathematics (SG included)	00NNNN	P0NNNN	N0PPPP	00PPPP	0000NN	P00000
3. Number of passes (SG included)		000000	000PPP	000000	P00NNN	000000
4. Average mark	0000PP	N0000P	N00000	000NNN	P000PP	000000
5. Mark at the 95th percentile	00PPPP	00000P	00PPPP	00000P	P000PP	000000
6. Number of high-level passes		000000	N00000	000000	0000PP	000000
7. Mark at 95th percentile relative to all Grade 12	P000PP	000000	00PPPP	P000P0	P0000P	0000PP
8. Mark at 95th percentile relative to earlier Grade 10	PPPPPP	000000	P0PPPP	N00000	0000PP	00PPPP

Note: Each string of six characters reflects the direction (negative or positive) of a coefficient, where that coefficient is statistically significant at least at the 10% level. The first of the six characters reflects the results if the fixed effects model spans the years 2005 to 2008, the second if the years are 2005 to 2009, and so on, up to the sixth character, which reflects the 2005 to 2013 model. The character 'N' refers to a statistically significant negative coefficient, 'P' a statistically significant positive coefficient, and '0' a statistically insignificant result.

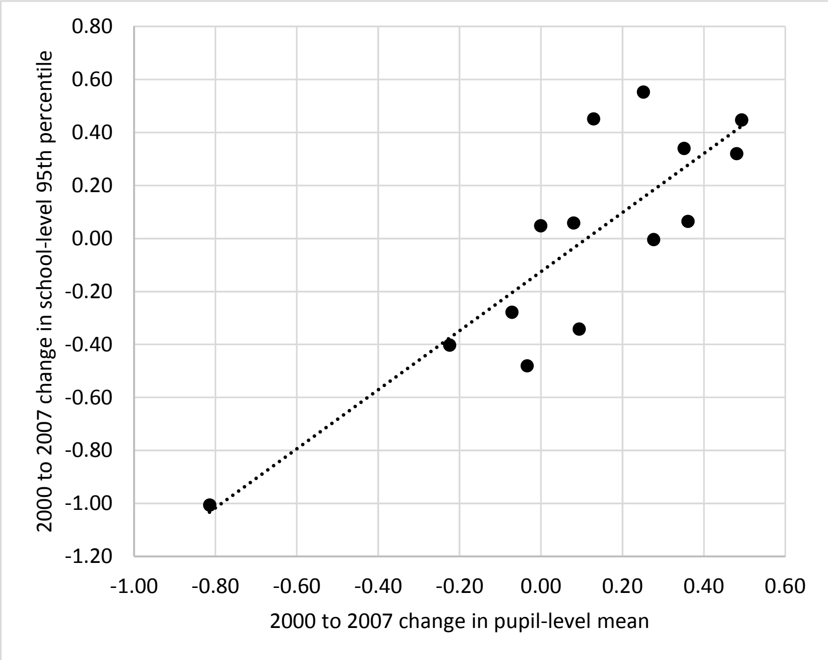
6.3 The meaning of the effect magnitudes

Examining educational improvement in terms of a standard deviation in the test scores across students has become common, and helps in the comparison of improvements observed across different studies[10]. For the present study, an obvious question is how remarkable the magnitudes of the improvements associated with administrative change and seen in the above analysis are. Any comparison must take into account that the measures of performance used above are not the typical student-level census-type standardised test scores of, for instance, the SACMEQ[11] programme, but instead school-level values drawn from various statistics, with not particularly strong standardisation over time, in a context where selection into the tested subject is a major issue.

Figure 9 below uses just SACMEQ data and compares change in the pupil-level mean, in terms of pupil-level standard deviations (a measure typically used in the literature), to change at the 95th percentile of the school (a measure used in the current paper). The relationship between the two is not easy to predict intuitively. On the one hand, one would expect more variation at the 95th percentile than in the school mean, whilst on the other hand any school-level statistic will display less variation than a pupil-level statistic. As it turns out, within the SACMEQ data the slope of the measure on the vertical axis against that on the horizontal axis is 1.13. Thus roughly one might say that the coefficient of around 0.08 seen in the last row of Table 6 is the equivalent of a 0.07 standard deviation movement in the average at the student level. This is high, if one makes a comparison to relatively fast and sustained system-level improvements. Gustafsson (2014: 136) argues that an annual improvement of around 0.06 of a standard deviation in the pupil-level mean represents a maximum for what one could expect for a well-performing country. The best improvement along the horizontal axis measure in Figure 9, which is that of Lesotho, comes to 0.07 in annual terms (0.49 on the horizontal axis), which is then in line with the fastest improvements seen in other standardised testing systems[12]. We can thus say that by 2013, schools moving to better provinces had seen an improvement, over and above that which may have existed in other schools, equivalent to around one year of progress in a rapidly improving country[13]. The conclusion that paying attention to a province's administration is a worthwhile policy priority seems supported. Details on what this implies are explored in a subsequent section.

[10] See for instance Hanushek and Woessman (2009) and Hill, Bloom, Black and Lipsey (2008).
[11] Southern and Eastern Africa Consortium for Monitoring Educational Quality.
[12] The corresponding figure for South Africa was 0.01, which is indicative of the difficulty of improving school performance in South Africa, at least up to 2007.
[13] South Africa's improvement in the TIMSS programme at the Grade 9 level between 2002 and 2011 appears large, in line with the 0.06 maximum referred to here. See for instance Reddy, Prinsloo, Arends and Visser (2012). However, questions have been raised about the applicability of the TIMSS programme to developing countries, such as South Africa, with large numbers of students performing at the bottom end of the test continuum.

Figure 9: 2000-2007 standard deviation changes in SACMEQ mathematics



Source: SACMEQ 2000 and 2007 microdata.
Note: Each point represents a country and changes are expressed in terms of the standard deviation for each of the two statistics (one a pupil-level statistic, the other a school-level one) as the standard deviations stood in 2000 within *countries. Pupil-level means are calculated using weights provided with the data. School-level statistics do not use weights, in order to be consistent with the Grade 12 statistics calculated for the current paper.*

The comparisons discussed above do not make reference to the magnitudes of improvements seen in project-type intervention programmes. Such improvements tend to be larger than those seen in whole countries, reaching around 0.15 of a standard deviation across students, achieved possibly in one year (McEwan, 2015). Given that the provincial change phenomenon studied in this paper was not a quality-focussed intervention programme, comparisons to system-wide improvement trends seemed more relevant.

6.4 Trends within specific switching categories

A series of similar graphs is discussed below which permit a deeper understanding of the dynamics behind the improvements of two of the province-switching groups, namely the North West to Gauteng group, and the Limpopo to Mpumalanga group.

Each graph, for instance Figure 10 below, illustrates the trend for four of the eight indicators (see Table 2) and the average Grade 12 enrolment per school. The indicator values are expressed as z-scores, using the data of the entire country. One clear trend within the 'NW>GP' group was a severe curtailment of the percentage of Grade 12 students taking mathematics. In raw terms, this decreased from around 60% to 30% over the entire period. In 2005, the percentage in the province-switching schools was higher than in North West as a whole, but by 2013 it has been reduced to a level even below that of the new province, Gauteng, which itself was a restrictive province in terms allowing Grade 12 students into mathematics (see the first three graphs below). The mean mathematics mark and performance at the 95th percentile within the mathematics class improved substantially relative to the country, the old province and the new province. However, this positive trend is likely to be, to a large extent, the result of allowing fewer weaker students into the class. Though at face value the trend may have looked good, it was no guarantee that the school was producing more mathematics skills. However, what does point to this desirable outcome in the schools in question is the fact that performance at the 95th percentile relative to earlier Grade 10 students was improving. In fact this improvement was as large as 0.6 of a school-level standard deviation, so greater than what was seen in the old and new province. Yet by 2013 the performance of the province-switching schools in terms of this indicator still fell short of the Gauteng level of 0.4 standard deviations above the national mean. It is noteworthy that in Figure 10 the indicator 8 trend is particularly smooth, which can be seen as indicative of the reliability of this measure for gauging deeper trends. By implication, a measure such as this should probably be used to hold schools accountable for their performance, rather than typically used measures such as the average mathematics mark, which is less stable and more susceptible to manipulation and selection effects. How did the province-switching schools achieve their improvement towards the performance levels of their new province? One can speculate that a mix of new intervention programmes (discussed below) and a reduction in the size of the mathematics classes brought this about.

Figure 10: Trends within NW>GP switching schools

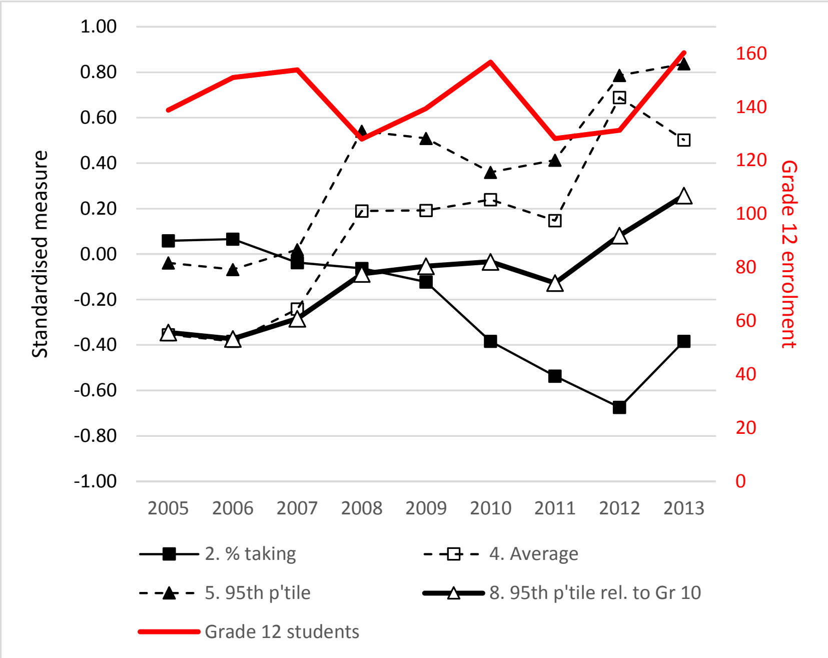


Figure 11: Trends within NW non-moving schools

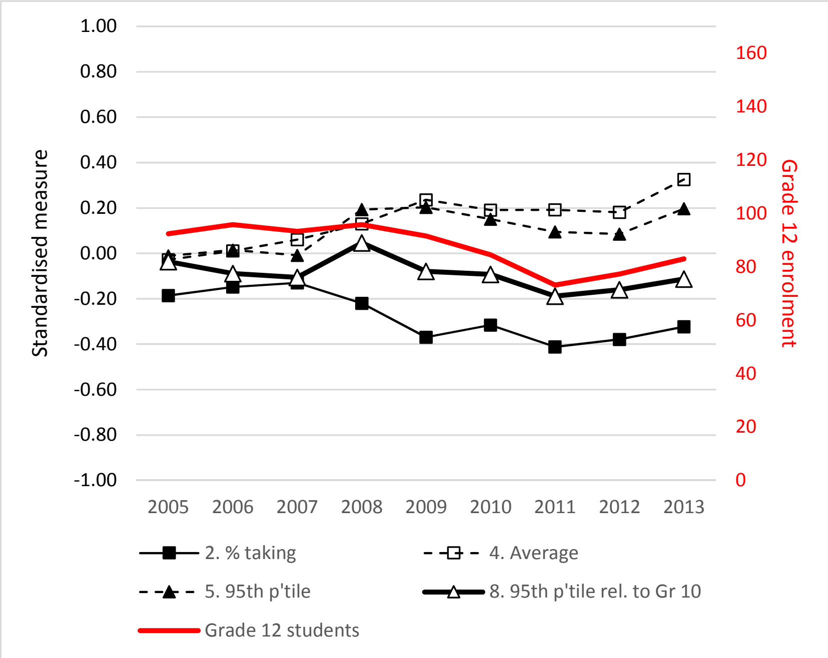


Figure 12: Trends within GP non-moving schools

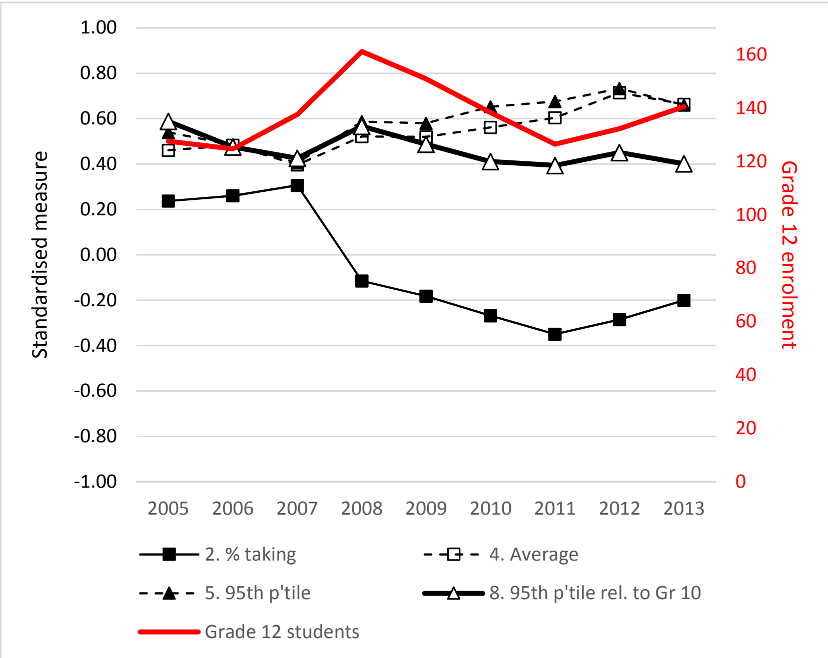


Figure 10 below points to a very different improvement trajectory in the case of the 'LP>MP' group. The relative increase in the percentage of students taking mathematics is noteworthy. In fact, the absolute number of mathematics students per school remained relatively constant in this group, whilst it declined for all other groups of schools (this was seen in Table 1 above). Relative to the old and new provinces, the average mark of the province-switching group's schools declined somewhat, yet performance at the 95th percentile, in particular if seen relative to earlier Grade 10, improved from a level well below the old province in 2005, to a level that roughly equalled the old province in 2013, but was still under the level of the new province. Unlike Gauteng, the new province in this case, Mpumalanga, was a province which had been improving relatively quickly, in terms of indicator 8. The ‘LP>MP’ patterns point to continuity, more or less, in terms of the numbers of mathematics students and their average performance, whilst performance at the top end of the performance spectrum improved exceptionally. This could have been because the schools in question were able to tap into successful interventions in the new province, a province which was making progress. What appears not to be an explanation is smaller classes, as in the case of the ‘NW>GP’ schools.

Figure 13: Trends within LP>MP switching schools

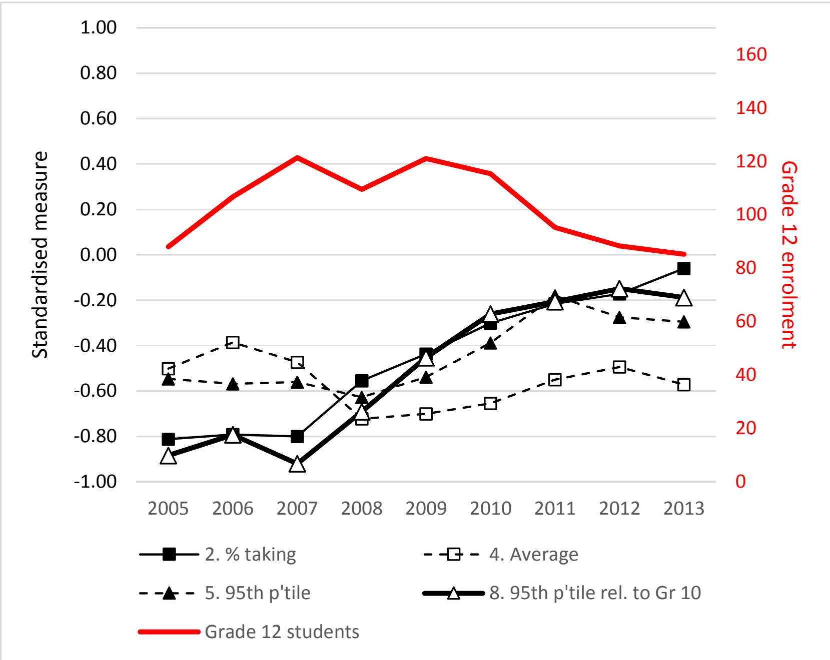


Figure 14: Trends within LP non-moving schools

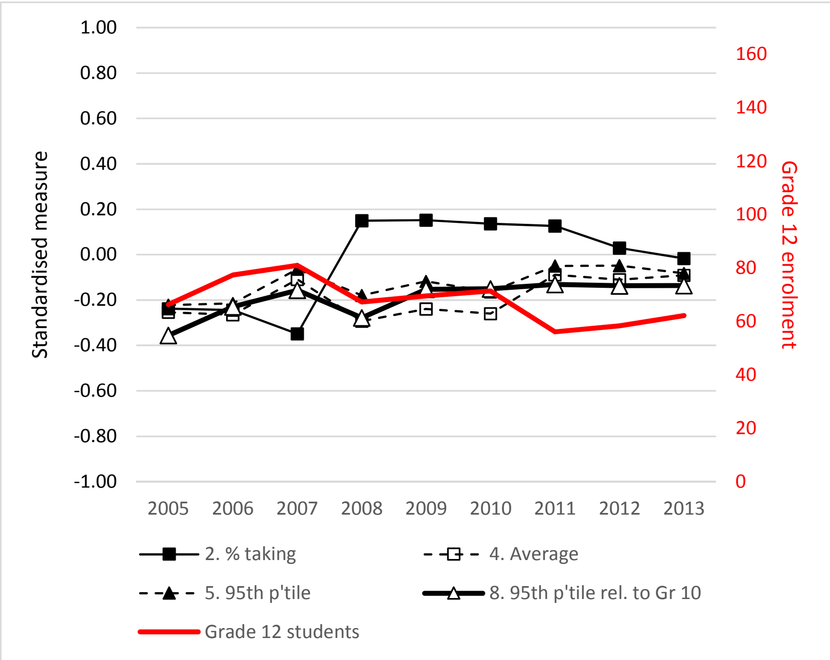
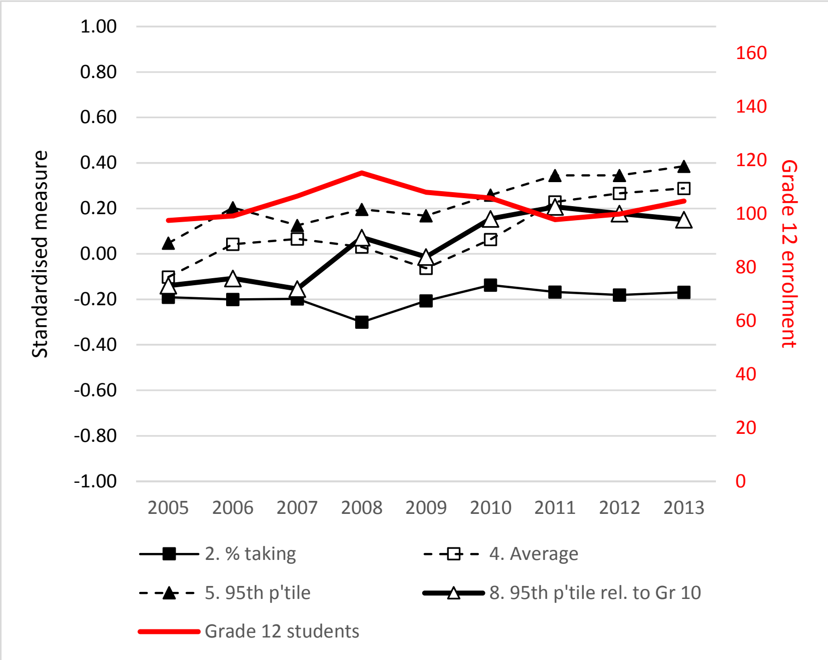


Figure 15: Trends within MP non-moving schools



6.5 Across-school migration of students

What has not been explored yet is the possibility that factors represented by *S*3 in equation (1) influenced the improvements for province-switching schools. Did performance in these schools perhaps increase at least partly because more capable students moved to these schools as they believed they would benefit from a better educational service? If this were the case, the estimates of the size of the improvements seen so far would be exaggerated in insofar as the *S*3 selection effects would not have been controlled for. To use the language of RCTs, the sample would have been contaminated.

The possibility of this scenario is explored here for just the schools switching from North West to Gauteng. The following simple algorithm was created to identify well-performing schools which appear to have pulled students from weakly performing schools nearby. Each school was compared to its closest neighbour with Grade 12, regardless of boundaries, as long as the closest school was within 15 kilometres. School s=1 was said to be an attracter of students from school s=2 if the following two conditions held true.

$$\hat{\beta}_{s=1} - \hat{\beta}_{s=2} > b \text{ and } \hat{\alpha}_{s=1} - \hat{\alpha}_{s=2} > a \qquad (5)$$

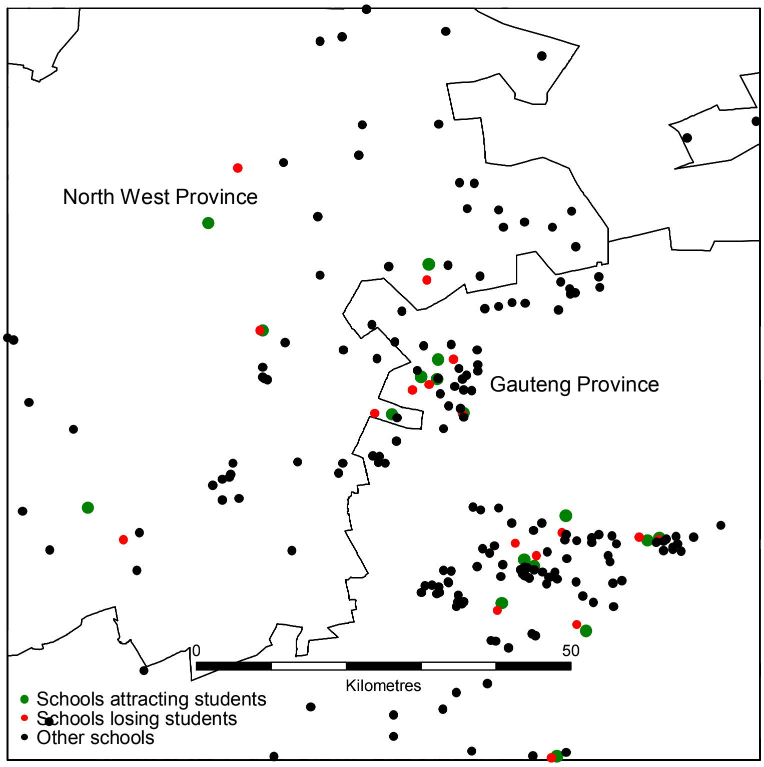
Here β and α are slope coefficients from simple regressions, run separately for each school to find the annual change in either school performance (E) or Grade 12 enrolment (L). The average mathematics score was used for E and years (Y) covered were 2005 to 2010 as this was assumed to be a period when one would see considerable change arising out of the boundary changes. The average mark was used for E as this would be information observers of schools would have relatively easy access to. The two school-level regressions predicting a school's E and L in each year y are represented below.

$$E_y = \hat{\omega} + \hat{\beta}Y + \hat{\varepsilon} \text{ and } L_y = \hat{\omega} + \hat{\alpha}Y + \hat{\varepsilon} \qquad (6)$$

The thresholds used were *b*=0.03 (for the annual improvement in the z-score of the average mark) and *a*=10 (for the annual increase in students). The reverse of the algorithm was used to determine if school *s*=1 was a loser of students relative to school *s*=2. All schools had the opportunity to be evaluated as school *s*=1. Schools which emerged as both attracters and losers of students, from different pairwise comparisons were considered neither (if school X's closest school is Y, this does not necessary mean that school Y's closest school is X).

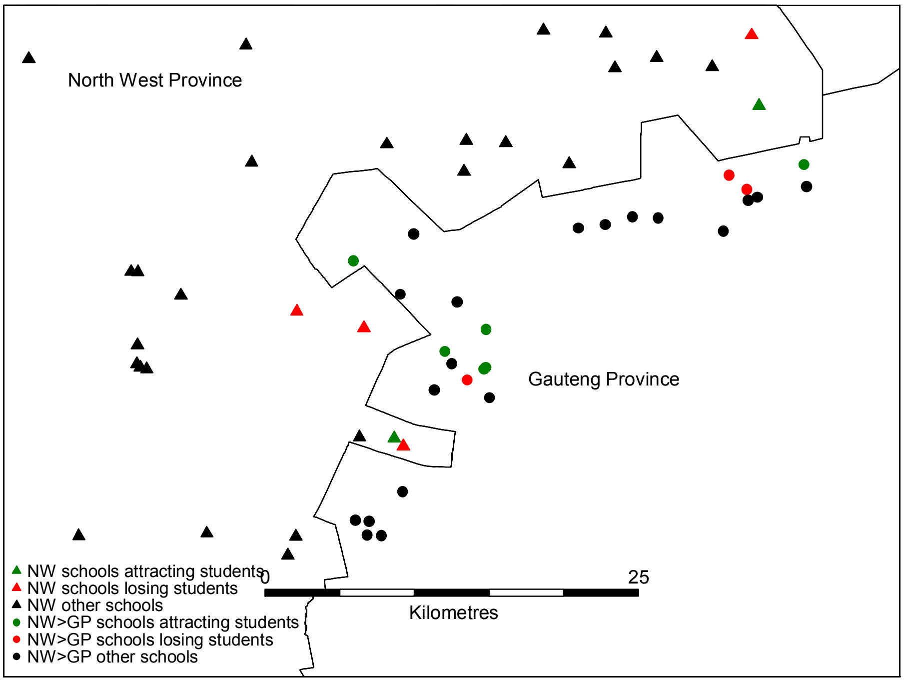
Results are illustrated in the following map. Clearly several schools fulfil the conditions described above, conditions which are rather stringent (*a*=10, for instance, means a loss or gain of 40 students over the five years). Overall 16% of schools appear either red (losers) or green (attracters) in the map, and this figure is similar for Gauteng and North West. In the case of these 16% of schools, around 7% of students 'move' each year, assuming that the lost and attracted students are the same students. What does not emerge is a systematic pattern of movement from North West to Gauteng.

Figure 16: Enrolment change correlated with performance change 2005-2010



A version of the above analysis was run which focussed just on possible interactions across the new boundary. The following map was the result. Here, instead of comparing each school to its closest school, each school was compared to its closest school across the border, up to a maximum of 15 kilometres. Only North West schools and 'GP>NW' schools were included in the analysis. Some losing and attracting across the new boundary appears to have occurred, but it occurred in both directions (there are red and green markers on both sides of the boundary). These patterns suggest that *S*3 across-school selection effects do not account in any noteworthy way for of the improvements of 'GP>NW' schools seen in, for instance, the fixed effects models of Table 5.

Figure 17: Enrolment and performance change special analysis



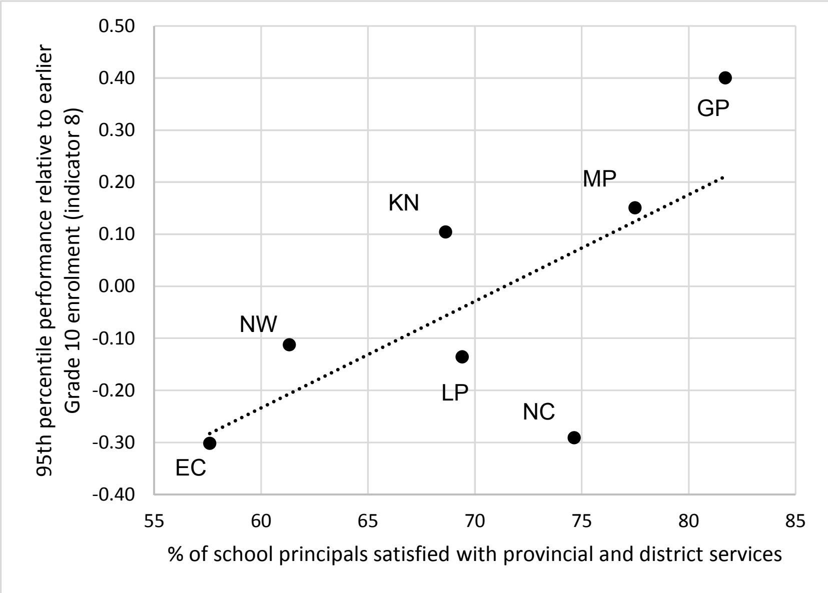
Note: Only schools remaining in North West and which moved to Gauteng are marked. Schools which were in Gauteng in all years are not marked.

7 Institutional and policy explanations

In the analysis presented in earlier sections, the average mathematics examinations performance of each province has been used to determine when schools moved to better provinces, and when the move was to a worse province. This approach produced results which largely supported the hypothesis that moving to a better province improved a school's performance, conditional on a number of factors. However, schools moving from North West to Northern Cape improved, though they appeared to move to a worse province. The alternative approach of gauging each province's performance based on mathematics results after controlling for the socio-economic status of schools, using official poverty rankings, did not produce interesting replications of the models seen in Table 5. What did produce interesting results was the use of a set of 2011 measures of school principal satisfaction with the services offered by the local education district office. These measures, based on a nationally representative sample of schools, are represented on the horizontal axis of Figure 18 below. The provincial rankings seen below are similar to what one would obtain from other effectiveness measures in the same 2011 survey[14]. Northern Cape is an outlier in the sense that satisfaction amongst school principals clearly exceeds what one might expect given the province's mathematics results (see the vertical axis). If δ in models A and B of Table 5 used the satisfaction measures of the horizontal axis below, as opposed to mathematics performance, the result would be a slightly higher t-value for the variable of interest, namely the interaction of period and δ. This is to be expected as the alternative approach implies that schools moving from North West to Northern Cape, which improved, moved to a more effectively managed province.

[14] South Africa: Department of Basic Education, 2013a: 44.

Figure 18: Comparing measures of provincial performance



Note: Values represented on the horizontal axis are from South Africa: Department of Basic Education (2013a: 44). Each provincial value represented here is the sum of 'satisfied' and 'very satisfied' in the original. The vertical axis represents indicator values from 2013. Only provinces affected by the boundary changes are included in the graph.

The criteria according to which school principals rated the effectiveness of the administration were fairly predictable: the administration's monitoring of school documents, the following of up of human resources grievances, providing management support, assisting in the provisioning of textbooks, to name a few.

Much of the literature on school financing points to differences in public spending playing little or no role in producing better education, beyond a basic level of per student spending (Glewwe, Hanushek and Humpage, 2011: 4). Indeed, an examination of provincial spending patterns reveals nothing that suggests changes in funding levels played a role in the improvements seen in province-switching schools. Per student funding has remained roughly similar across provinces during the years 2005 to 2013. The 'NW>NC' and 'LP>MP' groups of schools moved to provinces spending just 5% more whilst 'EC>KN' and 'NW>GP' schools moved to provinces spending slightly less (South Africa: National Treasury, 2009: 38; Kruger and Rawle, 2012: 33). What provinces do with their money rather than the amounts spent seems to be what matters.

The rest of this section focusses on the 'NW>GP' group as for this group there was more literature to draw from and interviewees were accessible for the authors. Above it has been pointed out that 'NW>GP' schools saw an exceptional decline in the proportion of students taking mathematics, possibly because the province they moved to, Gauteng, seemed to be promoting such a trend for all its schools. Such a strategy is a controversial one which many policymakers and researchers would understand as damaging for national development. In fact, South Africa's national development plan laments dwindling participation in mathematics in Grade 12 (South Africa: National Planning Commission, 2012: 317). The logic behind this is that the skills shortfalls in the country with respect to mathematics should be addressed by getting more secondary-level students to take mathematics. The problem with this logic is that it ignores the fact that the percentage of mathematics students who acquire the skills in this subject needed for mathematically-oriented university programmes is very low. In Gauteng, a relatively successful province, only produces around five high-level mathematics students a year per school, when enrolment in mathematics per school has been around 50. Gauteng's reduction in the number of mathematics students per school, from around 80 in 2005 to 50 in 2011 (Table 1), is perhaps indicative of an understanding amongst planners in the province that consolidating mathematics in the school through smaller classes is better than expanding these classes, if the desired outcome is more university-ready mathematics students. The fact that planners might promote such a strategy in the face of demands for mathematics classes to expand is possibly evidence of an informed and outcomes-focussed leadership.

A 350-page book released in 2014 on the history of Gauteng's schooling system, commissioned by the Gauteng education authorities and written by over twenty independent researchers, provides interesting pointers to what may lie behind the 'Gauteng factor'. What appears especially significant is the way the province has designed and implemented support and accountability systems focussing on schools (Dieltiens and Mandipaza, 2014). A national programme essentially involving the counselling of school staff by external advisors has been implemented in a particularly intensive manner in Gauteng, with schools being visited, on a rotational basis, by four to five outsiders who spend a week in the school assessing its processes and assisting with plans. The provincial version of this programme is run from an office which, whilst an integral part of the administration, is geographically separate from the head office in the province. In fact, the original name of this office was OFSTED, which is indicative of the influence of the Office for Standards in Education, or OFSTED, in the United Kingdom. Gauteng's strategies have in fact borrowed extensively from experiences in other countries.

The book also attributes success to careful management of difficult relations between the powerful teacher union, schools and communities. There has been a strong emphasis on concluding pacts between these stakeholders relating to the basic functionality of schools, starting with attendance by teachers and students (Dieltiens and Mandipaza, 2014: 321).

Extra tuition for Grade 12 students, organised by the administration, but run outside of and in addition to the normal school curriculum, has also featured strongly in Gauteng.

The book moreover refers to making senior managers more accountable, through better use of performance targets. One aspect of this not mentioned in the book, but confirmed by the authors of the current paper through analysis of payroll data, is the increasing use of fixed term contracts, as opposed to permanent tenure, in the case of senior managers in Gauteng's education administration. In all provinces except for Gauteng, the percentage of the top paid one hundred public servants employed on a permanent basis has been at least 90% in each province, during the period 2005 to 2014 (counting only the education sector). In Gauteng, however, this percentage has dropped steadily, from 95% in 2005 to just below 60% in 2014. Conversations with Gauteng officials indicate that employing new senior managers on a contract basis, generally for terms of around four years, has been a deliberate strategy aimed at making the organogram more responsive to changing circumstances, and improving the incentives for senior managers to perform well.

Even if moving to Gauteng did not mean an increase in per student spending, it appears that resourcing did play a role in improving performance. This emerged from interviews conducted with an official who had worked as the district director in the 2009 to 2011 period in the district that included the 29 'NW>GP' schools, a teacher who had been employed in one of the 29 schools since before 2005, and a senior planner at the Gauteng head office familiar with the boundary change process[15]. The interviewees pointed to the importance of additional education resources such as textbooks, videos of science experiments and equipment for practical exercises in technical subjects. The suggestion is thus that Gauteng's

[15] The three interviewees, whose insights were greatly appreciated, are (in the same order as the designations mentioned above): Rachel Chabedi, Humphrey Mafoko and Mohammad Sujee.

budget, whilst not larger than North West's in per student terms, displayed a more appropriate focus on educational inputs. In fact, the 2011 survey referred to above indicated that the area where Gauteng school principals felt the district office was particularly helpful was the area of textbook supply.

The interviewees also considered better district support in Gauteng a likely improvement factor. According to one anecdote, the schools which moved to Gauteng were for the first time confronted by district officials who often visited schools and pressurised them to show progress. In North West, on the other hand, if school principals visited the district office, there was the possibility that they would find the office closed for lunch, something which did not happen in Gauteng.

Not all of Gauteng's strategies referred to above would be easily replicable in other South African provinces. Gauteng concentrates 24% of the country's population in just 1.5% of the country's landmass, and is over 95% urban. Moreover, there is a concentration of universities in Gauteng, reflected by the fact that 34% of university students in the country are studying at universities in the province[16]. Gauteng's schools are relatively large, allowing for economies of scale, distances are small and access to skilled people relatively easy. This would facilitate interventions such as intensive support to individual schools by experts, interventions which might prove difficult to implement elsewhere, in particular due to a lack of school improvement experts. The other strategies described above seem more transferable to other contexts.

8 Conclusion

The paper has used examinations data across nine years, plus the fact that administrative boundaries in South Africa changed, to create a quasi-experiment examining the possible impact of a different administration, within the same country and general policy environment, on student performance at the secondary level. The analysis concludes that what administration a school falls under matters for performance. Whether one uses a province's average student performance or a client satisfaction measure to gauge a province's level of effectiveness, moving to a better province improves a school's performance. There is a lag, in some cases of five years, before the improvement becomes discernible in the data. This is consistent with the notion that improvements in Grade 12 at the secondary level are dependent on earlier improvements in lower grades. The school-level improvements ultimately brought about were considerable, about as large as one year of progress in a rapidly improving schooling system elsewhere in the world.

Examinations data, as opposed to data from standardised tests, are not easy to use for the analysis of trends and cause and effect. Yet as shown above, the task is not necessarily impossible. In fact, examinations data may be the best available option for studying within-country dynamics, given the relatively high frequency of examinations and the absence of sample size limitations. Two matters which must be controlled for when using examinations data, and were controlled for in the current analysis, are weak comparability of examinations scores over time and variation, over time and place, in the dropping out of students prior to the examination. The fact that an indicator which gauged Grade 12 mathematics performance relative to Grade 10 enrolments two years before produced particularly robust results and smooth trends is interesting. Indicators such as these may not be the simplest to calculate, yet they emerge as superior to typically used indicators, such as the percentage of mathematics students passing the subject, in terms of, for instance, their ability to rank schools reliably. These more reliable indicators should be used to a greater extent in, for instance, school accountability programmes.

[16] Distance learning students not counted here.

Many of the administrative strategies which seemed to have played a role are somewhat predictable: more intensive monitoring and support by the administration; extra tuition offered directly to students during the final examination year by the administration; a strong focus on ensuring that schools have the educational materials they need. Importantly, higher per student spending did not play a role. A strategy which one may perhaps not have expected, because it is one not directly observable within schools and might easily be overlooked by researchers, is the strategy of making senior managers in the administration more accountable for their actions, partly by relying less on permanent tenure and more on fixed term contracts amongst these managers.

The quasi-experiment created by historical circumstances has allowed for an unusual focus on the administration layer as a whole existing above schools, as opposed to interventions dealing with specific inputs such as teacher training, educational materials or accountability tools. Focussing on the latter is obviously important, but so is understanding what general characteristics of public sector management and leadership lend themselves to good decision-making with respect to education interventions. Importantly, the provinces receiving schools from another province did not see the exercise primarily as a school improvement exercise, but rather as an administrative exercise in redrawing borders. The fact that improvements occurred nonetheless, where the movement was towards a better province, lends support to the argument that organisational strategy and culture, manifested in attention to detailed logistics, responsiveness to schools and a culture of accountability amongst managers, are important. It would be difficult, or impossible, to unravel the precise mechanisms through which, for instance, the provincial education administration in Gauteng is better at creating an enabling environment for schools than the administration in, say, North West. However, understanding precisely the mechanisms in question may be less important than what one may believe, if a general adoption of good principles in the administration is clearly a prerequisite for effective support to schools.

A practical way of viewing the matter would be as follows. Conferences on how to improve the quality of schooling often pay a lot of attention to the question of what interventions to use. Should the focus be on teacher attendance? Are textbook shortages the key binding constraint? Do school principals need training? And so on. These are valid and important questions. But the current paper suggests conferences could be paying more attention to a different set of questions. Which administrative units appear to display the best improvements, after controlling for as many as possible of the confounding factors discussed in this paper? What is the total package of this administrative unit's strategy, including the mix of interventions prioritised, the incentives applicable to actors at various levels, and the general operational and leadership principles followed?

Several provincial administrations in South Africa are widely considered to be alarmingly weak and inefficient. Pupil performance in international standardised tests is below what one might reasonably expect across all provinces, though inter-provincial differences are large. The examinations data analysed above have revealed that around 12% of students are in 'performance deserts' insofar as their schools have not produced a single high-level mathematics student in nine years. Anecdotal evidence points to basic institutional failure. For instance, some schools struggle to make contact with officials whose job it is to initiate support for and monitoring of schools. As argued by Pritchett *et al* (2012) and others, the bar for institutional performance in developing countries is often set rather low. Improvement ought to be relatively easy, because it is off a low base, but this requires confronting debilitating practices such as corruption, but also less obvious ills such the use of superficial appearance to mask deeper problems, an over-reliance on externally produced blueprints and the insertion of unrealistic expectations into operational planning.

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