Factors Influencing Changes in Learning Achievement: Iran's Performance in TIMSS and PIRLS (2003 – 2011)

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Preface

To be written by the Iran Country Office

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Executive Summary

Over the last fifteen years, Iran has exhibited a rapid increase in the levels of achievement in the Trends in International Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS). Iran's increase in 4th grade science achievement between 1995 and 2011 exceeds all other countries while its increase in 4th grade math achievement is second only to Norway. Despite these improvements, Iran's TIMSS and PIRLS achievement is still below the international scale average score of 500 points in both fields. With its average achievement below the international mean, coupled with its rapid improvement, Iran poses a particularly relevant case for analysis. The objective of analysing the Iranian experience is to understand the drivers behind this improvement and produce lessons useful both for itself in further improving achievement, but also for other countries looking to improve their performance.

The report focuses on the analysis of the changes in results of TIMSS and PIRLS between 2003 and 2011, the most recent available data, and the period when the largest improvements in performance took place. Additionally, the report analyses the difference in performance between the wealthier 50 per cent and the poorer 50 per cent in 2011, as an effort to understand the role of equity in performance improvements. The data being used is the score in math and science of students in 4th and 8th grade and the score in language in 4th grade. The scores are analyzed together with the characteristics of students, teachers and their schools.

The report builds on the idea that different factors, such as the characteristics of students, teachers and schools can affect academic performance. Therefore, changes in these characteristics, and in how they relate to learning, can inform the understanding of changes in performance. Following this logic, the report applies a modification of the Oaxaca-Blinder decomposition to help identify factors that contributed to or hindered Iran's progress in the Trends in TIMSS and PIRLS. This methodology separates the difference in the average performance between two groups, for example students in 2007 and 2011, into two components: 1) A component that can be attributed to the changes of

students' characteristics, school resources and changes in teachers' characteristics, 2) A component on the changes on how these characteristics relate to learning. The first component is usually referred to as the proportion of the observed change that can be explained by the differences in the characteristics of the students and their environment. For example, a higher proportion of teachers with a bachelor's degree, more school hours per year, or a higher proportion of students coming from a wealthier background. The second component is deemed as "unexplained" by changes in the observed characteristics, and refers to the way the observed characteristics relate to learning outcomes. For example, how does the score of a student change, given everything else equal, if the student's teacher has a bachelor's degree?

The analysis finds that progress in 4th grade math and science between 2003 and 2007 is mainly unexplained by the changes in the observed characteristics of students, schools and teachers. However, it should be noted that the set of characteristics collected by TIMSS is limited, so the changes could be related to other variables at the school and teacher level, such as changes in curriculum, better training or a more enabling environment. Progress in the 4th grade math, science and reading between 2007 and 2011 is mainly by changes in the characteristics of teachers, schools and students. Particularly, an increase in teachers' average number of years of experience, a larger percentage of teachers with a university degree, more computers per student at the school level and a lower proportion of over-age students.

For 8th grade math and science, the main component behind the changes in scores between 2003 and 2011 is unexplained by the current methodology. However, there are two important findings from the component explained by the model, and the relation between different factors towards the learning outcomes. The first finding is that there was a positive effect of school and teacher characteristics; mainly the increase in computers per student and the proportion of teachers with university degrees. The second finding is that the aggregate effect of student's characteristics was negative for both math and science, mainly due to mother's education and variables related to household wealth. This should be interpreted cautiously and in context. Iran experienced large increases in

the adjusted enrollment rate for lower secondary in the same period of time, which allowed students from more disadvantaged backgrounds to access 8th grade and to be assessed in TIMSS. So even if this potentially implied smaller improvements in 8th grade performance, this is an overall positive element of equity in access, and the first step towards further improvements in school performance for a larger share of the population.

The report has important finding regarding equity. The differences of performance between the wealthier and the poorer 50 per cent of the population were mainly driven by differences in the student's characteristics and only marginally by differences in school and teacher characteristics for all grades (4th and 8th) and subjects (math, science and language). This highlights the importance of non-education policy on school performance, such as the key role of social policy in overcoming existing background characteristics. The finding also emphasizes the intergenerational role of education through the link of mother's education on performance.

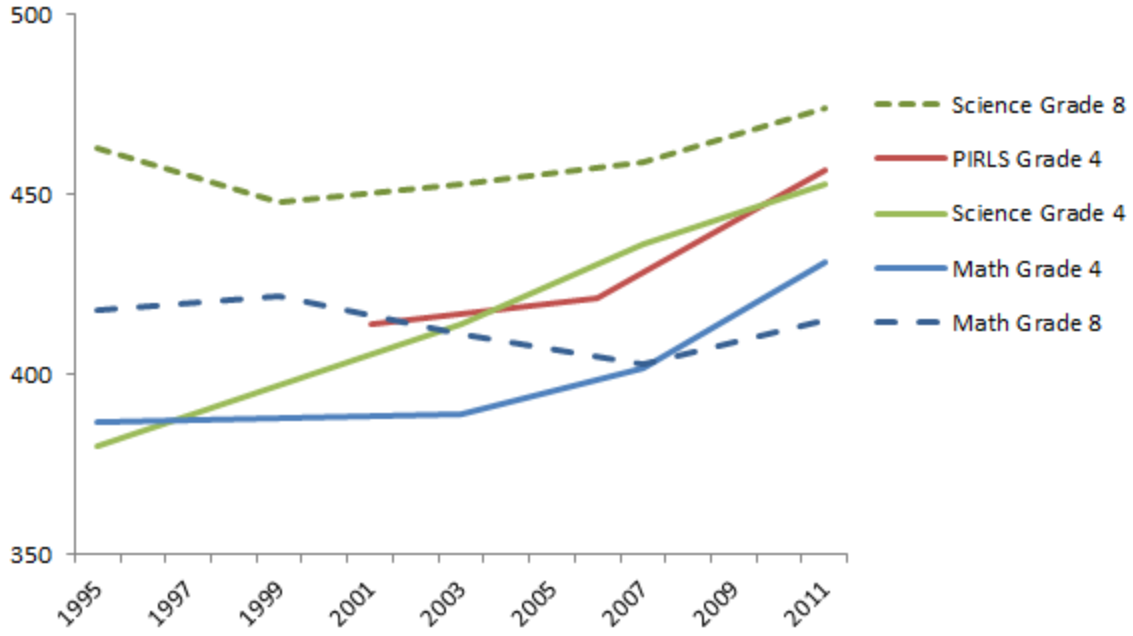
Important lessons from the Iran experience can be drawn from the findings of the report. The first is that improving teacher level of preparation and increasing school supplies can have an important effect in academic achievement in a middle income country like Iran. The study also finds that while school and teacher factors helped strengthen learning achievement for all students, mainly in 4th grade, their conduciveness to improve learning has diminished over time. This does not mean that policies to increase school supplies or improve teacher quality, beyond the college degree, would be ineffective. On the contrary, a significant gap in learning achievement between the wealthier 50 per cent of students and the poorer 50 per cent of students emphasizes the need to focus resources on the poorer students, potentially also through the implementation of actions outside the education realm. Iran has experienced outstanding progress in the average learning achievement over the last fifteen years. Progress going forward will be strongly linked to successfully increasing the level of learning for the most disadvantaged students.

1. Introduction

Over the last fifteen years, Iran has exhibited a rapid increase in the levels of achievement in the Trends in international Mathematics and Science Study (TIMSS) and the Progress in International Reading Literacy Study (PIRLS). For example, 4th grade science achievement increased from 380 points in 1995 to 453 points in 2011; 4th grade math achievement increased from 387 to 431 points (Figure 1). Reading achievement measured in PIRLS displayed a similar surge. However, at the 8th grade level, the results are mixed. 8th grade science achievement initially decreased from 1995, but has increased since 1999 with its most rapid growth from 2007 to 2011. Mathematics achievement has fluctuated starting from 418 points in 1995 to 415 points in 2011.

Iran's increase in 4th grade science achievement between 1995 and 2011 exceeds all other countries while its increase in 4th grade math achievement is second only to Norway. Despite these improvements, Iran's TIMSS and PIRLS achievement is still below the international scale average score of 500 points in both fields. With its average achievement below the international mean coupled with its rapid improvement in 4th grade achievement and mixed improvement in 8th grade achievement, Iran poses a particularly relevant case for analysis. The objective of analysing the Iranian experience is to produce lessons useful both for itself in further improving achievement, but also for other countries looking to improve their performance.

Figure 1. Iran TIMSS and PIRLS average score by subject across time



Source of data: Mullis et al. 2012a pp 52 and 57 (TIMSS Math); Martin et al. 2012 pp 50 and 55 (TIMSS Science); Mullis et al. 2012b pp 48 (PIRLS)

There is rich empirical literature that uses student assessment data to identify determinants of learning. The literature generally adopts a cognitive production function approach which uses a firm's production process as an analogy of learning achievement: inputs including household and personal factors, school and teacher characteristics combine together to produce cognitive achievement much like a firm combines inputs including materials, capital and labour to produce a good (Todd and Wolpin 2003). There are numerous examples of cognitive production function theory being applied to understand the importance of teacher, classroom, school and household factors on learning (for reviews of literature see Todd 2010; Fuller and Clark 1994; Velez et al. 1993 and Lockheed and Hanushek 1988) including studies using international student assessments such as TIMSS, PIRLS and PISA (for example, Arcia, Macdonald, and Patrinos 2014; Jakubowski et al. 2011; Garcia-Moreno and Patrinos 2007 and World Bank 2005).

This report builds on this literature by applying a modification of the Oaxaca-Blinder decomposition to help identify factors that contributed or hindered Iran's progress in TIMSS and PIRLS. The method decomposes a difference in learning achievement between two groups: (1) a component attributed to changes in observable determinants of learning, and (2) a component attributed to changes in the determinants' relationship with learning achievement. The methodology is used to decompose the effect of different factors on performance in the different waves of the assessment, which took place every four years between 1995 and 2011. The analysis is extended to the study of difference in performance between the wealthiest 50 per cent of students and the least wealthy 50 per cent. It decomposes these changes or differences in learning achievement into differences in underlying factors including student, teacher and school characteristics as well as to differences in how these characteristics relate to learning achievement.

The findings suggest that improvements in school and teachers characteristics have played an important role in improving learning achievement across time, but there is also evidence of what can be characterized as diminishing returns. At the 4th grade level, improvements in school and teacher characteristics played a large role in the significant increase in science, math and reading achievement, especially from 2003 to 2011. However, learning achievement is becoming less responsive to these characteristics across time. The 8th grade math and science results echo this finding; school and teacher characteristics have also improved but the subsequent increase in learning achievement has not materialized because these characteristics may not be as effective at increasing learning achievement as before.

The findings also suggest that despite the gains in learning achievement in 4th grade subjects as well as 8th grade science, a significant gap in learning achievement persists between the wealthier 50 per cent and poorer 50 per cent of students. When the decomposition method is applied to the wealth gap in achievement, it finds that differences in teacher and school factors play a role, but differences in household factors matter the most.

In terms of policy implications and lessons for improving learning achievement in Iran, these findings suggest a policy approach that is less about investing in teacher and school quality outright and more about allocating investments in teacher and school quality to benefit students that are in the poorest 50 per cent and 20 per cent of households. If diminishing returns are present, additional investments in teacher training and school resources may lead to stronger improvements if priority is given to students with the lowest current amount of resources. Given the stark difference in learning achievement between the wealthier and poorer students, there is a clear need to improve learning outcomes for the poorer students. Allocating existing or new investment in teacher and school quality could help alleviate this gap to some extent. A larger challenge—one where Iran is not alone—is how to overcome differences in household factors. Identifying alternative strategies that may be outside the realm of traditional education policy, including social policy interventions and comprehensive early childhood development, might be part of the answer.

The remainder of the report is organized as follows. Section 2 describes the background of the Iranian education system and its participation in TIMSS and PIRLS. Section 3 describes the decomposition methodology used in this analysis. Section 4 presents and summarizes the data used in the analysis. Section 5 presents the findings of the application. Section 6 describes policy implications in more detail and the final chapter, Section 7, provides a conclusion.

2. Background

In Iran, the Ministry of Education is in charge of education planning, financing and administration, curriculum and textbook development, literacy campaigns, teacher training, and grading and examination. The Supreme Council of Education is the legislative body that approves all education-related policies and regulations. Private schools (non-profit) are partially government funded and operate under the supervision of the Ministry of Education (WES, 2013).

There are five particular articles in Iran's 5th National Development Plan with direct relevance to the analysis of education policy, that highlight the objectives of the national government on the issue of education going forward:

- Article 18 on review of educational curriculums
- Article 23 on Integrated Plan for Institutional Development in Educational systems
- Article 24 on higher education, research and technology and technical vocational education, education and sustainable development
- Article 26 on privatization/administration of schools
- Article 28 on non-governmental schools and decentralization

The content of these articles refers to guidelines of the specific educational policy, and they focus on improving quality, increasing the funds available to research and assessing the administrative dimension of education, both in the role of the private sector and the dynamics of national and local governments. It is important to highlight that focusing on these issues has been possible in part due to the progress achieved in enrollment rates.

Iran has made significant advancements in basic and pre-primary education and the expansion of education for women since the adoption of the Dakar Goals of Education for All in 2000. The obligation to provide free primary and secondary education to all Iranians has been included in the Iranian Constitution under Article 30. Progress has

been particularly successful in providing access to primary school. In the latest assessment of progress towards the Millennium Development Goals (MDGs) conducted in 2006, primary school entry rate was 98 per cent. This has set the country in a position to achieve this MDG by 2015.

One of the reasons behind the progress in enrollment have been demographic changes, which have modified the demands to the national education system. In past decades, the system faced a surge in school-aged children under 15, from 8 million in 1980 to 18.5 million in 1997. Lower population growth rates have led the number to decrease to 14.2 million in 2006, with a further decrease to 10 million in the 5 – 15 age cohort in 2012 (UNESCO 2010, UIS 2015). The switch in demand has allowed efforts in educational planning to be centered on fostering education quality and providing improved learning beyond basic education.

Enrollment and achievement have also been improved due to targeted policy interventions focusing on specific disadvantaged groups. Between 2005 and 2006, a rural girls' education model was piloted by the Ministry of Education in the province of Sistan and Baluchestan with support from UNICEF. In its first year of implementation, Dashtyari district reported an 11 per cent increase in girls' enrolment. The model has since been replicated by the Government in three other provinces (UNICEF Annual report, 2014). However, there are still sectors of the population with specific needs that must be addressed. A number of minorities in Iran speak a language other than Farsi as their mother language (UNESCO 2010). The persistence of monolingual education is likely to have been detrimental to the performance of non-Farsi speaking groups. Non-Farsi speakers have on average performed below the average of Farsi speakers and below the national average in TIMSS math and science. This disparity emerged since the first participation of Iran in TIMSS in 1995 and persist as of the last available data for 2011.

As presented in the introduction of this report, some of the bigger improvements in TIMSS have been observed in the field of science. In its 5th National Development Plan, the Iranian Government aspires to become the second most advanced country within the

region in the field of science and technology. (UNESCO, 2010) Key strategies followed by the Government include: advocacy, synergy among policies and implementation of the national innovation plan, support to the commercialization of technologies as well as monitoring and evaluation of science parks. These initiatives might have permeated to primary and lower secondary schools, influencing class-time allocation as well as improved public perception of science.

Additional to education policy, there have been a meaningful number of changes in social policy that have likely influenced education outcomes. In recent years, the government has engaged in a series of initiatives aiming to increase human development and to meet the MDGs. Meaningful results have been achieved in poverty alleviation, in the reduction of infant mortality rates and in the improvement of maternal health. Despite these efforts, the incidence of poverty among children is markedly higher than among adults. Studies found that in 2007 the incidence of child poverty was 38 per cent in urban areas and 18 per cent in rural areas (UNICEF 2012). Social policy, therefore, is key to understanding changes in enrollment and a means for improving student performance going forward.

Iran has participated in a number of international student assessments that help benchmark the quality of its education internationally. The Trends in International Math and Science Studies (TIMSS) and Progress in International Reading Literacy Studies (PIRLS) are international student assessments that provide measures of learning achievement for students that are comparable across countries and time. Iran has participated in all five rounds of TIMSS from 1995 to 2011 as well as three rounds of PIRLS from 2001 to 2011.

In both TIMSS and PIRS, national estimates of learning achievement are obtained by testing a random sample of students selected using a multi-stage cluster survey design. TIMSS tests students at the 4th and 8th grades while PIRLS tests students at the 4th grades. Both studies assess achievement across a wide range of content and cognitive domains. For example, 4th grade TIMSS tests students' knowledge of life science, physical science and earth science as well as students' cognitive abilities in knowing, applying and

reasoning (Mullis et al. 2012a). In addition to testing children, TIMSS and PIRLS collect data from school directors, teachers, students, and, in the case of PIRLS, parents, about their backgrounds, attitudes, classrooms and schools (see Mullis et al. 2012a; Mullis et al. 2012b; Martin et al. 2012 for more details). This report uses the linked data on student performance, family and school characteristics to assess the influence of different factors on the performance of students. To do this, the report applies a modification of the Oaxaca-Blinder decomposition method (Oaxaca 1973; Blinder 1973) to identify potential constraints and enabling factors behind Iran's TIMSS and PIRLS performance.

3. Methodology

The Oaxaca-Blinder method gained popularity in the 1980's among labour economists as a technique to analyze the effect of discrimination in wages, and whether the observed wage differentials could be attributed to differences in the endowment of workers. More recently, it is increasingly being used to examine differences in learning outcomes (Ammermüller 2004; Meunier 2007; Auguste, Echart, and Franchetti 2008; Barrera-Osorio et al. 2011; World Bank 2012; Gevrek and Seiberlich 2012; Ramos, Duque and Nieto 2012; Nieto and Ramos 2013; Chuy and Nitulescu 2013). The method decomposes a difference in learning achievement between two groups: (1) a component attributed to changes in observable determinants of learning, and (2) a component attributed to changes in the determinants' relationship with learning achievement.

Following cognitive production function theory, differences in cognitive achievement between groups (years, grades, countries, etc.) are assumed to be explained by differences in student demographics (household factors and personal characteristics), teacher demographics (education, gender, training, etc.), school and classroom factors (materials, class size, etc.) and the impact of these factors (or returns to these inputs) on achievement and other unexplained factors. Note that these differences cannot be attributed to individual factors that are constant across the country; for example, the impact of changes to the national curriculum cannot be distinguished from other national policies, economic developments or other social changes.

The approach does not specify a cognitive production function per se, but rather a stochastic model where student achievement is conditional on a set of household, school, teacher and classroom variables. Following the previous notation, the conditional expectation of student achievement, y, is expressed as a linear function of a vector $\boldsymbol{x}$ representing student, school and teacher characteristics such that

$$E[y|\boldsymbol{x}] = \beta_0 + \boldsymbol{\beta}_1\boldsymbol{x} \quad (1)$$

where β_0 is a scalar constant and $\boldsymbol{\beta}_1$ is vector of coefficients representing the association between each variable (component of $\boldsymbol{x}$) and learning achievement. The Oaxaca-Blinder decomposition method decomposes the difference in a dependent variable between two groups into three components. If t denotes the year, and the accent over the variable denotes the mean for the specified year, then the Oaxaca-Blinder decomposition can be expressed as

$$\bar{y}_{t+1} - \bar{y}_t = (\beta_0^{t+1} - \beta_0^t) + \boldsymbol{\beta}_1^t(\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t) + \bar{\boldsymbol{x}}_{t+1}(\boldsymbol{\beta}_1^{t+1} - \boldsymbol{\beta}_1^t) \quad (2)$$

Part of the difference in learning achievement is attributed to the change or investment in inputs, $\boldsymbol{\beta}_1^t(\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t)$, to changes in the returns of the inputs, $\bar{\boldsymbol{x}}_{t+1}(\boldsymbol{\beta}_1^{t+1} - \boldsymbol{\beta}_1^t)$, and to an increase in the constant term, $(\beta_0^{t+1} - \beta_0^t)$.

Because of the qualitative nature of many education variables, the method is modified to give a better interpretation to changes in the returns and constant. This study adapts the methodology by subtracting the means of the explanatory variables such that

$$E[y_s|\boldsymbol{x}_s] = \tilde{\beta}_0 + \boldsymbol{\beta}_1(\boldsymbol{x}_s - \bar{\boldsymbol{x}}_t) \quad (3)$$

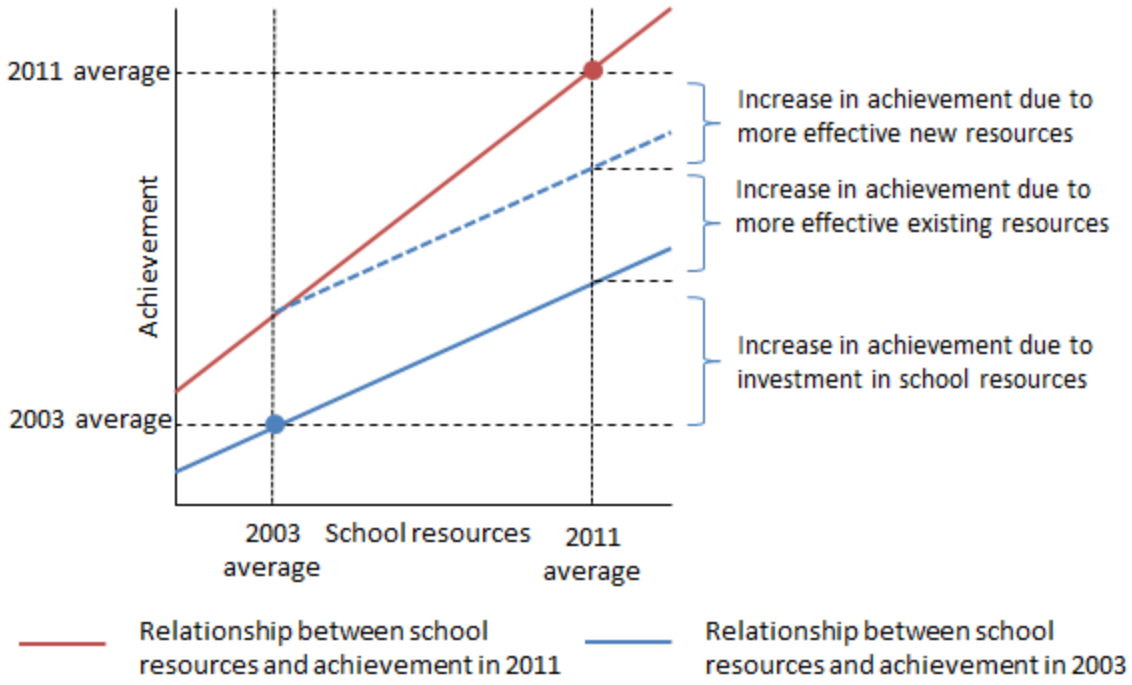
The decomposition is then expressed as

$$\bar{y}_{t+1} - \bar{y}_t = \left(\tilde{\beta}_0^{t+1} - \tilde{\beta}_0^t\right) + \boldsymbol{\beta}_1^t(\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t) + (\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t)(\boldsymbol{\beta}_1^{t+1} - \boldsymbol{\beta}_1^t) \quad (4)$$

Like the original methodology, part of the difference in learning achievement is attributed to an investment in inputs $\boldsymbol{\beta}_1^t(\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t)$. Under the revised methodology, part of the difference in learning achievement is attributed to an increase in the return of the *investment*, $(\bar{\boldsymbol{x}}_{t+1} - \bar{\boldsymbol{x}}_t)(\boldsymbol{\beta}_1^{t+1} - \boldsymbol{\beta}_1^t)$, rather than the inputs as a whole, and to an increase in the return of the initial stock of inputs captured by the differences in the constant term, $\left(\tilde{\beta}_0^{t+1} - \tilde{\beta}_0^t\right)$. Figure 2 depicts this method. In other words, any change unrelated to the

investment is subsumed in the constant term; if there had been no investment, then all of the change would have been attributed to an increase in the productivity of the existing inputs.

Figure 2. Modified Oaxaca-Blinder decomposition example



Note: This is a hypothetical example to illustrate the modified decomposition method only.

The language of the Oaxaca-Blinder decomposition is suited to production or labour force data where the explanatory variables can be conceptualized as investments with a return. In education data, this conceptualization is not always applicable; for example, a student's or teacher's gender cannot be conceptualized as an input with a return. The socio-economic status of a student may have a large impact on learning achievement, but this cannot be characterized as a return—it represents inequality in the system. As a result, this report generally refers to inputs as characteristics of the student, teacher or school and the return as the association between the characteristic and learning achievement or as the conduciveness for learning.

The second adjustment to the methodology is estimation of equation (3). The objective of the methodology is to attribute differences in learning achievement between different factors. However, many factors are unobserved in the TIMSS data as discussed previously. For example, the wealth of a household can be correlated with learning achievement through the student's home and early environment, but it can also be correlated through unobserved characteristics of a school's quality (wealthier households generally have access to better quality schools). To account for this, equation (3) is estimated in two stages following World Bank (2012): first the coefficients for the individual and household characteristics that vary within classrooms are estimated by using a classroom fixed effects model. These coefficients measure the association of the individual and household factors within classrooms and consequently do not include the correlation due to differences in classroom, school and other characteristics that are the same for the classroom. With these coefficients, learning achievement is reduced by the predicted achievement of the individual and household variables and subsequently the remaining coefficients are estimated using ordinary least squares (OLS) accounting for the survey design described below.

4. Data

The report uses data from different years of TIMSS and PIRLS. These databases include the student performance, as well as characteristics of the student, teachers and school director. The PIRLS database also includes information on the characteristics of the parents. Data collected from students include their responses to the test items as well as a questionnaire about their households, parents, attitudes and activities in their classroom. The teacher questionnaire includes information about the teacher's education background, experience, attitudes and impressions of the students in the class. The school directors' questionnaire records similar information as well as data about the school.

The TIMSS and PIRLS data contains numerous variables to choose from. The choice of variables for this report was influenced by (1) variables included in other reports' estimates of cognitive production functions, (2) variables that represented facts about students, teachers and schools rather than opinions, and (3) variables allowing for comparability across time.

Table 1 describes the variables used in the different models. Not all of these variables are used in any one model as some are available in some years but not others. Subsequent tables indicate which variables are used in which models. Student characteristics largely consist of proxies for socio-economic status: the education of the student's mother, household possessions, the number of books at home and the wealth index. Whether the student is over or under age is also included. The application excludes the small proportion of schools with mixed gender: consequently, students' gender is treated as a school-level variable as it does not vary within schools. School characteristics are represented by the school's urban or rural location, hours of mathematics or science instruction per week, hours of instruction per year, gender of the students and the size of the school. As proxies for school resources, the number of computers per student and number of books in the school library are used. Teacher characteristics include the teacher's gender, highest level of education attained and number of years teaching.

Whether or not the teacher's education specialized in either education or a specialization in math or science education is included as well. For all binary variables, the name of the variable indicates which value is set to 1 while the opposite is zero. For example, the variable "urban school" equals 1 when the school is in an urban area and zero otherwise.

Table 1. Variables used in the analysis

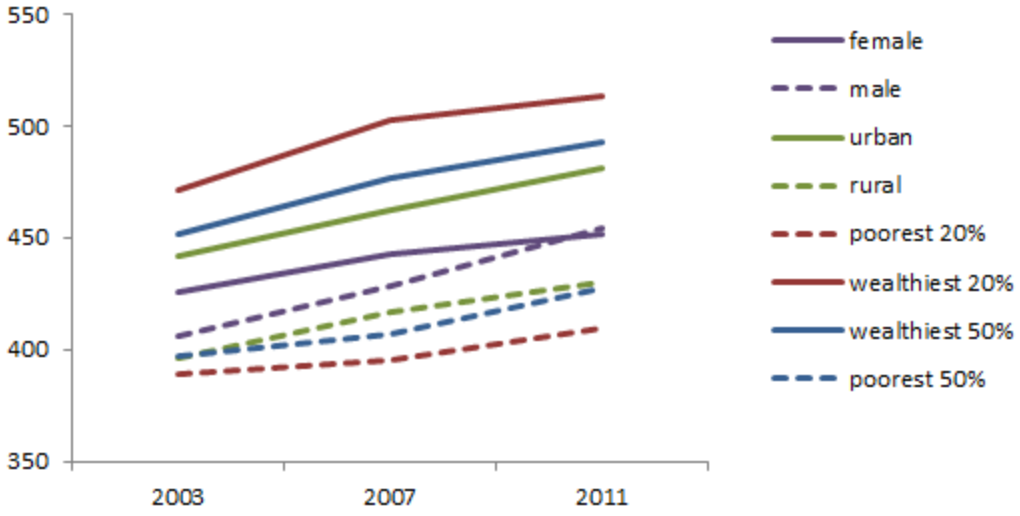
Variable(s)	Format
Representing student and household factors	
Over age	binary
Number of books at home	binary for each category
Household possessions	binary for each possession
Mother's education	binary for each category
Wealth index	real
Representing school characteristics	
Urban or rural school	binary
Hours of science or math instruction per week	real
Hours of instruction per year	real
Girls or boys school	binary
School size	real
School's 8th grade enrolment	real
Computers per student	real
School library with 500 or more books	binary
Representing teacher characteristics	
Teacher has a university degree	binary
Has a science or math education specialty	binary
Has an education specialty	binary
Years teaching	real
Female or male teacher	binary

In order to identify the wealthiest and least wealthy students, an asset or wealth index is constructed using the 2011 data on household possessions. Both TIMSS and PIRLS collects data on whether certain items (e.g.: a television, a car, number of books, etc.) are present in the students' households. The wealth index can be thought of as a weighted average of these possessions where the weights are generated using principle components analysis. This approach weights the possessions in order to maximize the variance of the index. This method is used in the major international household surveys including the Multiple Indicator Cluster Survey and the Demographic and Health Surveys (see Filmer and Prtichett 2001 for more information). Throughout the report, the analysis will focus on the comparison between the students in the top and bottom half of the wealth index, namely the wealthier 50 per cent of students and the poorer 50 per cent of students. For brevity, the report will refer to these groups as the "wealthier" and "poorer" students respectively. In some cases, the report will also refer to students in the top and bottom quintiles of the wealth index (top and bottom 20 per cent). When referring to these groups, the report will specifically refer to the income quintile to avoid potential misunderstandings.

The large gap in achievement between the wealthier students (top 50 per cent) and the poorer students (bottom 50 per cent) as well as the wealthiest 20 per cent and least wealthy 20 per cent are illustrated in Figures 3a to 3c. For all subjects and time periods, these gaps are large. For example, in 4th grade science achievement, the poorer and wealthier students differ by approximately 50 points. The gender gap, by contrast, is virtually zero by 2011. As the following analysis shows, this pattern persists for the other subjects and grades as well.

Figure 3a. Iran TIMSS and PIRLS achievement by sub-population

Iran 4th grade science achievement by sub-population and year



Iran 4th grade math achievement by sub-population and year

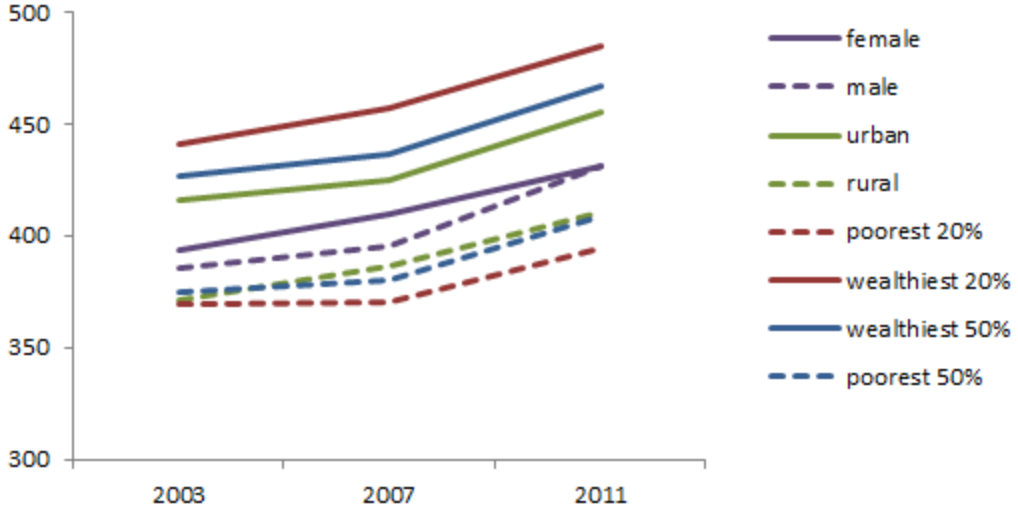
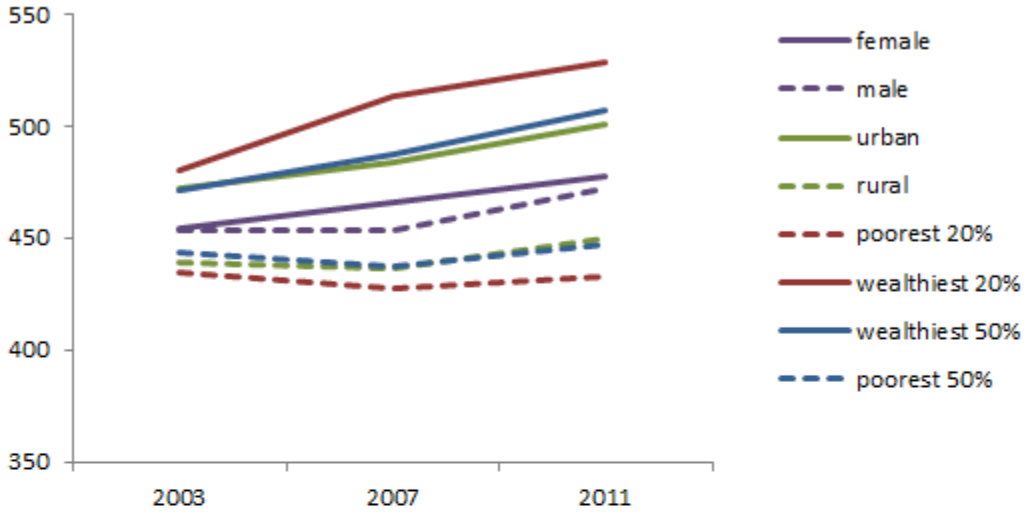


Figure 3b. Iran TIMSS and PIRLS achievement by sub-population

Iran 8th grade science achievement by sub-population and year



Iran 8th grade math achievement by sub-population and year

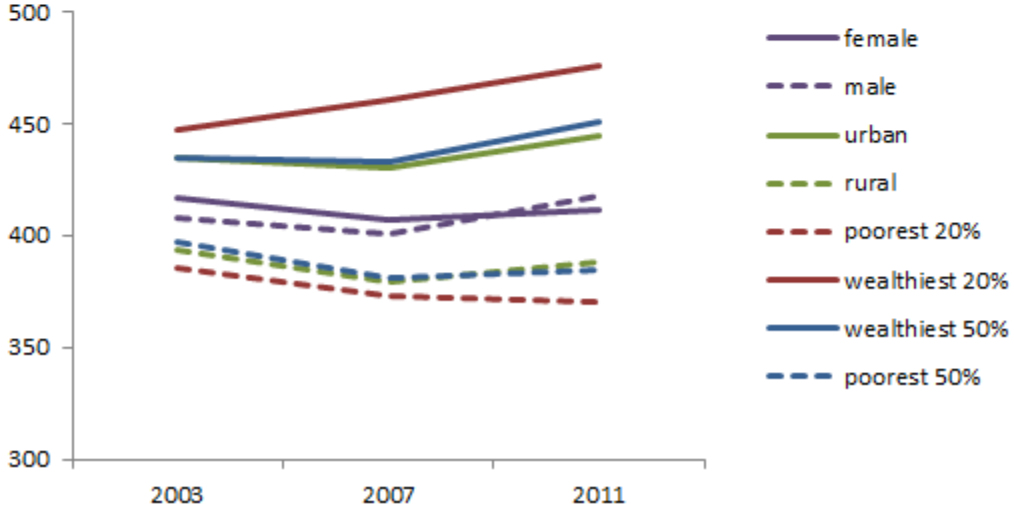
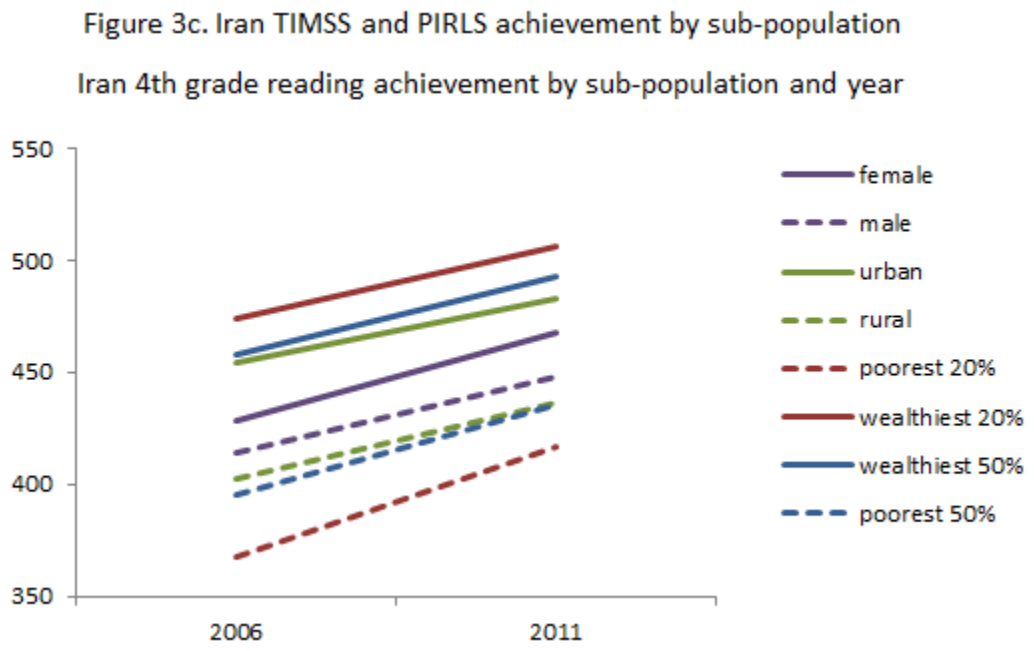


Figure 3c. Iran TIMSS and PIRLS achievement by sub-population



The report analyzes data for 4th and 8th grades coming from different years of TIMSS and PIRLS between 2003 and 2011. The analysis of the different grades for the different years, plus an analysis by income, leads to a total of 12 decompositions: Three for 4th grade science, three for 4th grade math, two for 4th grade reading, two for 8th grade science and two for 8th grade math. Tables A1 to A5 (Annex 1) present the means of the variables used in each of these 12 decompositions. The data is student-level data, and the means are interpreted for the average student. Means differ between subjects because of missing values in the subject specific variables: in order to be included in the decomposition, the students' observations must have valid responses for all of the variables in the model.

Comparing the means between different years reveals some important changes in Iran's education system. For example, in the 4th grade science decomposition sample, the per cent of children who are overage for their grade decreased from 15.6 per cent in 2003 to 5 per cent in 2011. In the 8th grade science decomposition sample, the per cent of over age children declined from 14.7 per cent in 2003 to 8 per cent in 2011. The percentages for math and reading are similar. There is also a higher percentage of girls in the student population since 2003. In the 4th grade science decomposition sample, 40 per cent of

students were girls while in 2011, 47 per cent of students were girls. The per cent of students with female teachers increased as well as the per cent of students with teachers with a university degree.

The means also expose differences between the wealthier and poorer students. For example, a higher percentage of the wealthier students at the 4th grade level have a female teacher compared to the poorer students. Wealthier students are much less likely to be over aged. Wealthier students at the 4th grade level are also much more likely to have a teacher with a university degree. However, at the 8th grade level they are equally as likely.

5. Estimates

This report reports a total of 12 decompositions, resulting from the application of the modified Oaxaca-Blinder decomposition to groups in different points in time and wealth groups. For each of the decompositions, the first step is to estimate two cognitive production functions (equation 3) one for each point in time or group[1]. This leads to a total of 24 cognitive production function estimates. Tables A6 to A10 (Annex 1) present the estimates of the 24 cognitive production function models[2]. Once the cognitive production function is estimated, the second step is to estimate the decomposition (equation 4).

The decomposition method described in Section 2 is first applied to analyze two points in time: between 2003 and 2007 and between 2007 and 2011 for 4th grade science and mathematics; between 2003 and 2011 for 8th grade science and mathematics, and between 2006 and 2011 for 4th grade reading. The choice of time points is determined by two main reasons: First, for comparability of data, the background questionnaires changed for each round of TIMSS and PIRLS; some variables that are available in some years are not available in others. A span of time preceding 2003 for math and science and preceding 2006 for reading significantly limited the availability of background variables. Second, the largest increase in achievement for 4th grade math and science and 8th grade science occurred from 2003 to 2011; for 4th grade math and science, the time period is divided into two periods, 2003 to 2007 and 2007 and 2011 to provide a more detailed picture.

The estimated coefficients of the cognitive production functions are mostly typical. The

[1] Note that the variables included in each of the decompositions differ because different variables are available at different points in time. In some cases, binary variables are reversed to improve the interpretation of the decomposition results. Private schools are omitted for the across time decompositions but retained in the wealth decompositions.

[2] The model and standard error estimation technique presented can be found in Annex 3.

number of books at home and possession variables are positively associated with learning achievement. The number of hours per week devoted to science and math instruction are positively associated with science and math achievement, respectively. Mother's education is positively associated with 4th grade reading achievement, but not at the 8th grade level for math and science. This may be the result of who is responding to the questionnaire: in 4th grade PIRLS, the mother's education variable is derived from the parents' questionnaire while in 8th grade TIMSS, parents' education is derived from students' responses. In general, the coefficients can be difficult to interpret individually, especially the household possession variables, due to the number of control variables. Also, the coefficients do not represent the causal impact of the variable on learning achievement because of the omitted variable bias, caused by the absence of important variables (such as motivation or innate skills) in the dataset. What is more interesting for the purpose of this report is not the coefficients themselves but how they are combined in the decomposition.

Tables A11 to A15 (Annex 1) present the decomposition results by variable and Tables 2 to 6 present the decomposition results aggregated into student, school and teacher categories. The decompositions attribute increases in learning achievement across time to improvements in student, teacher and school characteristics, but suggest that the ability of these characteristics to contribute to learning has decreased. This latter result may represent diminishing returns to investments in education inputs. The decompositions of the wealth gap in learning achievement also find differences in teacher and school characteristics to be important, but student and household factors matter much more.

Table 2. Decomposition summary - 4th grade science

	2003-07 decomposition		2007-11 decomposition		Wealth decomposition	
	Explained	Unexp.	Explained	Unexp.	Explained	Unexp.
Student characteristics	4.04	1.19	6.88	-0.63	23.70	-10.66

School characteristics	3.23	-7.71	11.47	-7.73	4.80	-0.92
Teacher characteristics	2.45	0.02	2.45	-1.05	5.78	0.42
Constant	0.00	22.84	0.00	8.91	0.00	36.86
Total	9.71	16.34	20.79	-0.50	34.28	25.69

Source: author's calculations using Iran TIMSS

Table 3. Decomposition summary - 4th grade math

	2003-07 decomposition		2007-11 decomposition		Wealth decomposition	
	Explained	Unexp.	Explained	Unexp.	Explained	Unexp.
Student characteristics	3.49	-0.25	5.25	0.16	17.67	-8.86
School characteristics	-1.54	-1.41	8.95	-6.45	4.67	-0.88
Teacher characteristics	2.54	-0.57	3.66	-0.53	4.75	1.71
Constant	0.00	12.93	0.00	19.16	0.00	34.91
Total	4.49	10.70	17.87	12.34	27.09	26.89

Source: author's calculations using Iran TIMSS

Table 4. Decomposition summary - 4th grade reading

	2006-11 decomposition		wealth decomposition	
	Explained	Unexp.	Explained	Unexp.
Student characteristics	11.48	-1.62	32.98	-3.13
School characteristics	2.56	1.33	8.51	-11.95
Teacher characteristics	10.04	-1.27	1.36	-10.50
Constant	0.00	10.69	0.00	34.65
Total	24.08	9.14	42.85	9.07

Source: author's calculations using Iran PIRLS

Table 5. Decomposition summary - 8th grade science

	2003-11 decomposition		wealth decomposition	
	Explained	Unexplained	Explained	Unexplained
Student characteristics	-7.92	16.89	21.36	-3.53
School characteristics	5.51	2.78	11.45	1.73
Teacher characteristics	5.35	-2.47	3.96	-1.32
Constant	0.00	0.18	0.00	23.15
Total	2.95	17.38	36.77	20.02

Source: author's calculations using Iran TIMSS

Table 6. Decomposition summary - 8th grade math

	2003-11 decomposition		wealth decomposition	
	Explained	Unexplained	Explained	Unexplained
Student characteristics	-5.82	14.27	21.84	-4.52
School characteristics	17.20	-11.94	13.11	0.94
Teacher characteristics	3.55	-2.68	6.66	2.38
Constant	0.00	-17.62	0.00	24.10
Total	14.93	-17.97	41.60	22.89

Source: author's calculations using Iran TIMSS

Table 2 summarizes the decomposition of 4th grade science achievement between 2003 and 2007. Between these two points in time, 4th grade science achievement increased by 26 points. The "explained" values in Table 2 represent the portion of the 26 point increase in achievement attributed to changes in the variables in the model (listed in Table A6) denoted $\boldsymbol{\beta}_1^t(\overline{\boldsymbol{x}}_{t+1} - \overline{\boldsymbol{x}}_t)$ in equation (4). For example, changes in student characteristics contributed 4.04 of the 26 point increase in science achievement. The "unexplained" values indicate the contribution to the 26 point increase resulting from the model's variables being more conducive to learning achievement. For example, the stronger association between the variables in the model and learning achievement contributed 16.34 points of the 26 point increase. The change in the strength of the association is denoted $\left(\tilde{\beta}_0^{t+1} - \tilde{\beta}_0^t\right)$ in equation (4). This is the increase in learning achievement that would have occurred had the student, school and teacher variables not changed from 2003 to 2007. The stronger association between the model's variables and learning

achievement in conjunction with the change in student characteristics contributed 1.19 points, denoted $(\overline{\boldsymbol{x}}_{t+1} - \overline{\boldsymbol{x}}_t)(\boldsymbol{\beta}_1^{t+1} - \boldsymbol{\beta}_1^t)$ in equation (4).

Table 2 is based on Table A11 which presents the decomposition results by variable for 4th grade science. In Table A11, changes in student characteristics contributed 4.04 points to the 26 point increase in learning achievement between 2003 and 2007; Table 2 shows that 2.5 points came from a decrease in the number of overage children and the remaining 1.5 points from improvements in socio-economic status represented by household possession variables. Table 2 also shows that school factors contributed 3.2 points to the 26 point increase; from Table A11, this is largely the result of an increase in the number of students at girls' schools which, in 2003, is positively associated with learning achievement. 2.45 points are attributed to improvements in teacher characteristics, mostly due to increases in teacher experience and teachers with university degrees. In total, 9.71 points of the 26 point increase in 4th grade science achievement is attributed to changes in the student, school and teacher characteristics; the remaining 16.34 points are unexplained by changes in these characteristics and attributed to changes in how the characteristics relate to learning achievement.

While the difference in 4th grade science achievement from 2003 to 2007 is mostly unexplained by changes in the modeled student, school and teacher characteristics, the increase in 4th grade science achievement from 2007 to 2011 is driven by changes in these characteristics. As shown in Table 2, changes in student characteristics contributed 6.88 points of the 21 point increase in 4th grade science achievement from 2007 to 2011. Table A11 reveals that 1.8 points are attributed to reduction in overage students and the remaining 5.1 points are attributed to improvements in students' socio-economic status. Table 2 also shows that improvements in school characteristics contributed 11.5 points of the 21 point increase in achievement; this is largely due to increases in the amount of school resources represented by computers per student and the number of science hours per week. Changes in teacher characteristics contributed 2.45 points stemming from teacher education and teacher gender. In the absence of changes in the student, school and teacher characteristics, 4th grade science achievement would have increased by 8.9

points, according to the decomposition methodology. However, because student, teacher and school characteristics became less conducive to learning achievement, the change in characteristics offset this 8.9 point increase. While changes in the gender composition of students improved learning achievement, the decrease in the association of gender with learning achievement resulted in 2 points lower achievement.

While changes in student, school, and teacher characteristics improved 4th grade science achievement between 2007 and 2011, especially school inputs, they became less conducive to learning achievement. This demonstrates diminishing returns for policy makers: the favourable changes to school and teacher characteristics do not result in as large of an increase as before.

This pattern found in 4th grade science achievement is also reflected in the other grades and subjects as well. As shown in Table 3, a large portion of the increase in 4th grade mathematics achievement between 2007 and 2011 is attributed to changes in student, school and teacher characteristics. However, decreases in the association between school and teacher characteristics offset this increase by approximately 7 points. In Table 4, the increase in reading achievement from 2006 to 2011 is offset by teacher characteristics being less conducive to learning; however, school characteristics do not exhibit this. The 8th grade science and math results differ from 4th grade. First, student characteristics changed between 2003 and 2011 as shown in Tables 5 and 6; average student socio-economic status decreased as secondary school become more inclusive for disadvantaged children. Consequently, student characteristics, especially socio-economic status, became a more important determinant of achievement in 8th grade. School and teacher characteristics improved in both 8th grade mathematics and science. In science, changes in the association between school characteristics and learning achievement contributed to the increase in science achievement while school characteristics became more conducive to learning and teacher characteristics became less conducive. For mathematics, both observable teacher and school characteristics became less effective in increasing learning; the decline in the conduciveness of school characteristics was especially severe, resulting in a net decline in achievement.

Table 2 also presents the decomposition of the wealth gap in learning achievement for 4th grade science achievement. The wealthier 50 per cent of students score 60 points higher than the poorer 50 per cent. Differences in household factors explain 23 points of this difference while 10 points can be attributed to differences in school and teacher characteristics. This methodology predict that even if the wealthier and poorer students had the same characteristics, the poorer students would still score 37 points lower than the wealthier students. This difference is unexplained by this methodology. This pattern is similar for the other grades and subjects with differences in teacher and school factors playing a slightly bigger role in explaining the gap between the wealthier and poorer students at the 8th grade level.

6. Findings

The application of the decomposition methodology provides several lessons on how Iran's learning achievement has evolved over time. At the 4th grade level, improvements in student, school and teacher characteristics explained the majority of the increase in learning achievement between 2007 and 2011 for science and math and between 2006 and 2011 for reading. In most cases, improvements in school and student characteristics coincided with a decrease in their conduciveness to learning; this is interpreted as diminishing returns.

At the 8th grade level the decomposition estimated a negative contribution to the results from the changes in student characteristics. However, this estimate should be interpreted carefully. The inclusion of students from more disadvantaged backgrounds into the education system might lead to an initial deterioration of the observed socio-economic status, performance, as well as greater inequity within the school system. It is important to acknowledge this happens because in the analysis we exclude the characteristics and potential performance of children out of school. So, as more disadvantaged students become part of the education system, a positive change, we are able to assess a greater share of the children, thus improving the accuracy of the assessment in relation to the population. It is important to highlight that science performance still increased across time albeit slowly, in part due to better school and teacher characteristics. For mathematics, a decrease in the conduciveness of school factors for learning posed a significant bottleneck to improving learning achievement.

The remerging pattern of favourable changes in school and teacher characteristics coupled with a decline in their conduciveness to learning suggests that future improvements in learning achievement requires a more in detailed analysis of teacher characteristics. This study included three coarse measures of teacher characteristics: gender, years teaching and weather the teacher had a university degree. As a university degree becomes a more common universal characteristic among teachers, as in Iran, the explanatory value of this observable characteristic decreases. However, this should not be

interpreted as teacher characteristics becoming unimportant. Teacher quality is key in improving learning and performance (see for example Rockoff, 2004). The findings should be interpreted as the need to move forward in improving the quality of teaching beyond providing a university degree, for example, through a review of the curriculum and the pedagogical aspects of teaching, supporting their in-class performance through feedback, and other measures that complement the increasing level of human capital put into teaching.

One way to guide policy towards improving education quality further is to address the significant disparity in learning achievement between the wealthier and poorer students. 4th grade science achievement in Iran in 2011 was 453 points. As presented in Figure 3, the wealthier 50 per cent scored 492 while the poorer 50 per cent scored 427. To put this in perspective, if the poorerstudents performed as well as the wealthier students, Iran's science achievement score would be on par with Norway. The gap in achievement between the wealthiest 20 per cent and the poorest 20 per cent is even starker; the poorest 20 per cent have scores approximately equal to Armenia while the wealthiest 20 per cent have scores approximately equal to Belgium.

Reducing the wealth gap in learning achievement is neither impossible nor outside the realm of education policy. First, the increase in learning achievement from 2003 to 2011 in 4th grade mathematics and science represents approximately two-thirds of the wealth gap in achievement. The magnitude of the disparity in learning achievement between the wealthier and poorer students is large, but Iran's past performance reveals that significant increases in achievement are possible. Second, the analysis methodology attributes a portion of the difference in learning achievement to differences in teacher and school factors, especially teacher experience and school resources. Prioritizing the allocation of school resources towards schools serving poorer communities emerges as a specific policy recommendation as does allocation of more experienced teachers.

However, the most difficult challenge in reducing the disparity in learning achievement between the wealthier and poorer students for education policy makers is addressing

disparate household factors. The analysis suggests that differences household factors are the largest contributor to the gap in learning achievement between the wealthier and poorer students. Household factors play a crucial role early in a child's cognitive, socio-emotional and physical development that ultimately contribute to his or her school readiness and learning achievement in the future (Cunha and Heckman 2007; Heckman 2006; Cunha et al. 2005; Carneiro and Heckman 2003; Shonkoff and Philips 2000). Early stimulation and learning activities may be as important as genetics in shaping a child's cognitive ability (Fernald et al. 2009). Consequently, promoting participation in high quality early childhood care and education programs emerges from this analysis for education policy makers aiming to overcome the bottleneck of disparate household factors. Early interventions have been found to be highly cost-effective compared to interventions later in a child's life (Naudeau et al. 2010; Nores et al. 2010; e.g.: see Schweinhart 2005; Ruhm and Waldfogel 2011). However, high quality early interventions are not strictly education interventions; nutrition and health of young children have a large impact on a child's learning outcomes at school (Irwin et al. 2007). Multi-sectoral approaches are also needed but orientated towards education. UNICEF has worked closely with the Ministry of Health in Iran to improve healthcare to newborn children including vitamin supplementation, and Iran has made considerable progress already in other areas of social development including health insurance reform, social transfers and other interventions.

7. Conclusion

The methodology presented here is another approach to studying learning assessment to add to the rich literature on education in Iran. The decomposition method provides an approach to attribute changes in achievement across time or differences between the poorest and wealthiest to observed characteristics of students, schools and teachers—the data collected in TIMSS and PIRLS. A major finding in applying this methodology to study the increase in learning achievement, is the importance of improving school resources and teacher characteristics. The methodology also finds the possibility of diminishing returns to standard measures of teacher and school characteristics. This links future improvements in performance to the need for detailed policy that fosters teacher quality beyond completing a university degree.

However, the methodology itself carries important limitations. The results are sensitive to the variables included in the models. In this application, almost all of the variables that were not based on opinions and that were comparable across time were included; of course, there are many other unobserved factors affecting children's learning which cannot be captured in the application and may alter the findings. The variables included in this application also tend to better explain changes in science achievement rather than mathematics or reading. Finally, the estimated models of cognitive production functions are stochastic models showing the association between the conditional mean of achievement and other covariates; it does not identify causal relationship.

The findings from this report also highlight the large role that the characteristics of the household have on student performance. Going forward, the analysis emphasises the need to focus on the gap in achievement between the wealthier and poorer students, as fundamental for both equity and general performance improvements. For education policy makers, it emphasizes the need to allocate school resources and the best possible teachers towards the poorer students, and for other policies such as high quality early childhood care. The importance of household factors puts equity as an important area of focus for policy dialogue in education and extending beyond the education sector.

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Annexes

Annex 1. Supplemental Tables

Table A1. 4th grade TIMSS science decomposition variable means

	2003-07 decomposition		2007-11 decomposition		wealth decomposition	
	2003	2007	2007	2011	Poorer 50%	Wealthier 50%
Over age	0.16	0.08	0.09	0.05	0.07	0.02
11-25 books at home	0.24	0.29	0.28	0.28		
26-100 books at home	0.13	0.13	0.14	0.20		
101-200 books at home	0.05	0.06	0.06	0.07		
200+ books at home	0.04	0.05	0.04	0.08		
wealth index					-1.40	1.49
computer at home	0.24	0.33	0.32	0.54		
has a desk	0.44	0.51	0.50	0.64		
urban school	0.54	0.58	0.57	0.61		
rural school					0.59	0.38
hours of science per week	2.43	2.43	2.32	3.03	2.94	3.09
girls school	0.40	0.53			0.45	0.48
boys school			0.46	0.53		
school size	282.17	276.82	285.83	288.59	261.07	310.52
school computers per student			0.00	0.01	0.01	0.01
teacher has university degree	0.25	0.29	0.33	0.38	0.34	0.43
teacher's years teaching	16.67	17.39	17.63	17.99	16.65	19.25
female teacher	0.59	0.60				
male teacher			0.40	0.38	0.42	0.35
female teacher x years teaching	9.91	10.65				
male teacher x years teaching			7.03	7.03		

years teaching x university degree	3.90	4.45	4.86	6.62	

Table A2. 4th grade TIMSS mathematics decompositions

	2003-07 decomposition		2007-11 decomposition		wealth decomposition	
	2003	2007	2007	2011	Poorer 50%	Wealthier 50%
Over age	0.15	0.08	0.09	0.05	0.07	0.02
11-25 books at home	0.23	0.28	0.27	0.27		
26-100 books at home	0.15	0.13	0.14	0.20		
101-200 books at home	0.04	0.06	0.06	0.08		
200+ books at home	0.05	0.05	0.04	0.08		
wealth index					-1.40	1.49
computer at home	0.26	0.32	0.32	0.54		
has a desk	0.43	0.51	0.49	0.64		
urban school	0.57	0.58	0.57	0.60		
rural school					0.60	0.38
hours of math per week	3.42	3.21	3.40	4.12	4.00	4.22
girls school	0.35	0.50			0.47	0.49
boys school			0.50	0.52		
school size	299.50	279.13	279.87	292.15	260.99	317.28
school computers per student			0.00	0.01	0.01	0.01
teacher has university degree	0.23	0.30	0.34	0.39	0.36	0.42
teacher's years teaching	17.02	16.68	16.86	17.94	16.52	19.27
female teacher	0.54	0.58			0.59	0.65
male teacher			0.40	0.37		
female teacher x years teaching	9.20	9.98				
male teacher x years teaching			6.88	6.91		
years teaching x university degree	3.76	4.22	4.46	6.59		

Table A3. 4th grade PIRLS reading decomposition variable means

	2006-11 decomposition		wealth decomposition	
	2006	2011	Poorer 50%	Wealthier 50%
Over age	0.07	0.04	0.06	0.02
11-25 books at home	0.24	0.28		
26-100 books at home	0.18	0.20		
101-200 books at home	0.05	0.08		
200+ books at home	0.05	0.08		
computer at home	0.27	0.54		
has a desk	0.46	0.64		
has own books	0.77	0.85		
car at home	0.37	0.60		
av recorder at home	0.31	0.51		
piano at home	0.07	0.09		
wealth index			-1.39	1.58
mother's education: lower sec.	0.31	0.22	0.23	0.20
mother's education: upper sec.	0.18	0.26	0.18	0.34
mother's education: non tertiary post sec.	0.00	0.03	0.02	0.04
mother's education: tertiary college	0.03	0.03	0.01	0.05
mother's education: tertiary university	0.04	0.09	0.02	0.16
mother's education: post graduate	0.00	0.01	0.00	0.03
urban school	0.57	0.61	0.50	0.72
schools' instruction hours per year	631.47	725.22	730.41	743.16
girls school	0.44	0.49	0.46	0.50
school size	292.75	293.82	262.15	316.69
school library with 500 or more books	0.53	0.48	0.39	0.57

teacher has post-secondary degree	0.66	0.88	0.84	0.90
teacher's years teaching	7.59	17.66	16.69	18.80
female teacher	0.60	0.61	0.58	0.65
female teacher x years teaching	4.51	10.53	9.15	11.87
years teaching x university degree	4.72	15.67	14.11	16.73

Table A4. 8th grade TIMSS science decomposition variable means

	2003-11 decomposition		wealth decomposition	
			Poorer	Wealthier
	2003	2011	50%	50%
Over age	0.15	0.08	0.13	0.04
mother's education: lower sec.	0.17	0.23	0.23	0.24
mother's education: upper sec.	0.13	0.10	0.07	0.13
mother's education: non tertiary post sec.	0.05	0.10	0.04	0.15
mother's education: tertiary college	0.00	0.08	0.03	0.13
mother's education: tertiary university	0.03	0.06	0.01	0.11
mother's education: post graduate	0.01	0.02	0.01	0.03
wealth index			-1.27	1.30
has a desk	0.51	0.57		
computer at home	0.26	0.57		
video player at home	0.67	0.83		
tv at home	0.98	0.93		
car at home	0.43	0.55		
11-25 books at home	0.31	0.34		
26-100 books at home	0.17	0.19		
101-200 books at home	0.06	0.07		
200+ books at home	0.07	0.09		
girls' school	0.41	0.46	0.45	0.47
grade 8 enrolment at school	102.02	82.44	67.64	96.87
computers per student at school	0.00	0.01	0.01	0.02
school's hours per year	366.97	386.47	987.69	1008.83
urban school	0.43	0.51		
rural school			0.63	0.36

teacher's experience	14.70	16.18	14.36	18.02
teacher has university degree	0.48	0.75	0.74	0.77
teacher has edu. science specialty	0.86	0.85		
teacher has no edu. scie. spec.			0.16	0.14
female teacher	0.39	0.46		
male teacher			0.56	0.53

Table A5. 8th grade TIMSS math decomposition variable means

	2006-11 decomposition		wealth decomposition	
			Poorer	Wealthier
	2003	2011	50%	50%
Over age	0.15	0.09	0.13	0.04
mother's education: lower sec.	0.17	0.23	0.22	0.24
mother's education: upper sec.	0.13	0.10	0.06	0.13
mother's education: non tertiary post sec.	0.06	0.09	0.03	0.15
mother's education: tertiary college	0.00	0.08	0.03	0.13
mother's education: tertiary university	0.03	0.06	0.01	0.11
mother's education: post graduate	0.01	0.02	0.01	0.03
wealth index			-1.29	1.30
has a desk	0.52	0.56		
computer at home	0.28	0.56		
video player at home	0.67	0.83		
tv at home	0.98	0.93		
car at home	0.45	0.55		
11-25 books at home	0.31	0.33		
26-100 books at home	0.18	0.19		
101-200 books at home	0.06	0.07		
200+ books at home	0.08	0.09		
girls' school	0.37	0.46	0.44	0.47
grade 8 enrolment at school	106.91	80.49	67.32	93.52
computers per student at school	0.00	0.01	0.01	0.02
school's hours per year	370.61	384.51	985.18	1007.58
urban school	0.46	0.50		
rural school			0.63	0.37
teacher's experience	14.49	14.67	12.62	16.74

teacher has university degree	0.41	0.64	0.64	0.64
teacher has edu. math specialty	0.35	0.51	0.51	0.51
female teacher	0.35	0.45		
male teacher			0.57	0.54

Table A6. Cognitive production function estimates - 4th grade TIMSS science

	2003-07 decomposition		2007-11 decomposition		wealth decomposition	
	2003	2007	2007	2011	Poorer 50%	Wealthier 50%
Over age	-30.93***	-33.74**	-46.87***	-53.66***	-43.95***	-69.2***
	(8.75)	(14.02)	(14.77)	(10.26)	(12.22)	(15.01)
11-25 books at home	10.05	12.57**	4.4	11.84***		
	(6.94)	(5.98)	(8.37)	(4.23)		
26-100 books at home	15.32**	16.14**	4.65	21.6***		
	(6.73)	(6.93)	(9.61)	(5.83)		
101-200 books at home	13.12	14.12	10.39	23.67***		
	(11.52)	(8.81)	(9.25)	(6.07)		
200+ books at home	6.39	21.32	2.5	22.72***		
	(14)	(13.5)	(17.92)	(5.36)		
wealth index					7.5*	3.39*
					(4.1)	(1.83)
computer at home	-0.85	11.5**	15.21*	3.8		
	(5.19)	(4.81)	(8.21)	(4.55)		
has a desk	13.27*	8.29	9.63	6.92		
	(6.69)	(5.02)	(6.89)	(4.14)		
urban school	5.47	-0.45	-4.23	28.13***		
	(13.89)	(12.84)	(19.46)	(8.44)		
rural school					-13.77	-13.55
					(9.7)	(9.16)
hours of science per week	-0.38	7.22	6.38	3.77	3.11	4.6
	(6.11)	(6.34)	(14.01)	(3.72)	(4.86)	(4)
girls school	24.11**	-32.47***			2.64	1.06
	(11.2)	(10.87)			(13.61)	(9.61)

boys school			25.51 (18.25)	-4.07 (10.87)		
school size	0.02** (0.01)	0.03 (0.04)	0.02 (0.05)	0.01 (0.02)	0.03 (0.03)	0 (0.03)
school computers per student			1355.97*** (409.9)	70.3** (31.45)	54.92** (26.59)	107.18** (40.65)
teacher has university degree	73.95** (31.83)	15.03 (28.42)	22.2 (52.36)	15.56 (21.72)	11.55 (9.72)	11.9 (10.47)
teacher's years teaching	1.41 (1.5)	1.66 (1.35)	1.9 (1.27)	2.67*** (0.83)	1.9*** (0.67)	1.96*** (0.54)
female teacher	-0.67 (27.2)	47.07* (28.25)				
male teacher			-60.02* (35.92)	14.22 (22.69)	1.91 (12.82)	-1.83 (13.01)
female teacher x years teaching	0.49 (1.48)	0.14 (1.48)				
male teacher x years teaching			0.56 (2.03)	-0.75 (0.93)		
years teaching x university degree	-3.95* (2.25)	-0.27 (1.59)	-0.48 (2.94)	-0.03 (1.02)		
constant	420.74*** (4.29)	443.58*** (4.96)	442.03*** (6.77)	450.95*** (5.16)	433.23*** (4.8)	470.09*** (7.2)

Significance at the 1, 5 and 10 per centper cent levels denoted by ***, **, and * respectively. Standard errors in brackets and calculated using Jackknife. Dependent variable is achievement measured by plausible values. Coefficients are estimated in two stages; please see the text for methodology.

Table A7. Cognitive production function estimates - 4th grade TIMSS math

	2003-07 decomposition		2007-11 decomposition		wealth decomposition	
	2003	2007	2007	2011	Poorer 50%	Wealthier 50%
Over age	-32.12***	-31.41***	-37.64***	-41.65***	-31.17**	-56.59***
	(7.77)	(8.27)	(10.43)	(8.29)	(13.46)	(16.02)
11-25 books at home	11.34**	8.73*	-1.44	6.45		
	(4.77)	(4.85)	(6.74)	(4.45)		
26-100 books at home	14.96**	19.47***	5.93	17.31**		
	(6.62)	(5.81)	(7.7)	(6.8)		
101-200 books at home	9.91	13.25	3.26	16.81**		
	(11.3)	(9.5)	(12.5)	(6.54)		
200+ books at home	10.64	11.83	-5.01	13.9**		
	(8.77)	(10.73)	(13.86)	(6.71)		
wealth index					5.61	2.14
					(3.86)	(1.47)
computer at home	-4.22	6.95	10.65	4.18		
	(4.35)	(4.59)	(6.51)	(5.13)		
has a desk	14.91***	5.65	8.16	7.08		
	(4.56)	(4.29)	(6.35)	(4.74)		
urban school	9	4.15	-4.99	27.71***		
	(8.91)	(8.82)	(15.28)	(7.8)		
rural school					-17.76**	-11.05
					(8.53)	(9.2)
hours of math per week	-1.14	-1.75	3.53	2.02	2	4.73
	(3.84)	(3.77)	(9)	(2.41)	(3.04)	(2.86)
girls school	-9.65	-21.57*			4.43	3.87
	(10.17)	(11.08)			(10.74)	(8.92)
boys school			11.22	-6.49		
			(14.4)	(9.41)		

school size	0.02**	0.01	0	0	0	0
	(0.01)	(0.02)	(0.03)	(0.02)	(0.02)	(0.03)
school computers per student			1495.11***	67.87***	55.43***	102.29***
			(440.44)	(20.49)	(17.81)	(27.54)
teacher has university degree	42.27	10.34	12	14.32	11.39	14.72
	(27.7)	(22.37)	(37.48)	(19.96)	(8.28)	(10.55)
teacher's years teaching	1.22	1.55	1.39	2.61***	1.5**	2.04***
	(1.1)	(0.96)	(0.95)	(0.72)	(0.59)	(0.51)
female teacher	13.61	45.94**			-2.33	-1.86
	(25.46)	(19.53)			(10.49)	(14.35)
male teacher			-62.01**	21.2		
			(26.05)	(21.24)		
female teacher x years teaching	0.83	-0.03				
	(1.31)	(1.09)				
male teacher x years teaching			0.99	-1.07		
			(1.54)	(0.96)		
years teaching x university degree	-2.27	0.12	-0.12	0.12		
	(1.72)	(1.3)	(2.25)	(0.96)		
constant	395.21***	408.14***	408.26***	427.42***	412.65***	447.56***
	(3.93)	(4.53)	(5.11)	(3.3)	(3.17)	(5.45)

Significance at the 1, 5 and 10 per centper cent levels denoted by ***, **, and * respectively. Standard errors in brackets and calculated using Jackknife. Dependent variable is achievement measured by plausible values. Coefficients are estimated in two stages; please see the text for methodology.

Table A8. Cognitive production function estimates - 4th grade PIRLS reading

	2006-11 decomposition		wealth decomposition	
	2006	2011	Poorer 50%	Wealthier 50%
Over age	-23.69***	-27.2***	-27.15**	-41.09**
	(8.61)	(10.07)	(11.35)	(18.08)
11-25 books at home	12.47***	2.69		
	(3.52)	(4.38)		
26-100 books at home	19.03***	10.74**		
	(5.56)	(5.24)		
101-200 books at home	28.46***	6.92		
	(8.98)	(5.87)		
200+ books at home	28.3***	9.08		
	(7.48)	(7.05)		
computer at home	4.13	3.33		
	(4.47)	(4.27)		
has a desk	1.62	6.75**		
	(4.56)	(3.25)		
has own books	24.04***	25***		
	(4.06)	(4.55)		
car at home	2.06	3.29		
	(3.71)	(3.02)		
av recorder at home	-11.2***	-5.36*		
	(3.74)	(2.98)		
piano at home	-23.36***	-20.97***		
	(6.29)	(4.95)		
wealth index			7.25**	0.56
			(3.19)	(1.69)
mother's education: lower sec.	14.06***	6	3.96	10.32
	(4.34)	(4.3)	(5.73)	(7.97)

mother's education: upper sec.	34.18***	21.17***	18.09**	25.96***
	(6.82)	(5.25)	(7.13)	(6.84)
mother's education: non tertiary post sec.	25.12	25.34***	5.73	41.45***
	(21.26)	(8.69)	(15.37)	(8.36)
mother's education: tertiary college	41.59***	28.47***	21.73	37.21***
	(12.84)	(7.69)	(15.86)	(8.62)
mother's education: tertiary university	61.16***	42.1***	46.13***	49.23***
	(9.83)	(6)	(11.29)	(7.63)
mother's education: post graduate	113.18***	37.47***	5.35	40.45***
	(19.89)	(12.43)	(40.77)	(12.52)
urban school	13.59*	15.8***	14.68*	10.94*
	(7.49)	(5.81)	(7.63)	(6.38)
schools' instruction hours per year	0.03	0.03**	0.03	0.04**
	(0.04)	(0.01)	(0.02)	(0.02)
girls school	0.4	21.4***	26.27**	26.85***
	(10.57)	(6.8)	(10.2)	(6)
school size	0.02	0.01	0.04**	-0.01
	(0.02)	(0.01)	(0.02)	(0.01)
school library with 500 or more books	18.93**	10.01*	11.03	10.63*
	(9.5)	(5.53)	(7.42)	(6.1)
teacher has university degree	-5.25	-7.73	20.83	-2.49
	(14.38)	(17.13)	(21.86)	(24.43)
teacher's years teaching	-0.97	0.38	1.42	1.19
	(1.43)	(0.83)	(1.19)	(1)
female teacher	3.02	6.27	5.14	3.9
	(19.01)	(14.67)	(17.09)	(16.16)
female teacher x years teaching	1.67	-0.05	-0.19	-0.35
	(1.4)	(0.69)	(0.8)	(0.68)
years teaching x university degree	1	0.63	-1.02	0.02
	(1.41)	(0.88)	(1.34)	(0.9)

constant	438.14***	448.84***	366.9***	401.55***
	(3.4)	(4.98)	(23.99)	(31.52)

Significance at the 1, 5 and 10 per centper cent levels denoted by ***, **, and * respectively. Standard errors in brackets and caclulated using Jackknife. Dependent variable is achievement measured by plausible values. Coefficients are estimated in two stages; please see the text for methodology.

Table A9. Cognitive production function estimates - 8th grade TIMSS science

	2003-11 decomposition		wealth decomposition	
	2003	2011	Poorer 50%	Wealthier 50%
Over age	-25.31***	-33.17***	-23.03***	-66.4***
	(4.34)	(5.84)	(6.37)	(10.18)
mother's education: lower sec.	-9.93***	-0.91	-7.37	6.68
	(3.7)	(3.64)	(5.75)	(5.03)
mother's education: upper sec.	16.09***	6.25	15.49*	7.95
	(5.97)	(4.78)	(8.02)	(6.94)
mother's education: non tertiary post sec.	4.59	19.44***	38.76***	21.77***
	(8.08)	(6.79)	(14.29)	(7.93)
mother's education: tertiary college	-73.46***	1.81	-2.69	6.78
	(17.64)	(5.7)	(14.6)	(7.02)
mother's education: tertiary university	8.12	23.75***	-1.87	31.32***
	(11.26)	(7.6)	(20.74)	(8.82)
mother's education: post graduate	-37.22**	5.95	-48.81	21.7*
	(14.26)	(11.48)	(32.48)	(12.44)
wealth index			5.94**	1.87
			(2.33)	(2.34)
has a desk	-2.6	-2.9		
	(3.76)	(3.34)		
computer at home	-7.45*	5.45*		
	(3.79)	(3.13)		
video player at home	-4.66	20.71***		
	(3.03)	(3.58)		
tv at home	20.36	17.27**		
	(13.45)	(6.99)		
car at home	2.37	1.41		
	(3.59)	(3.02)		

11-25 books at home	9.75**	9.95***		
	(3.82)	(3.3)		
26-100 books at home	16.31***	22.85***		
	(4.68)	(3.31)		
101-200 books at home	25.83***	32.41***		
	(6.56)	(4.92)		
200+ books at home	26.59***	22.78***		
	(7.46)	(5.21)		
girls' school	-15.18	16.38	2.65	53.73
	(10.43)	(30.42)	(19.65)	(49.59)
grade 8 enrolment at school	0.09**	0.09*	0.09	0.03
	(0.03)	(0.05)	(0.06)	(0.05)
computers per student at school	682.03	658.47***	733.7***	587.35*
	(505.3)	(181.98)	(108.18)	(304.58)
school's hours per year	-0.01	0.04**	0.04*	0.04*
	(0.02)	(0.02)	(0.02)	(0.02)
urban school	12.04	20.8***		
	(8.39)	(6.53)		
rural school			-14.67**	-25.81**
			(6.08)	(9.79)
teacher's experience	1.05***	1.18***	0.98**	1.02*
	(0.36)	(0.42)	(0.47)	(0.53)
teacher has university degree	10.84*	8.34	13.04*	5.67
	(5.74)	(5.75)	(7.39)	(8.71)
teacher has edu. science specialty	4.05	13.26*		
	(9.07)	(7.55)		
teacher has no edu. scie. spec.			-12.81*	-16.38
			(6.87)	(10.97)
female teacher	13.14	-14.09		
	(9.94)	(31.05)		

male teacher			4.84	45.52
			(19.61)	(50.49)
constant	461.52***	461.69***	453.42***	476.58***
	(2.68)	(3.78)	(3.43)	(7.37)

Significance at the 1, 5 and 10 per centper cent levels denoted by ***, **, and * respectively. Standard errors in brackets and calculated using Jackknife. Dependent variable is achievement measured by plausible values. Coefficients are estimated in two stages; please see the text for methodology.

Table A10. Cognitive production function estimates - 8th grade TIMSS math

	2003-11 decomposition		wealth decomposition	
	2003	2011	Poorer 50%	Wealthier 50%
Over age	-32.77***	-29.52***	-20.01***	-58.47***
	(4.79)	(5.36)	(6.49)	(8.79)
mother's education: lower sec.	-4.94	-0.22	-6.04	7.77
	(3.28)	(3.7)	(5.22)	(5.46)
mother's education: upper sec.	10.16	5.53	15.88*	6.36
	(6.11)	(5.43)	(8.15)	(7.35)
mother's education: non tertiary post sec.	0.68	20.01***	38.96***	22.56**
	(6.51)	(6.65)	(12.46)	(8.65)
mother's education: tertiary college	-71.51***	7.78	3.76	12.43
	(24.19)	(6.05)	(10.46)	(8.18)
mother's education: tertiary university	-2.17	22.27***	2.43	28.52***
	(10.65)	(6.85)	(17.59)	(9.62)
mother's education: post graduate	-22.69**	5.22	-33.22	14.65
	(10.34)	(9.06)	(29.22)	(10.07)
wealth index			5.56**	1.67
			(2.38)	(2.31)
has a desk	-8.7**	0.77		
	(3.65)	(2.88)		
computer at home	-2.63	9.01**		
	(3.6)	(3.38)		
video player at home	-5.94**	16.35***		
	(2.88)	(4.56)		
tv at home	30.56***	18.16***		
	(9.62)	(5.47)		

car at home	9.96***	-0.27		
	(3.16)	(3.15)		
11-25 books at home	10.22**	3.93		
	(4.27)	(2.62)		
26-100 books at home	18.3***	17.91***		
	(5.06)	(3.52)		
101-200 books at home	34.53***	23.42***		
	(6.24)	(5.24)		
200+ books at home	32.5***	15.94***		
	(6.89)	(5.62)		
girls' school	-5.28	-8.88	-12.97	1.55
	(17.68)	(26.52)	(26.63)	(51)
grade 8 enrolment at school	0.04	0.15**	0.12	0.1
	(0.05)	(0.06)	(0.07)	(0.07)
computers per student at school	1508.76	735.49***	798.81***	635.23**
	(919.55)	(200.42)	(129.85)	(285.27)
school's hours per year	0.01	0.05***	0.05***	0.06**
	(0.02)	(0.02)	(0.02)	(0.03)
urban school	24.45***	16.72**		
	(8.73)	(8.01)		
rural school			-12.51	-19.54
			(7.56)	(12.94)
teacher's experience	1.26***	1.88***	1.56***	2.15**
	(0.45)	(0.54)	(0.51)	(0.84)
teacher has university degree	6.31	-4.08	-7.38	-0.6
	(5.25)	(6.44)	(6.66)	(8.49)
teacher has edu. math specialty	3.74	3.83	-1.06	6.82
	(9.12)	(7.26)	(6.2)	(10.8)
female teacher	13.72	9.09		
	(17.93)	(26.84)		

male teacher			-6.06	-7.01
			(26.3)	(51.33)
constant	423.9***	406.29***	389.01***	413.11***
	(2.8)	(4.55)	(3.17)	(9.42)

Significance at the 1, 5 and 10 per centper cent levels denoted by ***, **, and * respectively. Standard errors in brackets and calculated using Jackknife. Dependent variable is achievement measured by plausible values. Coefficients are estimated in two stages; please see the text for methodology.

Table A11. Decomposition results - 4th grade TIMSS science

	2003-07 decomposition		2007-11 decomposition		Wealth decomposition	
	Explained	Unexp.	Explained	Unexp.	Explained	Unexp.
Over age	2.49	0.23	1.80	0.26	2.08	1.20
11-25 books at home	0.51	0.13	-0.03	-0.06		
26-100 books at home	-0.05	0.00	0.30	1.10		
101-200 books at home	0.15	0.01	0.14	0.18		
200+ books at home	0.03	0.08	0.09	0.70		
wealth index					21.62	-11.86
computer at home	-0.08	1.12	3.26	-2.45		
has a desk	0.98	-0.37	1.31	-0.37		
urban school	0.20	-0.22	-0.16	1.21		
rural school					2.82	-0.04
hours of science per week	0.00	-0.06	4.52	-1.84	0.48	0.23
girls school	3.14	-7.36			0.08	-0.04
boys school			1.75	-2.03		
school size	-0.11	-0.07	0.07	-0.05	1.26	-1.22
school computers per student			5.29	-5.02	0.16	0.15
teacher has university degree	3.26	-2.60	1.19	-0.36	0.94	0.03
teacher's years teaching	1.01	0.18	0.67	0.27	4.96	0.16
female teacher	-0.01	0.67				
male teacher			1.43	-1.77	-0.12	0.24
female teacher x years teaching	0.36	-0.26				
male teacher x years teaching			0.00	0.01		

years teaching x university degree	-2.17	2.03	-0.85	0.80		
constant	0.00	22.84	0.00	8.91	0.00	36.86

Table A12. Decomposition results - 4th grade TIMSS math

	2003-07 decomposition		2007-11 decomposition		Wealth decomposition	
	Explained	Unexp.	Explained	Unexp.	Explained	Unexp.
Over age	2.23	-0.05	1.54	0.16	1.44	1.18
11-25 books at home	0.59	-0.14	0.00	0.00		
26-100 books at home	-0.26	-0.08	0.36	0.69		
101-200 books at home	0.12	0.04	0.05	0.21		
200+ books at home	-0.06	-0.01	-0.17	0.65		
wealth index					16.23	-10.03
computer at home	-0.25	0.66	2.31	-1.41		
has a desk	1.11	-0.69	1.16	-0.15		
urban school	0.07	-0.04	-0.18	1.15		
rural school					3.81	-1.44
hours of math per week	0.24	0.12	2.55	-1.09	0.45	0.61
girls school	-1.41	-1.74			0.11	-0.01
boys school			0.26	-0.41		
school size	-0.43	0.25	0.02	-0.08	0.13	-0.17
school computers per student			6.29	-6.01	0.16	0.14
teacher has university degree	2.80	-2.12	0.59	0.11	0.75	0.22
teacher's years teaching	-0.40	-0.11	1.50	1.31	4.14	1.47
female teacher	0.52	1.24			-0.14	0.03
male teacher			1.80	-2.41		
female teacher x years teaching	0.66	-0.68				
male teacher x years teaching			0.04	-0.07		
years teaching x university degree	-1.04	1.09	-0.26	0.53		

constant	0.00	12.93	0.00	19.16	0.00	34.91

Table A13. Decomposition results - 4th grade PIRLS reading

	2006-11 decomposition		wealth decomposition	
	Explained	Unexp.	Explained	Unexp.
Over age	0.75	0.11	1.13	-0.24
11-25 books at home	0.55	-0.43		
26-100 books at home	0.44	-0.19		
101-200 books at home	0.90	-0.68		
200+ books at home	0.86	-0.58		
computer at home	1.12	-0.22		
has a desk	0.29	0.93		
has own books	2.10	0.08		
car at home	0.48	0.28		
av recorder at home	-2.24	1.17		
piano at home	-0.53	0.05		
wealth index			21.52	-10.56
mother's education: lower sec.	-1.23	0.70	-0.10	1.29
mother's education: upper sec.	2.98	-1.14	3.01	2.69
mother's education: non tertiary post sec.	0.69	0.01	0.08	1.34
mother's education: tertiary college	0.18	-0.06	0.83	0.78
mother's education: tertiary university	3.07	-0.96	6.37	0.48
mother's education: post graduate	1.08	-0.72	0.15	1.09
urban school	0.58	0.09	3.17	-2.68
schools' instruction hours per year	2.87	-0.19	0.40	3.93
girls school	0.02	1.00	1.02	0.29
school size	0.02	0.00	1.99	-13.26
school library with 500 or more books	-0.92	0.43	1.93	-0.23
teacher has university degree	-1.19	-0.56	1.19	-20.91

teacher's years teaching	-9.79	13.64	2.99	-4.33
female teacher	0.06	0.06	0.36	-0.80
female teacher x years teaching	10.06	-10.36	-0.52	-1.88
years teaching x university degree	10.91	-4.05	-2.66	17.42
constant	0.00	10.69	0.00	34.65

Table A14. Decomposition results - 8th grade TIMSS science

	2003-11 decomposition		wealth decomposition	
	Explained	Unexplained	Explained	Unexplained
Over age	1.64	0.51	1.98	3.73
mother's education: lower sec.	-0.58	0.53	-0.07	0.14
mother's education: upper sec.	-0.51	0.31	1.00	-0.49
mother's education: non tertiary post sec.	0.20	0.66	4.53	-1.99
mother's education: tertiary college	-5.87	6.01	-0.26	0.92
mother's education: tertiary university	0.28	0.53	-0.19	3.31
mother's education: post graduate	-0.16	0.19	-0.90	1.29
wealth index			15.26	-10.44
has a desk	-0.16	-0.02		
computer at home	-2.28	3.95		
video player at home	-0.75	4.06		
tv at home	-1.07	0.16		
car at home	0.27	-0.11		
11-25 books at home	0.26	0.01		
26-100 books at home	0.24	0.09		
101-200 books at home	0.21	0.05		
200+ books at home	0.35	-0.05		
girls' school	-0.77	1.59	0.07	1.32
grade 8 enrolment at school	-1.72	-0.03	2.74	-1.91
computers per student at school	7.20	-0.25	3.83	-0.76
school's hours per year	-0.10	0.80	0.79	0.03
urban school	0.91	0.66		
rural school			4.02	3.05
teacher's experience	1.55	0.19	3.58	0.17
teacher has university degree	2.96	-0.68	0.33	-0.19
teacher has edu. science specialty	-0.05	-0.12		

teacher has no edu. scie. spec.			0.22	0.06
female teacher	0.90	-1.86		
male teacher			-0.16	-1.37
constant	0.00	0.18	0.00	23.15

Table A15. Decomposition results - 8th grade TIMSS math

	2003-11 decomposition		wealth decomposition	
	Explained	Unexplained	Explained	Unexplained
Over age	2.10	-0.21	1.84	3.54
mother's education: lower sec.	-0.30	0.29	-0.08	0.18
mother's education: upper sec.	-0.35	0.16	1.03	-0.62
mother's education: non tertiary post sec.	0.03	0.73	4.70	-1.98
mother's education: tertiary college	-5.61	6.22	0.37	0.86
mother's education: tertiary university	-0.07	0.76	0.24	2.58
mother's education: post graduate	-0.05	0.06	-0.71	1.02
wealth index			14.44	-10.10
has a desk	-0.35	0.38		
computer at home	-0.74	3.28		
video player at home	-0.91	3.41		
tv at home	-1.58	0.64		
car at home	0.99	-1.02		
11-25 books at home	0.25	-0.16		
26-100 books at home	0.15	0.00		
101-200 books at home	0.21	-0.07		
200+ books at home	0.40	-0.20		
girls' school	-0.46	-0.31	-0.34	0.38
grade 8 enrolment at school	-1.10	-2.87	3.08	-0.40
computers per student at school	17.67	-9.05	5.89	-1.21
school's hours per year	0.16	0.60	1.12	0.28
urban school	0.93	-0.29		
rural school			3.35	1.88
teacher's experience	0.22	0.11	6.44	2.42

teacher has university degree	1.45	-2.38	0.02	-0.01
teacher has edu. math specialty	0.62	0.01	0.01	-0.05
female teacher	1.27	-0.43		
male teacher			0.20	0.03
constant	0.00	-17.62	0.00	24.10

Annex 2: TIMSS / PIRLS Workshop Report

October, 2013

1. Background

UNICEF is supporting a study on improving learning outcomes in Iran based on analysis of TIMSS/PIRLS data. The study's objective is to provide a better understanding and analysis of the trends differences between Iran and other countries revealed by TIMSS/PIRLS in order strengthen the evidence base for policy dialogue and education planning aimed at improving learning achievement in Iran.

TIMSS/PIRLS provide rich data on learning achievement in Iran as well as student, school and teacher characteristics; consequently, analysis of the data can help better understand which factors contributed positively to learning achievement in Iran and which factors constrain achievement which in turn can help guide future research and policy.

However, well-known limitations of analysis of student achievement data require that findings be interpreted carefully and thoughtfully. Thorough knowledge of education practices, policies, parenting, and culture are crucial to correctly interpreting analysis of student achievement data and identifying subsequent research and policy actions as best as possible. Effective quantitative research of learning achievement data requires the collaboration of expertize from many disciplines. To initiate this collaboration, an initial analysis of TIMSS/PIRLS data is currently underway. This analysis applies a decomposition method to help identify which factors measured in the data have contributed or inhibited learning achievement in Iran. This initial study aims engage researchers in Iran in order to further develop the methodology and build on the study.

2. Objectives

Researchers in Iran are familiar with analysis of TIMSS and PIRLS data; consequently, the objectives of the workshop were to

(1) present findings of the study for discussion

(2) introduce the decomposition methodology used in the study

(3) assist participants to adapt the methodology further for their own research

(4) receive feedback about the methodology for the draft report

3. Approach

Achieving the objectives of the workshop required participants to be able to apply the report's methodology; consequently, the approach of the workshop was based on hands-on training. The workshop began with a summary of the main findings of the report. The duration of the workshop was dedicated to learning software and methods for applying the decomposition method. Ample time was given for participants to work in small groups to independently apply the method. This helped participants fully understand the methodology used in the report and enabled them to provide a better critique of the methodology. It also helped enable them to apply the methodology to their own research in the future. Annex 1 presents the agenda for the two-day workshop.

4. Proceedings

The workshop was attended by XX people from different organizations in Iran…

In general, participants found the decomposition methodology interesting and useful. There was little critique of the methodology itself or the subsequent findings of the study.

Much of the discussion related to the decomposition method was related to interpreting the findings.

It was assumed the participants would have analyzed the TIMSS and PIRLS data before and therefore would have had expertise on modeling student assessment data and using software to estimate these models. However, only a handful of participants had this experience. The background of the participants varied. Consequently, a lot of discussion revolved around constructing and estimating models of learning achievement using student assessment data including the underlying concept, the statistical methods, and the interpretation of findings.

The workshop concluded with a discussion of approaches for using learning assessment data in general (beyond the methods presented during the workshop). Much of the discussions about research using learning assessment data were among participants especially the TIMSS/PIRLS team as well as experts on statistics.

5. Lessons learnt and next steps

The primary lesson from the workshop in terms of improving future workshops is on managing different expertise among participants. Workshop facilitators were expecting participants familiar with research methods using learning assessment data, but few participants had this expertise and many participants were not expecting to have to learn software and conduct their own small studies. However, the diversity in expertise provided different perspectives on this type of research and in general research using learning assessment data is higher quality of different perspectives are involved and more relevant if policy maker perspectives are involved. For future workshops, the diversity of expertise would be better managed if the expertise of participants were known in advance and then grouped during the workshop to ensure a mix of expertise in each group (including an expert on student assessment data research). This was attempted during the workshop but without prior knowledge of the expertise of individual participants,

posed a challenge.

There are several ideas for next steps within the country. This includes an international workshop to bring examples of how different countries improved learning outcomes through policy reform and programs. They also include a small research grant scheme to promote policy research and a network of researchers on education quality. There is a possibility to partner with ISESCO on some of these activities going forward.

Agenda

Tuesday, November 5th, 2013

8:30 – 9:00	Registration
9:00 – 10:00	Opening speeches (10 minutes), initial findings presentation
10:00 – 10:30	Distribution of data, installation of IDB analyzer
10:30 – 10:45	Coffee Break
10:45 – 12:00	Estimating models using IDB analyzer
12:00 – 13:00	Decomposition method
13:00 – 14:00	Lunch
14:00 – 15:30	Decomposition method continued
15:30 – 15:45	Coffee Break
15:45 – 17:00	Modified decomposition method

Wednesday, November 6th, 2013

9:00 – 10:30	Introduction to using Stata
10:30 – 10:45	Coffee Break
10:45 – 12:00	Individual / group work using methods
13:00 – 14:00	Lunch
14:00 – 15:30	Individual / group work continued
15:30 – 15:45	Coffee Break
15:45 – 17:00	Individual / groups present their findings

Annex 3. Technical Note on the Estimation Procedure

In TIMSS, PIRLS and other major international and national student assessments, a student's cognitive achievement is modeled as a random variable whose probability distribution depends on the student's responses to the test items, the difficulty of these items, and characteristics of the student, his or her teachers and school. This distribution is referred to as the posterior distribution and notated in equation (5) where $\boldsymbol{y}$ is a vector of achievements for students included in the sample and **R**, **H**, **S**, and **T** are matrices representing item responses, household and personal characteristics, school characteristics and teacher characteristics, respectively, for each student.

$$\boldsymbol{y} \sim f(\boldsymbol{y}|\mathbf{R}, \mathbf{H}, \mathbf{S}, \mathbf{T}) \tag{5}$$

An estimate of a statistic, g, based on student achievement (e.g.: average achievement for the sample) is denoted in equation (2).

$$E[g(\boldsymbol{y})|\mathbf{R}, \mathbf{H}, \mathbf{S}, \mathbf{T}] = \int g(\boldsymbol{y})\, f(\boldsymbol{y}|\mathbf{R}, \mathbf{H}, \mathbf{S}, \mathbf{T})\, d\boldsymbol{y} \tag{6}$$

As (6) demonstrates, statistics based on cognitive ability are actually statistics that are ultimately conditional on the observed variables of TIMSS and PIRLS: item responses and background variables. The variance of statistic g reflects the uncertainty in the estimate of achievement or equivalently the variance in posterior distribution, f. The TIMSS and PIRLS datasets report five draws from the posterior distribution called plausible values; to estimate equation (6) as well as the decomposition components, Rubin's (1987) combination methods are used as described in the TIMSS technical report (Olson et al. 2008; Martin et al. 2004).

TIMSS aims to provide an estimate of science and mathematics achievement for 4th and 8th grade students while PEARLS estimates reading achievement of 4th grade students. Both studies employ a multi-stage cluster survey design to collect data. Schools are the

primary sampling unit and, in Iran, are stratified according to location, school gender, and whether public or private, depending on the year of assessment. Within schools, 4th or 8th grade classes are selected and within those, the students. Because of this complex survey design, estimates of statistics are calculated using sampling weights representing unequal selection probability of students, and the sampling variance of statistics is estimated to account for intra-cluster correlation of achievement within schools. TIMSS and PIRLS provide Jackknife Repeated Replicate weights for calculating the sampling variance. The total variance of an estimate of a statistic would include the sampling variance and variance in the posterior distribution described above. For this study, Rubin's combination methods as described in the TIMSS technical report (Martin et al. 2004) are used to calculate estimates of statistics and their variances. This is implemented using the *pv* module in Stata by Macdonald (2008).