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Labor Market Returns, Marriage Opportunities, or the Education System? Explaining Gender Differences in Numeracy in Indonesia

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Abstract

This paper measures the evolution of the gender differences in numeracy among school age children using a longitudinal dataset from Indonesia. A unique feature of the dataset is that it uses an identical test for two survey rounds, which implies that any changes in the gender gap are caused by actual changes in numeracy. To my knowledge, this is the first study that is able to distinguish actual changes in numeracy from changes in the difficulty of the tests. I find that girls outperform boys by 0.09 standard deviations when the sample was around 11 years old. Seven years later, the gap has increased to 0.19 standard deviations. This gap is equivalent to around 18 months of schooling. I find evidence for two explanations for the widening gap. The first is that households invest more resources in girls relative to boys. This behavior appears to be rational, driven by the higher labor market returns to numeracy for girls than for boys. In contrast, I find no marriage market returns to numeracy for either gender. The second explanation is that the Indonesian education system appears to play some role in promoting the gender gap. A particular source of this appears to be the teachers, as the gender gap in numeracy only occurs in schools where more than half of the teachers are female.

Keywords: numeracy, gender gap, education, Indonesia
JEL codes: I21, J16, O15.

[Ψ] I have benefited from comments and suggestions provided by Evgenia Dechter, Paul Frijters, Arya Gaduh, Andrew Leigh, Peter Orazem, Robert Sparrow, Asep Suryahadi, Yuji Tamura, and seminar participants at Australian National University and the Labour Econometrics Workshop at Deakin University.

I. Introduction

Research on gender differences in education in developing countries usually focuses on differences in education attainment as opposed to differences in skills.[1] Given that the former is an input to the education production function and the latter is the output, it is more relevant to focus on the latter. Hanushek and Woessmann (2008) find that it is skills in mathematics and science that have a positive and causal relationship with economic growth, not education attainment. In addition, the issue of gender differences in skills is of pertinent interest because they are strongly correlated with courses chosen in college, which in turn significantly affects earnings (Paglin and Rufolo, 1990; Brown and Corcoran, 1997).

Most studies on gender differences in skills use cross-sectional datasets.[2] This is inadequate since in addition to measuring the differences at a point in time, researchers should also observe how the gap evolves as the sample becomes older. Comparing gender differences between different age groups at a point in time is not sufficient, as one cannot disentangle age effects from cohort effects. To my knowledge, there are only few studies that measure the evolution of the gap among the same sample of individuals over time. In the United States, Fryer and Levitt (2010) find that boys and girls perform similarly well in kindergarten, but the former outperform the latter by as much as 0.2 standard deviations by fifth grade. In China, Lai (2010) uses administrative records from a district in Beijing and finds that although girls outperform boys as they graduate from elementary school, the gap disappears by the end of middle school.

In this paper, I use a rich longitudinal household survey from Indonesia, the Indonesian Family Life Survey (IFLS), to document the evolution of gender gap in a specific subset of mathematics skills, numeracy, among primary school age children. In addition to focusing on the same set of individuals, IFLS is unique in that it administers an identical numeracy test over two survey waves. This rules out the possibility that any observed change in the gender gap over time is caused by the different tests, as opposed to a change in numeracy between girls and boys. By contrast, the two studies above could not directly control for the test differences. Indeed, Lai (2010) claims that the increasingly difficult tests are one reason for the decrease in the female superiority over boys. In addition, I also assess two potential explanations of the observed evolution. Specifically, I test whether the changes could be explained by household preferences or the school system preferring one gender to the other.

Summarizing the findings, girls initially outperform boys by 0.09 standard deviations. Seven years later, the gap has doubled to 0.19 standard deviations, or equivalent to 18 months

[1] There are exceptions, for example Alderman et al. (1996).
[2] For a survey of studies that look at different cohorts of children, see *inter alia*, Hyde, Fennema, and Lamon (1990), Hyde and Mertz (2009), and Bedard and Cho (2010). Notable cross-country studies include Guiso et al. (2008) and Machin and Pekkarinen (2008).

of schooling. I find two explanations for the widening gap. The first is that households invest more resources in girls relative to boys. I find that an increase in the share of daughters in a household is positively associated with household education expenditure per child. I also observe that the gender gap is wider among households at the bottom of the wealth distribution, corroborating a hypothesis that credit constraints force households to invest resources in the gender that would give them the highest return. This behavior appears to be rational, as I find a higher labor market returns to numeracy for females. In contrast, I find no marriage market return to numeracy for either gender.

The second explanation is that the Indonesian school system favors girls over boys. I find indirect evidence for this by observing that the gender gap widens only among individuals who remained in school, while remaining constant for those who had been out of school. In addition, using a sample of schools that participated in a survey on teacher absenteeism, I find suggestive evidence that the gender gap in numeracy only exists in schools whose majority of teachers are females. Given that two-thirds of teachers in Indonesia are females, this finding unearths a channel through which the education system contributes to the gender gap in numeracy.

I organize the rest of this paper as follows. Section II provides a country context on Indonesia. The subsequent section discusses the IFLS dataset in further detail. Sections IV and V estimate the evolution of gender difference in numeracy and explore possible explanations. The final section concludes.

II. Country Context

Indonesia is considered as a low middle-income country. It has a PPP GDP per capita of US$4000 in 2009. The economy grew at an average annual rate of five percent between 2007 and 2009, and about 15 percent of its population lives below the poverty line. It is a budding democracy, successfully going through three peaceful national elections since 1998. Despite having a secular constitution, 88 percent of Indonesia's 240 million residents are Muslims.[3] The Islam practiced by most Indonesians is the moderate kind. As an example, Davis and Robinson (2006) compare the support for Islamic Law in seven Muslim-majority countries and find Indonesia is ranked second from bottom with regards to supporting Islamic Law.

Relevant to this paper, Indonesia appears to not experience any missing girls (Das Gupta, 2005). The male-to-female ratio at birth was 1.05 in 2009, perceived to be the natural ratio. In the IFLS sample, the male-to-female ratio among 7-14 years old individuals was 1.06 in 2000. Kevane and Levine (2000) find that patterns of birth, birth spacing, and nutrition

[3] This information is taken from https://www.cia.gov/library/publications/the-world-factbook/geos/id.html.

allocations do not suggest any son preference. Although Levine and Kevane (2003) find roughly equal treatment of boys and girls within a household, there is a changing pattern with regards to school enrollment. Figure 1 shows the boy-to-girl ratio in primary and secondary education over the past decade. Although the ratio was relatively high in 1991, it has dipped below the natural boy-to-girl ratio since 2000, implying that there are more boys that dropout of school than girls.

[FIGURE 1 HERE]

III. Data

The IFLS is a longitudinal household survey that began in 1993.[4] Three additional waves were done in 1997, 2000, and 2007 respectively. The sample represents about 83 percent of the Indonesian population, covering 13 major provinces out of a total of 33 provinces in Indonesia. In 1993, IFLS contains information of around 7,200 households. It has since grown to around 10,000 households in 2000 and 13,000 households in 2007 as children in the original sample marry or leave their parents' households. The attrition rate is relatively low, around 5 percent between waves. Overall, 87.6 percent of households that participated in first IFLS wave were interviewed in each of the subsequent three waves (Strauss et al., 2009).

IFLS cognitive test module

IFLS has two sets of cognitive test modules, EK1 and EK2, administered to 7-14 and 15-24 years old individuals respectively. The former contains five numeracy problems and 12 shape matching problems, while the latter contains five numeracy problems and eight shape matching problems. The numeracy problems in EK2 are significantly more complex than those in EK1.

These modules were first included in the third wave of the survey in 2000. The identical modules were then re-enumerated to individuals in the 2007 survey round. The procedure is as follows. Individuals who had taken EK1 in the third wave were told to retake EK1 in the fourth wave. In addition, if these individuals were already at least 15 years old in the fourth wave, they were also asked to answer EK2. Note that these individuals had been 7 – 14 years old in the third wave and were around 14 – 21 years old in the fourth wave. Similarly, individuals who had answered EK2 in 2000 were also asked to work on EK2 in 2007. Finally, EK1 was administered to individuals who were 7 – 14 years old in 2007.

[4] The IFLS is publicly available at http://www.rand.org/labor/FLS/IFLS/.

In this paper, I focus on the individuals who had answered EK1 in 2000, retook it in 2007, and also completed EK2 in 2007. In other words, I focus on the longitudinal sample. In addition, I only use the five numeracy questions of EK. The difference in the individuals' performance in the numeracy test in EK1 between 2000 and 2007 is the measure of numeracy that they accrue over seven years. I also use their performance in EK2 as a second indicator of numeracy.

Attrition in the EK module

Given the focus on panel individuals, gender differences in the attrition rate between 2000 and 2007 could bias the results. For that reason, attrition is an important issue. For these specific modules, the attrition rate between 2000 and 2007 is around 20 percent. In 2000, 5,756 individuals participated in EK1 and 4,662 of those individuals retook EK1 in 2007. This results in an attrition rate of 19 percent. Out of those, only 4,204 individuals also answered questions from EK2 as the rest were younger than 15 in 2007.

Although the attrition rate for this specific module is larger than for the IFLS survey as a whole, it is smaller than other longitudinal surveys in developing countries.[5] More importantly, boys and girls have similar attrition rates. It is important to note, however, that Table 1 shows that those who attrited from the sample perform significantly worse in the EK1 test in 2000. Given that the pattern is similar across both genders, however, one may assume that the evolution of gender gap in numeracy between 2000 and 2007 is the pattern that would have been observed had there not been any attrition.

[TABLE 1 HERE]

Validity of the EK module

Other than attrition, there could also be some validity issues in using merely five questions to infer about an individual's numeracy. To check for the robustness of the EK modules, I compare the magnitude of the gender gap shown in IFLS EK1 2000 with two other numeracy tests. The first is from a World Bank survey on teacher absenteeism in Indonesia, undertaken in 2003.[6] The survey administered 13 numeracy questions to fourth grade students, which have a similar age range as the IFLS EK1 takers. The second comparison comes from the 2003 Trends in International Mathematics and Science Study (TIMSS)

[5] A 20 percent attrition rate over seven years implies an annual average of 2.6 percent. This is lower than the attrition rates of longitudinal surveys in South America, Africa, and India, as discussed in Alderman et al. (2000).

[6] A brief description of this survey is in Appendix 1. See Chaudhury et al. (2006) and Suryadarma et al. (2006) for a full description of this survey and its results.

mathematics test results of 8th graders in Indonesia.[7] The age range of TIMSS test takers is slightly higher, 11 – 18 years old, but it is the only TIMSS results available since the 4th grade mathematics test was not administered in Indonesia.

I estimate an OLS regression of Equation 1 on the three datasets separately, where $score_i$ is the standardized numeracy score for person i and $girl_i$ is a binary variable that equals to one if person i is a girl and zero otherwise. The results are shown in Table 2.

$$score_i = \alpha + \beta girl_i + \varepsilon_i \quad (1)$$

Table 2 suggests that although the EK1 only contains five questions, it is able to document similar gender gaps shown by more complex tests. The first column of Table 2 shows that girls outperform boys by 0.11 standard deviations in IFLS EK1. Meanwhile, Column 2 shows that the gender gap from the test in the World Bank survey is 0.16 standard deviations. Finally, although Column 3 shows that overall performance of boys and girls in the TIMSS test is not significantly different, girls perform 0.10 and 0.07 standard deviations higher in algebra and fractions test, while boys outperform girls by 0.09 standard deviations in data analysis and 0.14 standard deviations in geometry. Given that the tests in IFLS EK1 and the World Bank survey are algebra and fractions, the table shows that girls' superiority over boys in all three tests are relatively similar.

[TABLE 2 HERE]

IV. The Evolution of Gender Gap in Numeracy

In this section, I measure the change in numeracy in the seven years between the third and the fourth wave of the IFLS. Table 3 provides the summary statistics of the dataset, while Table 4 shows the evolution of the gender gap in numeracy. The results in Table 4 come from estimating Equation 1, with control variables added for the last three columns.

[TABLE 3 HERE]

The first two columns of Table 4 shows the mean gender gap in numeracy as measured using EK1 in 2000 and 2007, while the the third column shows the mean gender gap in 2007 when measured using EK2. Without any additional controls, these three columns show that the gender gap in numeracy increases from 0.11 standard deviations to 0.20 standard deviations, when measured using an identical test, and increases to 0.26 standard deviations

[7] Information on TIMSS can be accessed from http://timss.bc.edu/

when the skills are measured using a more difficult numeracy test.[8] The last three columns of Table 3 show that the evolution of the gender gap remains robust after I control for differences in age, religious affiliation, school participation, mother's education level, mother's age at first pregnancy, and measures of household wealth.

Given that one year of additional schooling provides 0.13 standard deviations of additional numeracy, the results imply that boys started out around 9 months behind similarly educated girls in 2000, and in 2007 they were about 18 months behind.[9]

[TABLE 4 HERE]

Figure 2 estimates the polynomial fit of the standardized scores in 2000 and 2007 for boys and girls. The first aspect shown by the figure is the fact that there are children who performed worse in 2007 compared to 2000. Secondly, there are more girls who improved between 2000 and 2007 (i.e. lying above the 45-degree line) compared to those who deteriorated (i.e. lying below the 45-degree line). In contrast, the share of those improved relative to those deteriorated was more balanced among boys. Thirdly, the pattern between boys and girls are significantly different. Specifically, among those who improved, girls improved further than boys. And, among those whose performance deteriorated, girls deteriorated less than boys. These factors contribute to the higher improvement in the average score for girls compared to boys, as shown in Table 3.

[FIGURE 2 HERE]

In summary, I find that the gender gap in numeracy, measured on the same sample of individuals using an identical set of questions, have doubled as the individuals in the sample grew older. Comparing the results to findings from other countries, it appears that the Indonesian case is unique when compared to both China and the United States. In China, Lai (2010) finds that the gender mathematics gap initially favor girls at the end of primary school before disappearing three years later. In contrast, Fryer and Levitt (2010) find no gender gap in mathematics during kindergarten, but document a large gender gap favoring boys in fifth grade.

[8] In addition to estimating OLS on separate years, like shown in Table 3, it is also possible to estimate a panel fixed effects model. The results are very similar, indicating that the OLS results do not suffer the bias that stem from time-invariant unobserved heterogeneity at the individual level.

[9] This calculation (not shown) is done by estimating an OLS regression with standardized EK2 2000 score as the dependent variable and years of schooling as the independent variable on a sample of adults who are already out of school.

V. An Investigation into Potential Explanations

In investigating the explanations of gender gap, Bedard and Cho (2010) state that isolating the role played by any particular factor is difficult.[10] True to their statement, previous studies find very little explanation for the evolution in gender gaps. In China, Lai (2010) considers factors ranging from demographic and socio-economic characteristics to school atmosphere, and finds that virtually none of those factors can explain the gender gap. In the United States, Fryer and Levitt (2010) admit that their search for explanation for a gender gap in mathematics is a failure, after considering a wealth of factors including parental expectations and time spent studying mathematics. In this section, I test two potential explanations that could explain the increasing gender gap in Indonesia.

Do households invest more resources in girls' human capital?

The first potential explanation is that households invest more resources in girls' human capital. The first direct test for this hypothesis is shown in Table 5, where I estimate a least squares regression with household annual education expenditure per capita as the dependent variable, and the main independent variable is share of daughters among children in the household. If it is the case that households invest more in girls' human capital, then the per children education expenditure should be higher in households with a higher share of daughters. I use all IFLS households in 2000 and 2007 that have at least one child under the age of 19 as the sample.

[TABLE 5 HERE]

Table 5 shows that after controlling for children's age, household wealth, and region of residence, a household whose children are all girls would have a higher annual education expenditure per child of Rp. 427 thousand compared to a household whose children are all boys. This is a substantial amount, since the average annual education expenditure per child is Rp. 1.3 million. Therefore, it is indeed the case that households invest more in girls relative to boys.[11]

The second evidence for this behavior comes from examining the evolution of gender differences across households at opposite ends of the wealth distribution. According to

[10] There has been much research done on attempting to find an explanation on the existence of gender gap in achievement. Fryer and Levitt (2010) provides a concise review.

[11] It should be noted that a difference in the cost of education for females and males could also explain this phenomenon. As an example, most schools in Pakistan are segregated by gender. In addition, there is a lack of local school availability for females (Alderman et al, 1996; Sawada and Lokshin, 2009). The result is that girls must travel farther to get to school, which implies it is more expensive to educate girls than boys. However, there is no such phenomenon in Indonesia, where the vast majority of schools are not segregated by gender and it is not more expensive to educate girls than boys.

Goldin, Katz, and Kuziemko (2006), households at the top of the distribution are more gender neutral than households at the bottom of the distribution, which are more credit constrained. Based on this proposition, one should see a wider gender gap in numeracy among households at the bottom relative to the top.

The results are shown in Table 6. Among households in the first expenditure quartile, the gender gap in numeracy significantly increased between 2000 and 2007. In 2000, the gap was not statistically significant at 0.06 standard deviations. By 2007, girls outperformed boys by 0.23 standard deviations. On the other hand, the evolution of gender gap in numeracy among households in the fourth quartile follows a different pattern. In 2000, the gender gap among these households was 0.05 standard deviations; not statistically different from zero. By 2007, the gap measured using EK1 was 0.14 standard deviations. In summary, when evaluated using identical test, the gender gap among worse-off households increased much higher than that among better-off households. This result confirms the hypothesis that poor households are less gender-neutral than rich households, and they prefer to invest more in girls relative to boys.

[TABLE 6 HERE]

Why would households invest more in girls? One reason for this behavior is that parents accrue more returns by investing in girls than in boys (Alderman and King, 1998). Based on Alderman and King (1998) and Rosenzweig and Schultz (1982), the following simple model could provide some testable hypotheses. Consider a household with two children, a boy and a girl, whose utility function is

$$u = u(x_h, w_b, w_g) \tag{2}$$

where x_h is the present value of an aggregate consumption good, w_b is the present value of the wealth of the boy, and w_g is the present value of the wealth of the girl. Households allocate x_i, $i=b,g$, which is a market input to the human capital production of each gender, respectively, such that

$$h_b = \delta(x_b), \delta' > 0, \delta'' < 0 \tag{3}$$

$$h_g = \delta(x_g), \delta' > 0, \delta'' < 0 \tag{4}$$

where h_i, $i=b,g$, is the level of human capital of each respective gender, and δ is the production function, assumed to be identical for the boy and the girl. An example of x_i would

be years of schooling, while h_i would be numeracy. In addition, the level of human capital accrued by the children influences their labor market outcomes and opportunities in the marriage market, such that

$$y_i = \gamma_i h_i \tag{5}$$

$$m_i = \eta_i h_i \tag{6}$$

$$w_i = y_i + m_i \tag{7}$$

where y_i is the earning of gender i, γ_i is the gender-specific constant returns to human capital in the labor market, m_i is the earning of the spouse, and η_i is the gender-specific constant returns to human capital in the marriage market. Ignoring discounting and letting the price of the market input to the human capital production to be p and the share of child income that is transferred from the boy and the girl to the parents to be R_b and R_g respectively, the household's budget constraint is

$$V + R_b\left(\gamma_b \delta\left(x_b\right) + \eta_b \delta\left(x_b\right)\right) + R_g\left(\gamma_g \delta\left(x_g\right) + \eta_g \delta\left(x_g\right)\right) - x_h - p\left(x_b + x_g\right) = 0 \tag{8}$$

where V is exogenous household earning.[12] The household maximizes its utility by allocating its resources to consuming x_h and purchasing x_b and x_g, subject to the budget constraint. For simplicity, assume that the utility function is additively separable. The first order conditions are

$$\frac{\partial u}{\partial x_h} p = \left(\gamma_b + \eta_b\right)\delta'_{x_b}\left[\frac{\partial u}{\partial x_h} R_b + \frac{\partial u}{\partial w_b}\right] \tag{9}$$

$$\frac{\partial u}{\partial x_h} p = \left(\gamma_g + \eta_g\right)\delta'_{x_g}\left[\frac{\partial u}{\partial x_h} R_g + \frac{\partial u}{\partial w_g}\right] \tag{10}$$

Equations 9 and 10 imply that households purchase market inputs to their children's human capital production to the point where the marginal cost of doing so in terms of x_h is equal to the marginal benefit accrued from the investment in the children's human capital.

The two equations above produce three testable hypotheses with regards to gender differences in human capital investment. The first hypothesis is that households would invest

[12] It is possible for p to differ by gender, either due to differences in direct costs or opportunity costs (Alderman and King, 1998). In Indonesia, the direct costs are the same for boys than for girls, and it is very difficult to properly calculate the opportunity cost of education for boys and girls.

more in girls if $R_g > R_b$. In the Indonesian context, however, this is not the case. Park (2003) uses IFLS and finds no statistically significant difference in the amount of transfers received by parents from their daughters or sons in Indonesia, controlling for the parents' characteristics and children's education, marital status, and working status.

The second hypothesis is that households could explicitly prefer one gender to the other. In the model, this is indicated by $\frac{\partial u}{\partial w_b} \neq \frac{\partial u}{\partial w_g}, \frac{\partial^2 u}{\partial w_b^2} \neq \frac{\partial^2 u}{\partial w_g^2}$. According to Kevane and Levine (2000), however, this is unlikely to be the case in Indonesia.

The final hypothesis that the model predicts is that households would invest more in girls in the case where the total returns to the human capital is higher for girls than for boys. I investigate whether it has an empirical backing by estimating the labor market returns to numeracy. Following Glewwe (2002), I estimate the model in Equation 11.[13]

$$\log y_i = \alpha + \beta numeracy_i + \tau female_i + \kappa numeracy_i * female_i + \pi Z_i + \varepsilon_i \qquad (11)$$

where y_i is the hourly earnings of individual i. Meanwhile, $numeracy_i$ is the standardized score of the individual's performance in the IFLS EK2 2000 numeracy test, and $female_i$ is equal to one if individual i is a female. Finally, Z_i is a vector of control variables, which includes education attainment, age, and father's education attainment. The coefficient of interest is κ. If it is positive, it implies that the labor market returns to numeracy is higher for females than for males. The sample for this estimation is individual in all IFLS waves who had taken the EK2 test in 2000.

It should be noted that I make no attempt to remove any selection issue with regards to females in the labor market. For the purposes of this paper, estimation results of Equation 11 using OLS show the upper bound of females' returns to ability. In other words, it is the potential returns observed by parents when they allocate their resources to purchasing the input to their children's human capital. Therefore, the parents' expected γ_g would actually be $\beta + \kappa$, and that γ_b would be β.

Meanwhile, in order to measure the marriage returns to numeracy, η_i, I use the log of hourly earnings of the spouse of individual i. The basic idea is to see whether highly numerate individuals are more likely to marry another high achieving individual. I estimate two specifications for each dependent variable, with and without controlling for education

[13] Another way of testing the predictions would be the strategy used by Qian (2008), who takes advantage of a natural experiment that exogenously increase female income, while holding male income constant, and examines the effect of the exogenous increase on female's outcomes. To my knowledge, there is no suitable setting for such strategy in Indonesia.

attainment, because in the theoretical propositions above all the effect of education attainment is translated into higher numeracy.

The results are shown in Table 7. The first column shows that the labor market returns to a one standard deviation higher numeracy are 14.3% for males and 27.5% for females. After controlling for education attainment, the second column shows that the returns to higher numeracy for males decrease to 3.2%, not statistically different from zero. On the other hand, the returns to numeracy for females stand at 8.4%. Therefore, the estimation results confirm the hypothesis that $\gamma_g > \gamma_b$.

The final two columns show the returns to numeracy in the marriage market. Columns 3 and 4 show that higher numeracy is not significantly associated with higher spouse earnings. Although the point estimate is large, it is not precisely estimated. In addition, the estimated coefficient on the interaction of numeracy and sex implies a small penalty in the marriage market for bright females. Again, the coefficient is not significantly different from zero. These results imply that there is no marriage premium to higher numeracy.

[TABLE 7 HERE]

In summary, from Table 7, I find that $\gamma_g > \gamma_b$ and cannot reject the hypothesis that $\eta_g = \eta_b$. This provides evidence for the theoretical proposition for the reasons behind higher investment in the human capital of girls relative to boys. Specifically, it appears that the higher labor market returns to numeracy for females are the main cause for the higher investment in girls, not marriage market returns.

This finding is similar to the review by Cox (2007), who provides several empirical evidence of preference towards girls from both developing and developed countries exactly due to this reason. Similarly, Qian (2008) finds in China that an agricultural reform that increases the price of tea—an overwhelmingly female-dominated sector—increases the survival rate of girls.

The previous results are further corroborated by the 2007 outcomes shown in Table 8. Among children from households at the bottom quartile, the gender gap in junior secondary completion is 7.2 percentage points; substantial given that the mean completion rate at that level is only slightly above 50 percent. In contrast, the gender gap is not only smaller in absolute terms among the children in households at the top quartile, it is also proportionally small relative to the mean junior secondary completion rate of the children in those households. These results corroborate a recent cross-country analysis of developing countries by Grant and Behrman (2010), and indicate that households invest more education input in girls.

[TABLE 8 HERE]

In addition, almost three out of ten girls from households at the bottom quartile were already married by 2007, a rate that is more than twice that of the boys even after controlling for age differences. In contrast, only one out of ten girls from households at the top quartile were married. Note that the average age of these children in 2007 was only 18 years, implying that girls from poor households were married at a younger age than girls from better-off households. Finally, one in three boys from poor households were already engaged in the labor market in 2007, while only18 percent of boys from rich households were already working in 2007. This is an indication that poor households are eager to realize the returns to their investment in the human capital of their children.

Does the Indonesian education system favor girls?

There are several studies that find the education system of a country to be biased towards one gender relative to the other. In the United Kingdom, Machin and McNally (2005) state that the most likely cause of the widening gender gap over time, which favors girls, is the change in the examination system in the country. In the United States, Benbow and Stanley (1980) find large gender differences, where boys outperform girls, among individuals with essentially identical educational experiences.

In this paper, I assess the merits of this explanation by comparing the evolution of gender gap between those who were still in school in 2000 and those who already left school that year.[14] The rationale is that if the system is gender-biased, then the gender gap in numeracy should widen further among those who are in school longer. As a check, I also compare the evolution of gender gap among those who were in school both in 2000 and 2007 with those who were out of school in both 2000 and 2007.

Table 9 shows the results. Looking at Panel A, the gender gap in numeracy among children who were still in school in 2000 was 0.07 standard deviations in 2000. It had significantly increased by 2007, to 0.20 standard deviations. In contrast, the gender gap among those who were already out of school in 2000 started out at 0.22 standard deviations, before decreasing to 0.11 standard deviations in 2007.

[TABLE 9 HERE]

[14] The school drop out appears to be permanent for most individuals in the sample. Only 5.5 percent of girls who were out of school in 2000 subsequently returned to school. The rate is 7.8 percent for boys, and the gender difference is not statistically significant.

Moving on to Panel B, the pattern appears to be qualitatively the same to the results in Panel A. It is interesting to see that among children who remained in school in both survey waves, the gender gap in numeracy increased from parity in 2000 to 0.23 standard deviations in 2007. In contrast, the gender gap among those out of school in both periods remained relatively constant over the years. This is suggestive evidence that the school system may be playing a role in widening the gender gap in numeracy.

It is difficult to precisely pinpoint the specific aspect of the education system that favors girls over boys. A factor that could be responsible for the favoritism is teachers. Dee (2007) finds that children perform better when taught by an individual of the same gender. Given that two-thirds of Indonesian teachers are females, it is possible that this is the source of the bias that favors girls.

I investigate this conjecture by using the 2003 World Bank dataset. Specifically, I divide the sample into schools in which more than half of the teachers are females and school in which less than half of teachers are females, and estimate Equation 1 on these subsamples.

There are several endogeneity biases that could be overcome from this estimation, given the characteristics of the Indonesian schools. Firstly, there are no multiple grade classes in most primary school in Indonesia. In other words, there is only a single fourth grade class in most schools. Secondly, the vast majority of Indonesian schools are coeducational. Thirdly, students in Indonesian primary schools follow an identical course schedule, meaning that a student cannot opt out of a course. These characteristics indicate that teachers are likely to be randomly allocated to students. Finally, most parents choose the primary school that is nearest to their residence. This implies that school choice at the primary level is not a source of bias. Unfortunately, there is no information on the gender of the fourth grade mathematics teacher. However, given that I am only using a cross-sectional dataset, the estimation results should only be considered as merely indicating correlation as opposed to establishing causality.

Table 10 shows the results. The first column shows that after controlling for a number of school characteristics and the education level of the students' mother, fourth grade girls outperform boys by about 0.18 standard deviations. The important point to note is that Column 2 shows that there is no gender gap in schools where the share of female teachers is less than half. Among these schools, the gap favors boys, although small and statistically insignificant. Meanwhile, the last column shows that in schools whose teachers are mostly female, girls outperform boys by 0.26 standard deviations. This preliminary evidence suggests that a channel through which the education system favors girls is the teacher.

[TABLE 10 HERE]

VI. Conclusion

The issue of gender differences in human capital has been the focus of much research. In this paper, I contribute to the literature by measuring the evolution of the gender gap in numeracy among school age children using a longitudinal dataset from Indonesia. A unique feature of the dataset is that it uses an identical test for the two survey waves, implying that any changes in the gender gap indicates actual changes in numeracy, as opposed to changes caused by a different test.

I find that the gender gap increased from 0.09 standard deviations when the sample was around 11 years old to 0.19 standard deviations by the time the sample was around 18 years old. I find that the widening gap is due to the fact that boys' numeracy remained relatively constant over the period, while girls' numeracy increased.

I find two explanations for the widening gap. The first is that households invest more resources in girls relative to boys. Using the sample of households from the IFLS 2000 and 2007 waves, I find that an increase in the share of daughters in a household is positively associated with household education expenditure per child. I also observe that the gender gap is wider among households at the bottom of the wealth distribution, corroborating a hypothesis that credit constraints force households to invest resources in the gender that would give them the highest return. By utilizing predictions from a simple two-children household model, I find that this is the rational decision given the higher labor market returns to numeracy among females compared to males. In contrast, I find no marriage market returns to numeracy for either gender.

The second explanation is that the Indonesian school system favors girls over boys. I find indirect evidence for this by observing that the gender gap widens only among individuals who remained in school, while remaining constant for those who had been out of school. In addition, using a sample of schools that participated in a survey on teacher absenteeism, I find suggestive evidence that the gender gap in numeracy only exists in schools whose majority of teachers are females. Given that two-thirds of teachers in Indonesia are females, this finding unearths a channel through which the education system contributes to the gender gap in numeracy.

It is important to note that there could be other explanations for this phenomenon. One example of which is that girls could invest more effort in studying. Hence, they accrue more numeracy even with the same level of household investment. However, it is very difficult to measure effort. In addition, I find a very similar pattern in the gender gap in numeracy when I estimate the model using an individual fixed effect. Therefore, to the extent that effort is constant across time, it no longer plays a role in explaining the gap. However, it remains an important research topic that should be investigated in the future.

In closing, given that numeracy has a significant effect on an individual's future job choice and income, policymakers have an incentive to ensure that children accrue numeracy regardless of gender. With regards to addressing the lower household investment in the human capital of boys, there may need to be provision for school scholarships. Indeed, in a review of a school scholarship program in Indonesia, Sparrow (2007) finds that the scholarship significantly increases school enrollment for boys. Regarding the bias stemming from the education system, meanwhile, the issue is much more complex. I leave an investigation of ways to address this to future studies.

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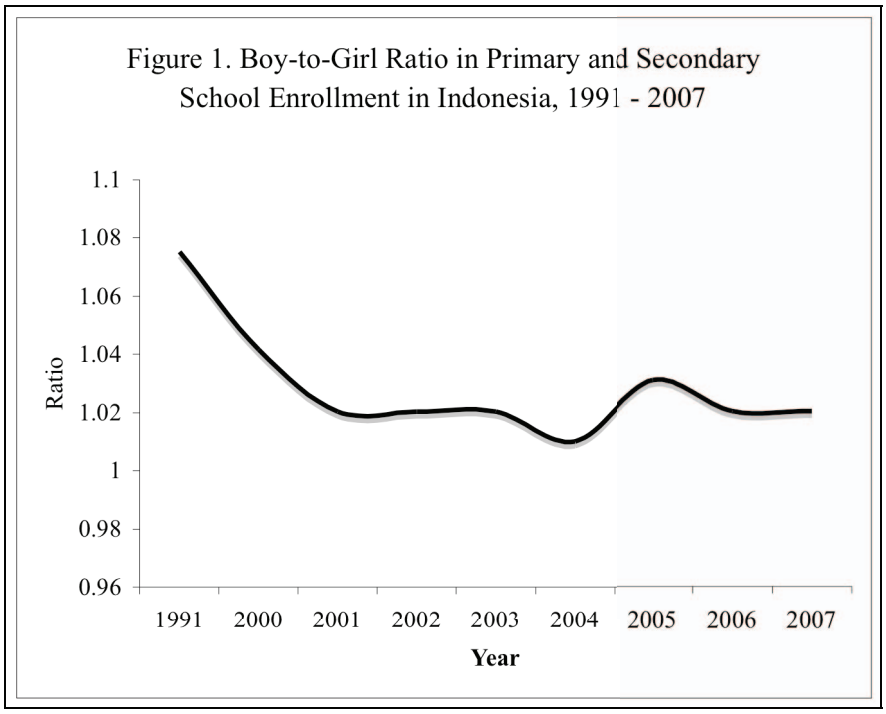

Source: World Development Indicators

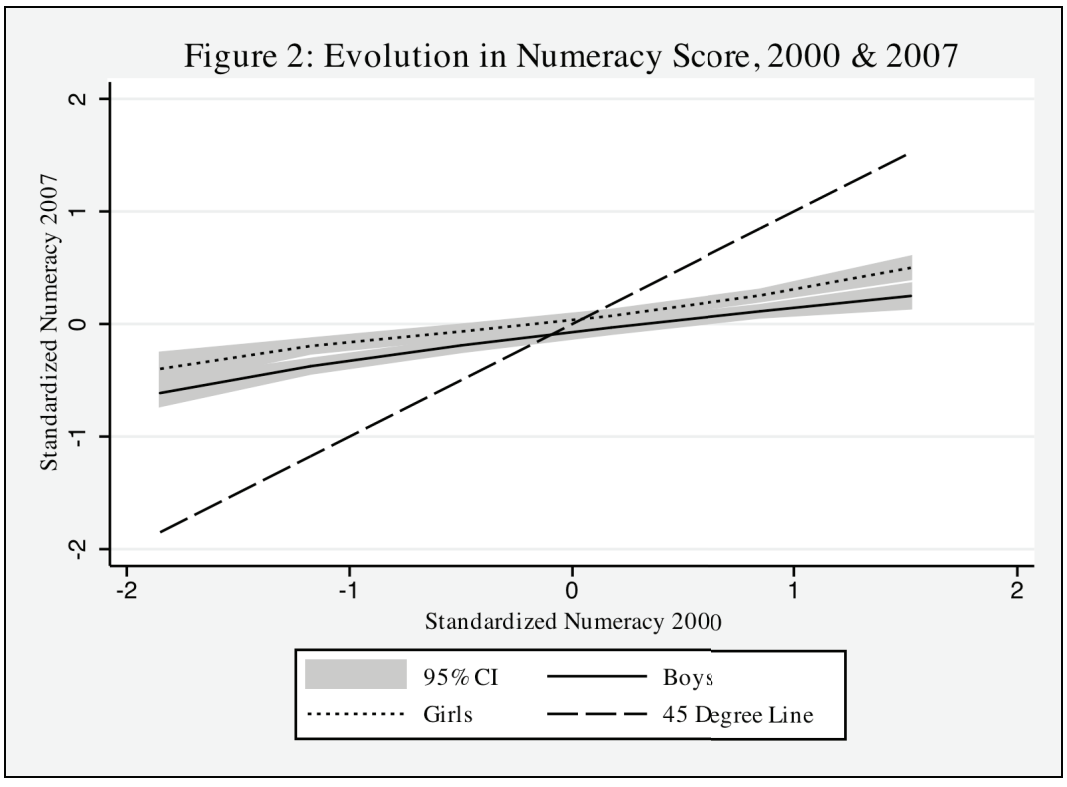

Table 1. Attrition in EK1 between 2000 and 2007

	Sample size		
	Total	Boys	Girls
Took EK1 2000 and EK1 2007	4662	2410	2252
Only took EK1 2000	1094	534	560

	Average EK1 2000 score		
	Total	Boys	Girls
Took EK1 2000 and EK1 2007	2.78	2.69	2.89
Only took EK1 2000	2.64	2.60	2.67

Table 2. Gender Gap in Numeracy in Indonesia

	IFLS EK1 2000 7-14 years old	WB 4th Grade Survey 2003 +/- 10 years old	TIMSS 8th grade 2003 11 - 18 years old					
			Overall	Algebra	Data Analysis	Fractions	Geometry	Measurement
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Girl	0.114***	0.159**	0.023	0.103***	-0.093***	0.074***	-0.143***	-0.023
	(0.032)	(0.062)	(0.029)	(0.028)	(0.027)	(0.028)	(0.029)	(0.034)
Sample size	4204	1089	5762	5762	5762	5762	5762	5762
Boys/Girls ratio in the sample	1.06	1.03	0.97	0.97	0.97	0.97	0.97	0.97

Notes: * 10% significance, ** 5% significance, *** 1% significance; figures are estimated coefficients from weighted least squares regressions (except Column 2, which is ordinary least squares), in standard deviations; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the household level in Column 1, and at the school level in Columns 2 - 8; the TIMSS results that are shown are those that give the upper bound of the absolute gender gap for each test type.

Table 3. Summary Statistics, by Gender

	Boys (N = 2167)		Girls (N=2037)		Mean difference significant at 5%
	Mean	Std. Dev	Mean	Std. Dev	
Numeracy test in EK (max score is 5)					
Actual score in EK1 2000	2.82	1.44	2.99	1.38	Yes
Actual score in EK1 2007	2.92	1.44	3.20	1.40	Yes
Actual score in EK2 2007	2.11	1.56	2.54	1.62	Yes
Individual characteristics					
Age in 2000 (years)	10.89	1.98	10.97	1.98	No
Age squared	122.49	43.59	124.24	43.73	No
Islam (=1)	0.93	0.26	0.94	0.24	No
Still in school in 2000 (=1)	0.86	0.35	0.84	0.37	No
Mother graduated from high school (=1)	0.15	0.35	0.16	0.37	No
Mother was younger than 20 at first pregnancy (=1)	0.52	0.50	0.53	0.50	No
Household condition in 2000					
Household owns a television (=1)	0.60	0.49	0.63	0.48	Yes
Household owns a refrigerator (=1)	0.24	0.43	0.25	0.44	No
Household owns a private toilet with septic tank (=1)	0.41	0.49	0.43	0.50	No
Household own a stove (=1)	0.60	0.49	0.64	0.48	Yes
Per capita monthly education expenditure (Rp 000)	13.04	20.46	13.40	21.84	No
Per capita monthly household expenditure (Rp 000)	130.86	160.23	135.15	151.47	No

Notes: the statistical significance of the mean difference is calculated using a two-tailed t-test; the expenditure figures are nominal values.

Table 4. The Evolution of Gender Gap in Numeracy between 2000 and 2007

	Module EK1 2000 (1)	Module EK1 2007 (2)	Module EK2 2007 (3)	Module EK1 2000 (4)	Module EK1 2007 (5)	Module EK2 2007 (6)
Girl	0.114***	0.197***	0.264***	0.094***	0.185***	0.250***
	(0.032)	(0.033)	(0.033)	(0.029)	(0.032)	(0.032)
Age in 2000				0.631***	-0.015	-0.008
				(0.091)	(0.099)	(0.100)
Age squared				-0.023***	-0.000	-0.001
				(0.004)	(0.004)	(0.005)
Islam				-0.086	-0.042	-0.021
				(0.058)	(0.058)	(0.063)
Still in school in 2000				0.302***	0.272***	0.220***
				(0.050)	(0.052)	(0.047)
Mother graduated from high school				0.242***	0.225***	0.212***
				(0.049)	(0.048)	(0.052)
Mother was younger than 20 at first pregnancy				0.017	-0.069*	-0.130***
				(0.036)	(0.037)	(0.037)
Household owns a television				0.179***	0.197***	0.212***
				(0.039)	(0.040)	(0.040)
Household owns a refrigerator				0.035	-0.113***	-0.070
				(0.042)	(0.043)	(0.043)
Household owns a private toilet with septic tank				0.107***	0.102***	0.122***
				(0.038)	(0.038)	(0.041)
Household own a stove				0.181***	0.160***	0.139***
				(0.038)	(0.039)	(0.040)
Per capita monthly education expenditure (Rp 000)				0.003***	0.002*	0.002**
				(0.001)	(0.001)	(0.001)
Per capita monthly household expenditure (Rp 000)				0.000	0.000**	0.000
				(0.000)	(0.000)	(0.000)
Constant	0.051**	-0.058**	-0.073***	-4.472***	-0.301	-0.266
	(0.024)	(0.024)	(0.024)	(0.497)	(0.532)	(0.542)
Sample size	4204	4204	4204	4204	4204	4204
R-squared	0.004	0.010	0.017	0.156	0.083	0.096

Notes: * 10% significance, ** 5% significance, *** 1% significance; figures are estimated coefficients from weighted least squares regressions; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the household level; the household variables are from 2000; the estimations include indicator variables for missing values in the control variables.

Table 5. Household Education Expenditure per Child and Share of Daughters

	Coefficient
Share of daughters	0.427**
	(0.209)
Average age of children (years)	0.141***
	(0.020)
Asset index	0.216***
	(0.055)
Household per capita annual expenditure, excluding education (Rp millions)	0.091***
	(0.016)
Year = 2007	0.562***
	(0.129)
Constant	-1.152***
	(0.234)
Province dummies	Yes
Sample Size	16164
R-squared	0.277

Notes: * 10% significance, ** 5% significance, *** 1% significance; dependent variable is annual household education expenditure per child in Rp. Million; Asset index is the first principal component of asset ownership and toilet type, as described in Table 2; figures are estimated coefficients of a weighted least squares regression; standard errors are in parentheses, robust to heteroskedasticity, and clustered at the household level.

Table 6. The Evolution of Gender Gap, by Household Expenditure Quartiles

	EK1 2000	EK1 2007	EK2 2007
Bottom Quartile			
Girl	0.063	0.233***	0.176***
	(0.060)	(0.065)	(0.062)
N	1046	1047	1047
R-squared	0.156	0.099	0.096
Top Quartile			
Girl	0.053	0.142**	0.284***
	(0.058)	(0.060)	(0.066)
Sample Size	1047	1047	1047
R-squared	0.172	0.089	0.095

Notes: * 10% significance, ** 5% significance, *** 1% significance; figures are estimated coefficients from a weighted least squares regressions; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the household level; estimations include the control variables in Columns 4-6 in Table 3.

Table 7. Labor Market Returns to Numeracy

	Own earnings		Spouse's earnings	
	ln(hourly earnings) (1)	ln(hourly earnings) (2)	ln(hourly earnings) (3)	ln(hourly earnings) (4)
Standardized Numeracy	0.134***	0.032*	0.145	0.060
	(0.019)	(0.019)	(0.116)	(0.106)
Female	-0.337***	-0.367***	0.624***	0.668***
	(0.031)	(0.030)	(0.132)	(0.123)
Female x Numeracy	0.109***	0.081***	-0.046	-0.044
	(0.031)	(0.029)	(0.121)	(0.110)
Education attainment dummy	No	Yes	No	Yes
Sample size	6381	6381	1500	1500
R-squared	0.098	0.159	0.043	0.087

Notes: * 10% significance, ** 5% significance, *** 1% significance; Numeracy is total score from the IFLS EK2 2000 numeracy test; figures are estimated coefficients from weighted least squares regressions; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the individual level; all estimations include age, age squared, and survey wave dummies.

Table 8. Outcomes in 2007, by 2000 Quartile of Household Expenditure

	Girls	Boys	Difference (Girls - Boys)	
Bottom Quartile				
Completed primary school (%)	90.1	85.9	4.2	*
Completed junior secondary (%)	56.8	49.6	7.2	**
Married (%)	27.3	12.0	15.3	***
Working (%)	20.0	34.4	-14.4	***
Top Quartile				
Completed primary school (%)	97.6	97.7	-0.1	
Completed junior secondary (%)	89.1	83.4	5.7	**
Married (%)	10.3	4.6	5.7	***
Working (%)	15.8	18.4	-2.6	

Notes: * 10% significance, ** 5% significance, *** 1% significance; the differences are estimated marginal effects at the mean from weighted probit regressions, controlling for age differences between boys and girls; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the household level; note that children in households at the top quartile are 0.2 years older than children in households at the bottom quartile, on average.

Table 9. Gender Gap and School Participation

Panel A. Comparing those in school and out of school in 2000			
	EK1 2000	EK1 2007	EK2 2007
In school in 2000			
Girl	0.074**	0.200***	0.240***
	(0.031)	(0.034)	(0.035)
N	3603	3603	3603
R-squared	0.150	0.065	0.079
Out of school in 2000			
Girl	0.218**	0.107	0.326***
	(0.086)	(0.096)	(0.086)
N	601	601	601
R-squared	0.167	0.171	0.217

Panel B. Comparing those in school and out of school in both 2000 and 2007			
	EK1 2000	EK1 2007	EK2 2007
In school in 2000 and 2007			
Girl	0.048	0.225***	0.325***
	(0.049)	(0.049)	(0.054)
N	1484	1484	1484
R-squared	0.177	0.048	0.068
Out of school in 2000 and 2007			
Girl	0.208**	0.140	0.324***
	(0.090)	(0.098)	(0.087)
N	564	564	564
R-squared	0.159	0.192	0.243

Notes: * 10% significance, ** 5% significance, *** 1% significance; figures are estimated coefficients from a weighted least squares regressions; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the household level; estimations include the control variables in Columns 4-6 in Table 3.

Table 10. Gender Gap in Numeracy and Share of Female Teachers

	All sample	Share of female teachers	
		Less than half	More than half
	(1)	(2)	(3)
Girl	0.179***	-0.053	0.260***
	(0.059)	(0.108)	(0.069)
School infrastructure index	0.085*	0.093	0.079
	(0.049)	(0.118)	(0.052)
Student per teacher ratio	-0.016***	-0.006	-0.021***
	(0.005)	(0.009)	(0.007)
Teacher absence rate	0.015	0.319	-0.115
	(0.343)	(0.691)	(0.405)
Proportion of qualified teachers	0.349	-0.152	0.454
	(0.238)	(0.530)	(0.273)
Average teacher experience (years)	0.024**	0.029	0.022*
	(0.012)	(0.020)	(0.013)
Mother graduated from high school	0.465***	0.386*	0.453***
	(0.090)	(0.198)	(0.098)
Constant	-0.944**	-1.107	-0.790*
	(0.403)	(0.837)	(0.447)
N	1089	286	803
R-squared	0.078	0.033	0.096

Notes: * 10% significance, ** 5% significance, *** 1% significance; figures are estimated coefficients from least squares regressions; standard errors are in parentheses and are robust to heteroskedasticity, clustered at the school level; sample is from the 2003 World Bank survey on teacher absenteeism.

Appendix 1. Description of the 2003 World Bank Survey on Teacher Absenteeism

The data were collected through a health and education provider survey conducted by the World Bank in cooperation with SMERU Research Institute. The main objective of the survey was to collect data on the condition of primary schools and public health centers. The survey was part of a multicountry survey that also included Bangladesh, Ecuador, India, Peru, and Uganda.

The survey had three objectives: to document every health and education provider-related issues; to gain an understanding of the differences in the characteristics among districts and among primary schools and public health centers; and to allow assessments of the differences in quality and quantity of service delivery across countries, with the focus on the impact of regional autonomy, public participation, labor policies, and income. Data collection in Indonesia took place during two separate rounds of visits to the schools, in October 2002 and February 2003. Schools were visited twice each to improve the accuracy of the estimates on variables that were measured twice (such as teacher absence), as well as to gauge the similarity of the responses from the two visits, thus giving us better understanding of the nature of problems that exist.

In Indonesia, as in the other countries in the study, the sample was a stratified, clustered, nationally representative random sample. The Indonesia data were collected from eight provinces chosen randomly: Banten, West Java, Central Java, East Java, Bengkulu, Riau, West Nusa Tenggara (NTB), and Southern Sulawesi. After stratification of the country into four regions, a total of 10 districts were chosen randomly on a probability-proportionate-to-population basis: five urban districts (Cilegon, Bandung, Surakarta, Pasuruan, and Pekanbaru) and five rural districts (Gowa, Lombok Tengah, Rejang Lebong, Magelang, and Tuban). In each district ten villages were chosen at random, and in the chosen village up to three primary schools were surveyed at random with the requirement of at least one private and one public school. For public health centers, ten were chosen at random from each district.

The questionnaire in the survey included 3 levels: facility level, individual level, and national level. The facility level included the size of the facility; number of employees; operating hours; employees' activities when visited by the enumerators; types of services available (for public health centers); remoteness; public participation; average education level of the patients and students' parents; supervision; financial condition; employees' education background; and the availability of supporting facilities. In the individual level, the survey covered means of transportation used by the employees to get to the facilities; relation between the employee and the surrounding area; employee's rank in the facilities; demographic characteristics; mother tongue and ethnic background; work-related education; marital status and number of children; other sources of income; work experience; salary

payment method; his or her motivation for choosing his or her particular occupation; and his or her satisfaction. Lastly, for national level the questionnaire included the different positions in the facility, number of employees, and qualifications; tolerated absenteeism level among employees; policies regarding appointment, placement, and transfer of employees; employees' participation in facility management; private sector service and condition of private facilities; rewarding and sanction systems; stakeholder participation in policies; and employees' union.