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“Convexification” and “Deconvexification” of the Peruvian Wage Profile: A Tale of Declining Education Quality¹

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Documento de Discusión

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Abstract

Peruvian average wage profile with respect to schooling is convex. Returns to higher education are around nine percentage points larger than returns to basic education. We explore two possible explanations for this phenomenon: a composition effect driven by differences in individual ability and heterogeneous education quality. We use the theoretical models developed in Card (1994) and Card and Krueger (1996) to analyze the effects that individual ability and education quality can have on the observed relationship between wages and schooling. We test the implications of these models using Peruvian data from a novel survey that includes measures of cognitive skills. We do not find evidence of increasing returns by ability. Instead, empirical results are consistent with the predictions of a model of endogenous schooling with heterogeneous education quality. Evidence suggests that the Peruvian convex wage schedule is the result of two superimposed wage profiles: one corresponding to a low quality basic education system and, the other, to a higher education system with better quality. Declining education quality at basic and higher education, thus, appear to have a role when explaining the “convexification” and recent “deconvexification” of the wage profile, respectively.

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1. Introduction

In Peru, as in several LAC countries, the average wage profile with respect to schooling is convex. This phenomenon is not new and has been documented by several authors². As discussed in Binelli (2008), possible explanations for this phenomenon are: (i) changes in the market value of education for different educational levels; and (ii) changes in the composition by level of education of individual characteristics (observable and non-observable) that affect earnings, or changes in their returns.

Within the first explanation we can find stories related to the effect of international trade and/or labor market reforms on the demand for skilled labor. For example, skill-biased technological change (SBTC) increases the demand for skilled labor causing an increase in the wage premium for higher education³. If we focus on the second group of effects, we can find explanations related to the role of selectivity and/or financial constraints that limit access to higher education, leading to increased relative wages responding to increased relative ability in those that access this educational level.

If we focus on the Peruvian “convexification” process, there are two elements worth highlighting. First, the “convexification” occurred in the 90s was not only related to an increase in the higher education wage premium but also involved a decline in the return to basic (primary and secondary) education (see Figure 1). The second element worth noting is that since mid-2000s we are witnessing a process of “deconvexification”. This has been driven by a decline in the return to higher education (see Figure 1).

In the 90s, Peru underwent a period of significant structural reforms that involved trade and financial market liberalizations. This, in principle, makes Peru’s convexification process a good candidate to be explained through an increase in the demand for skilled labor due to SBTC. However, this story will not accommodate the decline in the return to basic education that occurred in the 90s nor the recent decline in the return to higher education, especially if we note that Peruvian growth figures have been particularly high during the second half of the last decade (around 7% per year).

Access to higher education in Peru is remarkably regressive. Financial constraints have a role but also poor basic education quality and poor family environments that prevent adequate development of basic skills (Castro, *et al.*, 2011). This fact points towards two additional suspects for the evolution of the Peruvian wage profile implicit in Figure 1. The first has already been presented and has to do with a composition effect by ability. The second suspect has not been directly addressed in the literature as a possible explanation for the convexification of the wage profile and has to do with the quality of education.

When we talk about “quality” we refer to an attribute of the education system that affects the increase in human capital offered by an additional schooling year within that particular system. Within basic education (and especially pre-school and primary education) this increase in human capital can be understood as an increase in basic skills or ability. Within higher education, the contribution to human capital can be understood as an increase in the

² See Binelli (2008) and Bourguignon, *et al.* (2005) for evidence on several LAC countries. See Yamada (2007) for specific results on Peru.

³ Binelli (2008) argues that the convexification process experienced in several LAC countries was a matter of changes in the market value of education, but that its main cause was not SBTC but a change in its supply.

individual's proficiency when performing a particular set of tasks related to her career and valued in the labor market⁴.

In this paper, our objective is to provide analytical and empirical evidence to support the hypothesis that declining education quality has a role when explaining the “convexification” and recent “deconvexification” of the Peruvian wage profile. For this, in section 2 we present trends on various indicators that account for the evolution of basic and higher education quality in Peru. In what follows, we analyze the implications that individual ability and education quality can have on the observed relationship between wages and schooling. Section 3 presents this analysis based on the theoretical models developed in Card (1994) and Card and Krueger (1996). In section 4, we use the results of a novel survey that includes special tests to measure cognitive skills to test these implications. Section 5 summarizes our main conclusions.

2. Trends on education quality in Peru

It is customary to refer to learning outcomes when documenting basic education quality (see, for example, Hanushek and Wöbmann, 2007). Learning outcomes are measured through standardized literacy and numeracy tests and their results depend on individuals' basic skills.

A cross-country comparison using the latest results provided by the Program for International Student Assessment (PISA) evaluation provides strong evidence to support the fact that basic education quality in Peru is very poor. PISA evaluations are applied to a nationally representative sample of 15 year-olds, comprise three areas (reading comprehension, mathematics, and science) and their results are classified in six levels. Students scoring in level 2 or above can be considered to have “passed” the evaluation. As shown in Figure 2, little more than a third of Peruvian 15-year olds exhibit adequate reading comprehension skills, while only 26% show adequate mathematical skills according to PISA standards. These results place Peru among the bottom three (out of 65 countries). Countries in the top three, on the other hand, produce results where more than 90% of their youngsters exhibit adequate reading comprehension and mathematical skills.

National evaluations performed on second grade students (7-9 year olds) reveal even worse results. In the 2010 evaluation, only 29% and 14% of students were able to demonstrate adequate reading comprehension and mathematical skills, respectively. Although the recent trend evidences an improvement (back in 2007 the above percentages were 16% and 7%), this does not suffice to claim that basic education quality problems in Peru have been abated.

The evidence presented above is consistent with the presence of a low quality basic education system. If it is true that quality has a role when explaining the slope of the wage profile, this evidence suggests that there are little prospects of recovery, at least in the near future, from the diminished return that basic education has exhibited throughout the last decade (see Figure 1). The above statistics, however, say nothing about the decline

⁴ Basic skills comprise cognitive (e.g., literacy, numeracy, problem-solving) and non-cognitive (e.g., self-discipline, perseverance, dependability) abilities. There is consensus that the first are well set by the age of 10, while the latter remain malleable during adolescent years (Cunha and Heckman, 2008). Individual's proficiency when performing a particular set of tasks related to her career can also be referred to as professional skills.

experienced between mid-80s and late 90s. To document relevant basic education quality affecting returns between those years we would require test results back from the 70s⁵. Unfortunately these are not available. The oldest PISA evaluation in which Peru participated dates from year 2000 while the oldest national student evaluation which allows assessment in absolute terms was performed in 2001. Results in these evaluations confirm that poor basic education quality has been the norm during the last 10 years and are consistent with the persistently low return exhibited by this educational level during the same period⁶.

It is possible, however, to present indirect evidence of the declining quality of the basic education system between the 70s and early 80s. Starting in the 1970s, and due to demographical pressure, the Peruvian government decided to split full time school schedules in public schools into a morning-shift (from 8 am to 1 pm) for part of the students and an afternoon-shift (from 1 to 6 pm) for the rest of students (Yamada, 2008). This decision allowed a significant increase in enrolment rates, especially in secondary education. Between 1970 and 1980, gross enrolment in secondary education grew from 30% to 60% (Cotlear, 2006). However, it also implied an actual reduction of teaching and learning time by a full third, which materialized through a significant decline in government spending per student. In fact, spending per student fell by 36% between 1975 and 1985, and has only recently recovered its 1970s level. As shown in Figure 3, the reduction in spending per student occurred between 1975 and 1985 was followed by a sharp decline in the return to basic education during the subsequent 15 years (1985-2000).

Accounting for the evolution of higher education quality is a much more difficult task due to the lack of consensus regarding its concept and measurement (see Harvey and Green, 1993). If we recall our definition of quality, our aim should be to account for the evolution of those elements that can influence the contribution that an additional year of higher education has on individuals' professional skills. Also, consistent with the decline in the return to higher education occurring since mid-2000s (see Figure 1) and our main hypothesis, we need to document this evolution starting in the late 90s.

Interestingly, this period coincides with an important shift in terms of incentives for higher education providers. In 1996, using special legislative powers granted by Congress, the Peruvian government passed a law (Legislative Decree 882) to promote private investment in education. This decree allowed private schools and universities to operate under the same rules as a private business. There are no reasons to suspect that private investment, per se, should hinder higher education quality. However, there is a large risk that a profit maximizing initiative will end up overlooking educational outcomes if it is not accompanied by strong regulation. A profit maximizing college faces powerful incentives to maximize enrollment in the short run and keep fixed costs as low as possible. Once fixed costs have been covered, an additional student translates almost entirely into profit.

Throughout the last decade, these incentives have been accompanied by a significant increase in higher education demand (real per capita GDP grew 53% between 2000 and 2010, making financial constraints less binding for higher education access) and the

⁵ Test results refer to the student population while returns to schooling are estimated comparing wages of the entire workforce with different schooling levels. It is reasonable to wait at least a decade for a change in skills in the student population to transpire into a change in mean wages in the labor market.

⁶ In the 2000 PISA evaluation, only 20% of 15 year-old Peruvians passed the reading comprehension test. In the 2001 national evaluation only 18% and 22% of fourth grade students exhibited sufficient communications and mathematical skills, respectively.

absence of quality assurance mechanisms. In fact, Peru lacks as a comprehensive and enforceable evaluation to authorize the creation of new universities and an accreditation system to guarantee continuous monitoring and quality control⁷.

All the above has promoted a surge in the supply of private universities: in the period 1996-2010, the number of private universities grew from 29 to 65 while the participation of this type of institutions in total enrollment raised from 40% to 60%. This growth in private supply has aided in coping with demographic pressure and has allowed an important increase in university higher education enrollment. Private universities created between 1996 and 2010 currently accommodate 134,370 students, which represent 17% of the total university student population. Unfortunately, it has also fueled three results that conspire against university education quality as defined above.

First, it has provoked a decline in selectivity: the average admissions ratio (the number of admitted students divided by the number of applicants) has raised from 0.30 in 1996 to 0.45 in 2009. In a country with poor basic education learning outcomes, this implies a decline in the stock of basic skills of the average college student⁸.

Second, it has implied a shift in the faculty composition towards more part-time lecturers and less full time professors: the participation of full time professors in university education fell from 47% in 1996 to 35% in 2010. Currently, full time professors represent 68% of total faculty in public universities; in private universities this ratio is only 17%. This trend implies a decline in research activity per student and has an effect on the analytical content of courses and lectures.

And, third, it has promoted a career composition that does not necessarily respond to the demands of the labor market but rather to interest in short term profit. It is remarkable that professional underemployment has remained above 30% in the past five years despite Peruvian record-breaking growth figures (see Figure 4)⁹. In fact, new higher education institutions face strong incentives to offer popular programs that do not entail major investments in infrastructure or equipment, with no particular concerns on their potential labor market outcomes. For example, careers related to Economics and Business are currently within the most popular among high school graduates (they account for 27% of total university enrollment). Not surprisingly, 70% of private universities created between

⁷ In Peru, the operation of a new university must be authorized by the Consejo Nacional para la Autorización de Funcionamiento de Universidades (CONAFU) which is part of the National Assembly of Rectors (Asamblea Nacional de Rectores - ANR). Currently, however, more than 40% of private universities operate with a “provisional” authorization (meaning that some of the official requirements are still pending) while many regional subsidiaries operate without any official permit. The National System for the Evaluation, Accreditation and Certification of Education Quality (SINEACE) was created by law in 2006. However, the higher education accreditation process has formally started only a couple of years ago. As for today, accreditation is only mandatory for health and education related careers, no university program has completed the accreditation process, and only 10 universities have started their external evaluation.

⁸ Measures of cognitive ability obtained from the urban working-age population (to be used in the empirical analysis below) reveal that university graduates who attended college before year 2000 have more cognitive ability than those who attended college after this year (the former score, on average, 0.2 standard deviations more than the latter).

⁹ Following Clogg and Shockey (1984), professional underemployment can be estimated considering university graduates who are overeducated according to the schooling standard in their occupation. In particular, university graduates are underemployed if their educational attainment is above the mean schooling in their respective occupation, plus one standard deviation. Estimates using the 2010 ENAHO show that 35% of university graduates between 24 and 45 years of age are currently underemployed. This figure was 29% back in 2004. Between these years, GDP grew at an annual average rate of 7.1%,

1996 and 2009 offer at least one program in this area. At the same time, a third of underemployed professionals have graduated from these careers¹⁰.

3. Ability, education quality, and the returns to schooling

3.1 Ability and increasing returns to education

Card (1994) provides a simple theoretical framework to understand the potential effects of ability on schooling decisions and their implications for the estimation of the effect of schooling on log-wages.

We can assume individual i chooses schooling to maximize utility given by:

$$U(y_i, S_i) = \log(y_i) - f(S_i) \quad (1)$$

Where y_i represents earnings, S_i are years of schooling, and $f(\cdot)$ is a convex cost function. The first order condition satisfied by the optimal number of schooling years (S_i^*) is given by:

$$\frac{\partial \log(y_i)}{\partial S_i} = f'(S_i) \quad (2)$$

Following Card (1994), we can further assume that the marginal return and cost are linear functions of schooling with individual specific intercepts.

$$\begin{aligned} \frac{\partial \log(y_i)}{\partial S_i} &= MR_i(S) = a_i - kS \\ f'(S_i) &= MC_i(S) = r_i + mS \end{aligned} \quad (3)$$

Note that, for each individual, schooling exhibits diminishing marginal returns. The optimal number of schooling years is given by:

$$S_i^* = \frac{a_i - r_i}{(k + m)} \quad (4)$$

According to this simple model, cross sectional variability in schooling choices arises from differences in ability (a_i) and marginal discount rates for schooling (r_i). Differences in discount rates are determined by differences in access to funds and preferences for education.

The log-wage equation implicit in $MR_i(S)$ is given by:

$$\log(y_i) = c + a_i S_i - (k/2) S_i^2$$

¹⁰ Professionals in Business and Economics currently represent 20% of the total number of 24-45 year old university graduates in the workforce. Underemployed professionals graduated from Business and Economics, however, represent 33% of total number of underemployed 24-45 year old university graduates.

An important implication of this is that the data can present us with a convex relation between log-earnings and schooling because the latter is positively correlated with ability and ability also affects the slope of the log-earnings equation. In fact, in a simple Mincerian equation relating log-wages to schooling, our estimate of the marginal effect of schooling would be an estimate for $MR_i(S)$ which, as specified in (3), is positively affected by ability and negatively affected by schooling.

The convexity of the cross-sectional relation between log-wages and schooling will depend on the variance of ability relative to the variance of marginal costs or discount rates¹¹ (Card, 1994). Fixing a_i and shifting the marginal cost (r_i) will produce a concave relation. On the other hand, fixing the marginal cost and shifting ability will produce a convex relation (see Figure 5, panels (A) and (B), respectively).

Increased ability accompanied by increased returns to education is one of the possible explanations invoked in the first section to account for the “convexification” of the wage profile. More able people choose more schooling, so more schooling is accompanied by a larger return in the data: the return observed for higher education corresponds to the return to schooling for more able people which is larger. This story is consistent with the equilibrium outcomes shown in panel (B) of Figure 5.

The above analysis, however, ignores potential correlation between a_i and r_i . There are several reasons to suspect a negative correlation between ability and marginal costs. More educated parents lead richer families and have stronger preferences for education (which lowers r_i) while having higher ability (and this raises a_i to the extent in which ability is inherited or influenced by family background). Psychic costs of education (related to the marginal disutility of schooling) are also smaller for more able individuals.

Nordin and Rooth (2008) exploit the implications of this negative correlation between ability and costs to explain why returns to schooling are increasing by ability in Sweden but not in the US. They argue that the Swedish higher education system is heavily subsidized and exhibits weak credit constraints. This lowers the correlation between a_i and r_i : it is no longer true that schooling costs are particularly large for less affluent families and, thus, for less able individuals. This setting is consistent with a convex wage profile and, in a regression of log-earnings on schooling interacted with ability, returns should be larger for high ability groups.

Nordin and Rooth (2008) find this type of evidence using Swedish data. They fail, however, to find a similar pattern for the US and claim this is due to stronger credit constraints and more rigorous selection process for higher education leading to stronger correlation between ability and marginal costs of schooling. Panel (C) of Figure 2 depicts this type of result: if correlation between ability and costs is large, raising ability will not necessarily imply increasing returns. These equilibrium outcomes are not consistent with a convex wage profile.

3.2 Education quality and increasing returns to education

¹¹ Interaction (and compensation) of both effects is what would be behind the linear relationship usually documented using US data (Card, 1994).

The notion of education “quality” has not been directly addressed in the literature as an explanation for observed increasing higher education wage premium or the “convexification”¹² of the wage profile¹³. As discussed in Card and Krueger (1996), more school quality should lead to a larger marginal return for each additional year of schooling. Changes in quality at different educational levels, thus, should provoke changes in the wage profile and could be in part responsible of its “convexification”.

This explanation can be classified within the second driver discussed in the first section and could be regarded as a “supply-side” effect. It has to do with the characteristics of the labor force, not with its number or composition by age, experience or ability, but with its composition according to the productivity shift provided by the educational level attended.

In the absence of demand-side shocks such as SBTC¹⁴ and with a constant supply of labor, a decline in the quality of education at a particular level (which comprises a certain number of schooling years) will reduce the proficiency gain offered by that level when performing certain tasks priced in the labor market. Note that in a general equilibrium setting, this type of shock is different from a SBTC in that there are no changes in the production function of goods (as in SBTC) but in the production function of human capital¹⁵. The final effect, however, can be equivalent. A smaller contribution to output of an additional unit of human capital (for a completed educational level) or a smaller contribution to human capital of an additional year of schooling (within the same educational level), both should reduce the wage increase related to an additional year of schooling within that same educational level.

We can use the simple model proposed in Card and Krueger (1996) to formalize the role of education quality on schooling decisions and further explore its implications for the empirical relation between log-wages and schooling. We can start with the same basic formulation summarized in equations (1) and (2) above, but will change the specification for the marginal return to schooling to allow for a specific role for quality. For this, assume that log-earnings for individual i attending schooling system s are determined by:

$$\log(y_{is}) = a_i + b_s S_{is} + u_{is} \tag{5}$$

Note that ability a_i now affects the intercept of the earnings function while “school quality” is expressed in b_s ; i.e. the marginal productivity offered by schooling system s . This linear specification for log-wages with no person-specific components in its slope

¹² Notice that the “convexification” of the wage profile is not the same as an increasing higher education wage premium. The latter implies “convexification” but the opposite is not true. “Convexification” can also be caused by a decline in the return to basic education.

¹³ Binelli (2008) invokes poor basic education quality as a potential reason to explain why relaxation of credit constraints were not enough to allow increased supply at the intermediate level to translate into a proportional increase at higher education (thus preventing a decline in wages for higher education and leading to the “convexification” of the wage profile). Poor basic education quality, however, was not acknowledged as a direct cause of the “convexification”.

¹⁴ SBTC can be modeled as a permanent increase in the contribution of skilled labor in the composition of human capital. An increase in this contribution can be interpreted as an increase in the productivity or in the demand for skilled labor (Binelly, 2008).

¹⁵ It is not that an additional unit of a certain form of human capital (say, unskilled) now increases output in a smaller amount (as in SBTC). It is that an additional unit of time devoted by the household in human capital accumulation increases human capital in a smaller amount.

implies a constant marginal return to education which depends solely on the education system attended: $MR_S = b_S$. If we retain the same specification for the marginal cost of schooling as in (3), the first order condition for the optimal number of schooling years implies that:

$$S_{is}^* = \frac{b_S - r_i}{m} \quad (6)$$

Note that all cross sectional variation within the same educational system is given by differences in schooling costs. This model has two important implications for the possibility of observing a convex wage profile. First, the data will present us a convex wage profile if quality is increasing with schooling. The second implication has to do with the effect of quality on earnings conditional on schooling. In particular, with the fact that more school quality does not necessarily imply higher earnings for low levels of education.

Let us briefly develop this last point following the analysis of Card and Krueger (1996) since it heavily depends on the very same fact that prevents the framework developed in the previous section from delivering a convex wage profile: negative correlation between ability and schooling costs. Denote the theoretical regression coefficient of ability on discount rates as $\rho_{ar} = \frac{Cov(a_i, r_i)}{Var(r_i)}$. Using the expression for the marginal cost of schooling given in (3) and the first order condition for the optimal number of schooling years, we can express the conditional expectation of ability given observed schooling and quality as:

$$\begin{aligned} E(a_i | S_{is}, b_S) &= \alpha + \rho_{ar}(r_i) \\ &= \alpha + \rho_{ar}(b_S - mS_{is}) \end{aligned} \quad (7)$$

Expected ability within the same educational system and for a given number of schooling years is clearly decreasing in quality if $\rho_{ar} < 0$. Reasons to suspect a negative correlation between ability and schooling costs have already been discussed in the previous section. To see the implications for the wage schedule, consider that the population regression function that relates log-wages to schooling can be expressed as:

$$\begin{aligned} E\{\log(y_{is}) | S_{is}, b_S\} &= E(a_i | S_{is}, b_S) + b_S S_{is} \\ &= \alpha + \rho_{ar} b_S + (b_S - m\rho_{ar}) S_{is} \end{aligned} \quad (8)$$

Clearly, if $\rho_{ar} < 0$, an increase in quality (b_S) raises the slope and lowers the intercept of the wage schedule, so that more quality does not necessarily imply higher earnings (see Figure 3).

4. Increasing ability or declining quality?: empirical results for Peru

From the discussion above is clear we have two competing explanations for the potential composition effects that are behind the ‘‘convexification’’ of the wage profile. The first composition effect has to do with ability: increasing ability raises the return to education and the optimal number of schooling years. The equilibrium outcomes observed in the

data, thus, correspond to larger returns for the more educated. As discussed above, however, this explanation requires weak correlation between ability and schooling costs.

Another explanation has to do with quality. If the higher education system exhibits (on average) more quality than the basic education system, the wage profile related to higher education should have a more pronounced slope. In addition, endogenous schooling decisions would imply that equilibrium outcomes observed in the data are consistent with a lower intercept for the higher education wage schedule. As opposed to the ability composition effect, this result requires a strong negative correlation between ability and schooling costs.

The importance of family income, ability, and family background for higher education access in Peru (Castro, *et al.*, 2011), suggests a strong negative correlation between ability and schooling costs. If credit and skill constraints are in place for higher education enrolment, it is clear that schooling costs are larger for less able individuals¹⁶. This implies that, at least theoretically, increasing ability accompanying more schooling does not appear as a convincing explanation for a convex wage profile. Increasing education quality accompanying more schooling years, however, still holds as a possible explanation.

In what follows we present empirical evidence in support of the above. For this, we use the results from a novel survey developed specifically to explore the relationship between labor outcomes, education and skills in Peru (ENHAB 2010). This data comes from a random sample of the working-age (14-50) urban population. The survey includes a battery of tests specially designed to measure cognitive skills and non-cognitive skills or personality traits. On the cognitive side, the survey includes the Peabody Picture Vocabulary Test, and tests of verbal fluency, working memory, and numeracy/problem-solving. All four measures were aggregated into a single measure of “cognitive skill” (Cueto, *et al.*, 2010).

Results shown in column (A) of Table 1 correspond to a simple model to account for a convex wage profile. The regression takes the form:

$$\log(y_i) = \alpha_0 + \beta S_i + \gamma S_i D_i + \delta D_i + x_i' \theta + u_i \quad (9)$$

Where S_i are individual i schooling years and D_i is an indicator variable reflecting if the individual attended higher education. Return to basic education (the percent wage increase for each additional schooling year) is given by β while higher education return is given by $\beta + \gamma$. Additionally, we allow for an intercept shift in the higher education wage profile given by δ . Note that if $\gamma > 0$ and $\delta < 0$, basic and higher education wage profiles will be consistent with the low and high quality wage schedules depicted in Figure 3, respectively.

Before describing the rest of the empirical specifications used for Table 1, it is worth noticing that (9) corresponds to the unrestricted version of:

$$\log(y_i) = \alpha_0 + \beta_1 S_{Bi} + \beta_2 S_{Hi} + x_i' \theta + u_i \quad (10)$$

¹⁶ Even if only credit constraints were binding, the negative correlation between schooling costs and ability would still hold to the extent in which less affluent families face larger credit constraints and, at the same time, are unable to provide adequate environments (both at home and at school) for the formation of basic skills.

Where S_{Bi} and S_{Hi} are the number of schooling years in basic and higher education of individual i , respectively. In this specification, β_1 will capture the return to basic education while β_2 the return to higher education. Note, in addition, that $S_i = S_{Bi} + S_{Hi}$ and that the maximum number of schooling years in basic education in Peru is 11. Therefore, if the individual has attended higher education ($D_i = 1$), $S_{Hi} = S_i - 11$ and $S_{Bi} = 11$. If she has not attended higher education ($D_i = 0$), then $S_{Hi} = 0$ and $S_{Bi} = S_i$. This implies that (10) can be rewritten as:

$$\begin{aligned} \log(y_i) &= \alpha_0 + \beta_1(S_i(1 - D_i) + 11D_i) + \beta_2D_i(S_i - 11) + x_i'\theta + u_i \\ &= \alpha_0 + \beta_1S_i + (\beta_2 - \beta_1)S_iD_i + (\beta_1 - \beta_2)11D_i + x_i'\theta + u_i \end{aligned} \quad (11)$$

This is a restricted version of (9) where we have imposed $\delta = -11\gamma$. In terms of Figure 3, this restriction is related to the number of schooling years for which the high and low quality wage schedules cross. Regressing (9) implies allowing the data to indicate this crossing point. Thus, if we cannot reject the restriction $\delta = -11\gamma$ in (9) it would mean that the return shift occurs in year 11 which is, precisely, the number of years it takes to complete basic education.

Column (B) in Table 1 shows the results of a regression of log-wages on schooling interacted with ability. The potential effect of ability on the return to schooling is captured with four dummy variables that indicate the individual's ability group (A_{ji} for $j = 1, \dots, 4$). According to (12) below, the return to schooling for an individual belonging to ability group j is given by β_j ¹⁷. Ability groups were built using cognitive tests score quartiles from the ENHAB distribution.

$$\log(y_i) = \alpha_0 + \sum_{j=1}^4 \beta_j A_{ji} S_i + \sum_{j=2}^4 \alpha_j A_{ji} + x_i'\theta + \varepsilon_i \quad (12)$$

For column (C) we extend (12) to include schooling and variables $S_i D_i$ and D_i used in (9)¹⁸. It is a mixed model that allows for increasing returns by ability and by schooling.

In column (D), we drop the interactions between ability and schooling and allow ability to affect only the intercept of log-wages. Finally, columns (E) and (F) show results for the basic model given in (9) using the subsample of individuals who attended basic education in the capital city (Lima) and outside Lima, respectively.

Several results are worth highlighting from Table 1. First, column (A) confirms that returns to higher education are significantly larger than returns for basic education (around 9 percentage points larger)¹⁹. In addition, the projection of the higher education wage profile

¹⁷ This specification is similar to that used in Nordin and Rooth (2008) to evaluate the hypothesis of increasing returns to schooling by ability.

¹⁸ Note that we need to drop one of the interactions with the ability group.

¹⁹ These results are consistent with returns estimated using the ENAHO 2010 survey shown in Figure 1. In Appendix 1 we present results for this same specification using data from the 1991 ENNIV (*Encuesta Nacional de Niveles de Vida*) and the 2004 and 2010 ENAHOs. We also simulate the average wage schedule for each year using coefficient estimates obtained for schooling years (S_i), schooling years if attended higher education ($S_i D_i$), and the higher education indicator variable (D_i). Consistent with a decline in basic education quality, "convexification" occurred between 1991 and 2000 was in part driven by a decline in the slope of the basic education wage schedule, accompanied by a lower intercept for the higher education schedule. "Deconvexification" occurred between 2004 and 2010, on the other hand, occurred through a decline in the

has a lower intercept and it is not possible to reject that $-11\gamma = \delta$. This implies that the basic and higher education wage schedules are consistent with Figure 3, with a cross-over point equal to the number of schooling years in basic education.

Second, results presented in column (B) do not show evidence of increasing returns by ability across the entire ability distribution. While it is true that moving from the first to the third skill quartile raises the return to schooling around 9 percentage points, shifting from the third to the upper quartile implies even a slight decline. Consistent with strong correlation between ability and marginal costs of education, moving up from the first to the third quartile of the cognitive skill distribution involves a significant increase in average schooling. Moving from ability group 1 to ability group 3 implies raising higher education access from 8% to nearly 45%. This ability boost captures a shift from basic to higher education and, thus, the return increase is similar to that shown in column (A) for variable $S_i D_i$. This is not at odds with our hypothesis: the return boost we observe in column (B) can be due to a quality shift and not an ability shift. The fact that moving up from ability group 3 to 4 does not imply an increase in the return to schooling contributes to this explanation. In fact, once the quality threshold has been crossed, additional ability will still imply more schooling²⁰ but not larger returns.

What happens if we control for the educational level attended? This involves introducing variables $S_i D_i$ and D_i back into the regression. When doing so, all ability group variables lose significance (see column (C)). If we compare results in column (A) and (C), we will note that the higher education indicator variable is robust to the possibility of increasing returns by ability: the return to higher education is larger but this is not because the return for more able people is larger²¹.

According to the model with heterogeneous education quality described in section 3.2, ability should have a role when explaining log-wages. Holding quality constant, more ability should induce more schooling because skill is correlated with lower schooling costs. Holding quality and schooling constant, more ability should imply larger salaries. This last effect is captured in column (D): belonging to the upper quartile of the skill distribution implies almost a 22% increase in hourly wages.

Finally, results shown in columns (E) and (F) are also revealing. First, one should consider that there is a significant learning outcome gap in favor of schools in Lima vs. schools in the rest of the urban domain²². In column (E) we identify schooling returns for those individuals who attended basic education in Lima with the objective of isolating a high quality system within basic education. If this mitigates the convexity of the wage profile, it would provide additional evidence suggesting that quality has a role explaining this

slope and an increase in the intercept of the higher education wage schedule. Both are consistent with a decline in the quality of higher education.

²⁰ Moving up from the third to the upper quartile of the skill distribution further increases higher education access in 30 percentage points.

²¹ In Appendix 2 we provide results using the distribution of scores obtained for a non-cognitive skill related to individuals' perseverance or grit (Duckworth, *et al.*, 2007). As in column (C) from Table 1, the existence of larger returns to schooling for those who attended higher education is robust to the inclusion of ability group indicators. There is, however, evidence that grit affects the return to schooling. This is not at odds with our analytical discussion. Results provided in Castro, *et al.* (2011) show that grit has a smaller effect than cognitive ability on higher education access, while evidence discussed in this study suggest a weak correlation between grit and the marginal cost of schooling.

²² The difference in learning outcomes for both mathematics and communication skills between schools in Lima and the rest of the urban domain is now around 0.5 standard deviations. If the gap was different in the past decades, larger economic centralism only points towards an even bigger difference.

phenomenon. Results show that variables $S_i D_i$ and D_i lose significance for the subsample of individuals who attended basic education in the capital city (see column E). Also, the convexity of the wage profile is much more pronounced within the low quality basic education system (see column (F) for outside Lima).

5. Summary and concluding remarks

This paper has explored two possible explanations for the convexity of the average wage profile with respect to schooling observed in Peruvian data. The first is a composition effect driven by differences individual ability: we observe increasing returns to education because larger ability implies larger returns and more able people choose more schooling. The second explanation involves heterogeneous education quality: returns to higher education are larger because this system exhibits more quality than basic education.

We have defined quality as an attribute of the education system that affects the increase in human capital offered by an additional schooling year within the system. To motivate its role when explaining the convexity of the wage profile, we have documented trends on several indicators that can be directly or indirectly related to the outcomes of basic and higher education. These trends suggest that: (i) education quality in basic education is currently very poor; (ii) decline in basic education quality can be traced back to the 1970s; and (iii) education quality in higher education has deteriorated in the last 10 years. If we relate schooling returns to education quality, this evidence appears consistent with the “convexification” of the wage profile observed since mid 80s and throughout the 90s, and the “deconvexification” verified since the second half of the 2000s.

To formalize our discussion, we have revisited the models developed in Card (1994) and Card and Krueger (1996). These models explain how endogenous schooling decisions can affect the observed relationship between schooling and wages under increasing returns by individual ability and education quality, respectively. An important difference between both models is that the first will deliver a convex relationship between log-wages and schooling if the correlation between individual ability and the marginal cost of schooling is low. The second model, on the other hand, predicts a larger slope and a lower intercept for a high quality education system under a strong negative correlation between skill and schooling costs. This prediction is consistent with a convex average wage schedule if we postulate that the high quality system corresponds to higher education.

The significance of credit constraints, skill and family background for higher education access in Peru implies a strong negative correlation between ability and schooling costs. Thus, at least theoretically, this advocates for heterogeneous education quality when explaining the convexity of the wage profile.

We have tested the implications of both models using data from a novel survey that includes measures of cognitive ability for the urban working-age population. After controlling for the educational level attended, we found no evidence of increasing returns by ability. Instead, we found a wage schedule for higher education which robustly conforms to the predictions of the model with heterogeneous education quality. Finally, we tried to isolate a high quality education system within basic education using data from individuals who attended this educational level in the capital city. Homogenizing education quality should mitigate the convexity of the wage profile if education quality has

a role when explaining this phenomenon. Consistent with this, we could not find evidence of a convex wage profile using the proposed subsample of individuals.

The exploration and results summarized above provide both analytical and empirical evidence that point towards the fact that the Peruvian convex wage schedule is the result of two superimposed wage profiles: one corresponding to a low quality basic education system and, the other, to a higher education system with better quality. Declining education quality at basic and higher education, thus, appear to have a role when explaining the “convexification” and recent “deconvexification” of the wage profile, respectively.

An important implication of these findings is related to role that wage dynamics are currently playing in the reduction of income inequality in Peru. The Gini coefficient measured using household income has decreased nearly 9% during the second half of the 2000s. While a rigorous decomposition of this reduction is pending, labor income has surely played a role. Consistent with the “deconvexification” of the wage profile documented here, during this same period, real wages for skilled labor have raised significantly less than wages for unskilled labor (12% vs. 25%, respectively). This contributes to the reduction of the income gap between rich and poor families which, in principle, could be regarded as desirable. Our enthusiasm about this result, however, should be tamed if we learn that it is in part due to a reduction in the quality of higher education, especially if we suspect that this can have a negative effect on long term growth.

Additional enquiry on the implications of the decline in education quality is beyond the scope of this paper and makes a good candidate for further research. Another potential topic has to do with the role of non-cognitive skills. We have presented and discussed preliminary evidence regarding their effect on the return to schooling and hope to motivate additional exploration on the matter.

6. References

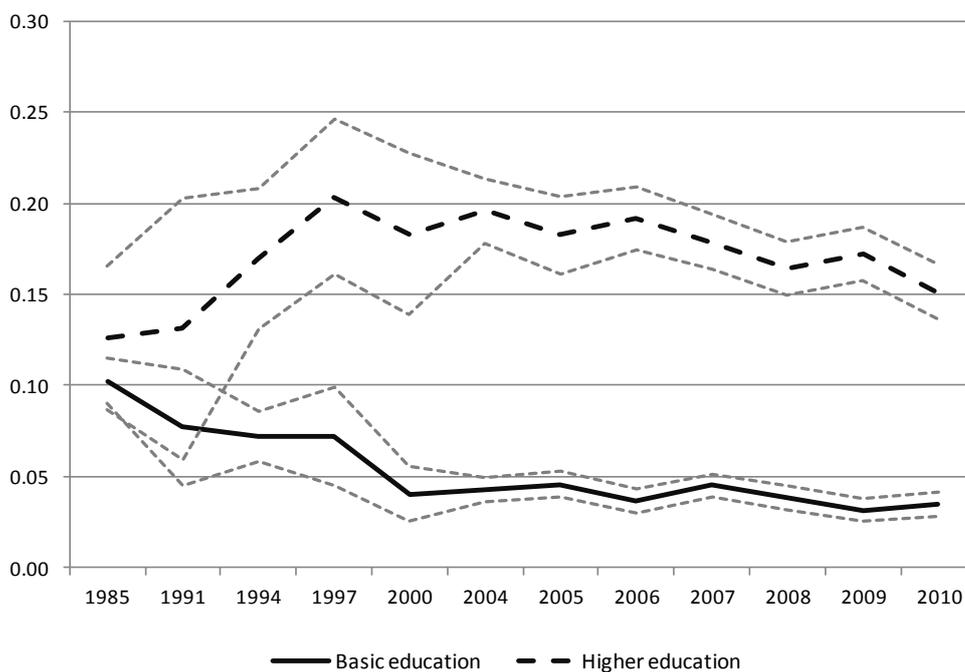
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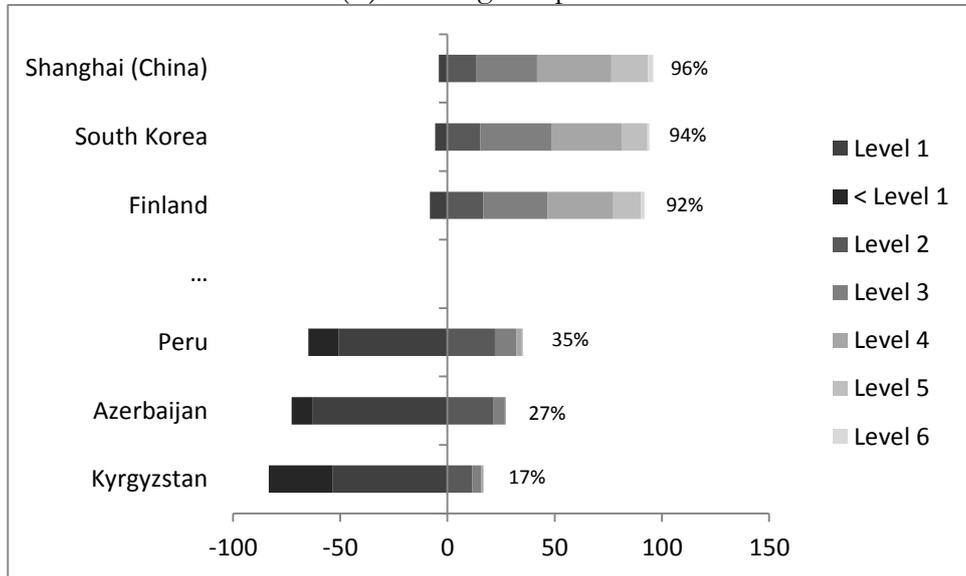
Figure 1
Returns to basic and higher education in Peru /1



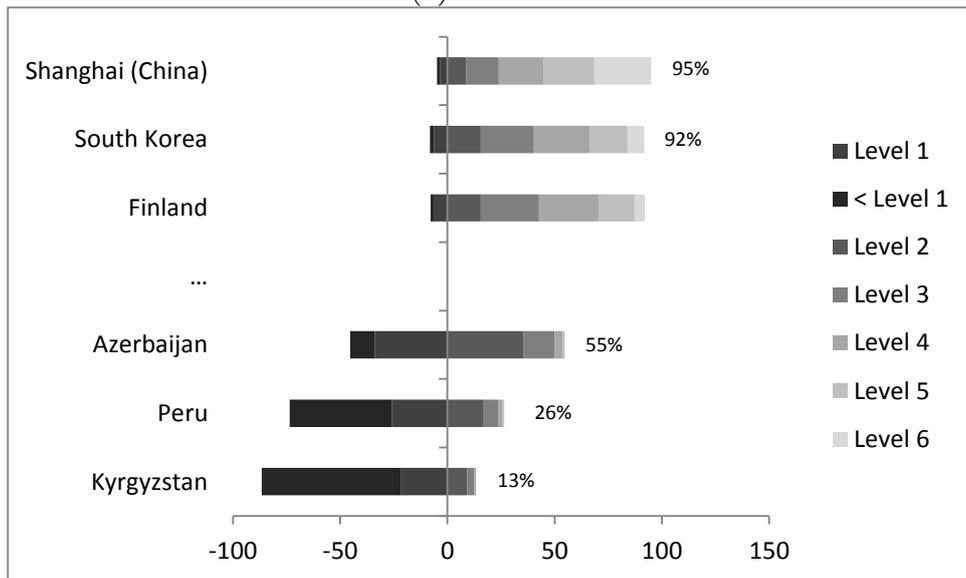
/1 Returns correspond to OLS coefficient in a regression of log-hourly wages on schooling years. Returns to higher education were differentiated with a dummy variable indicating if schooling years correspond to higher education (> 11). All regressions control for experience and its square, sex and capital city. Dotted lines indicate 95% confidence interval. Databases used were ENNIV surveys for 1985-1997 period and ENAHO surveys for 2000-2010 period.

Figure 2
2009 PISA evaluation results
 (% of total population in each level)

(A) Reading comprehension

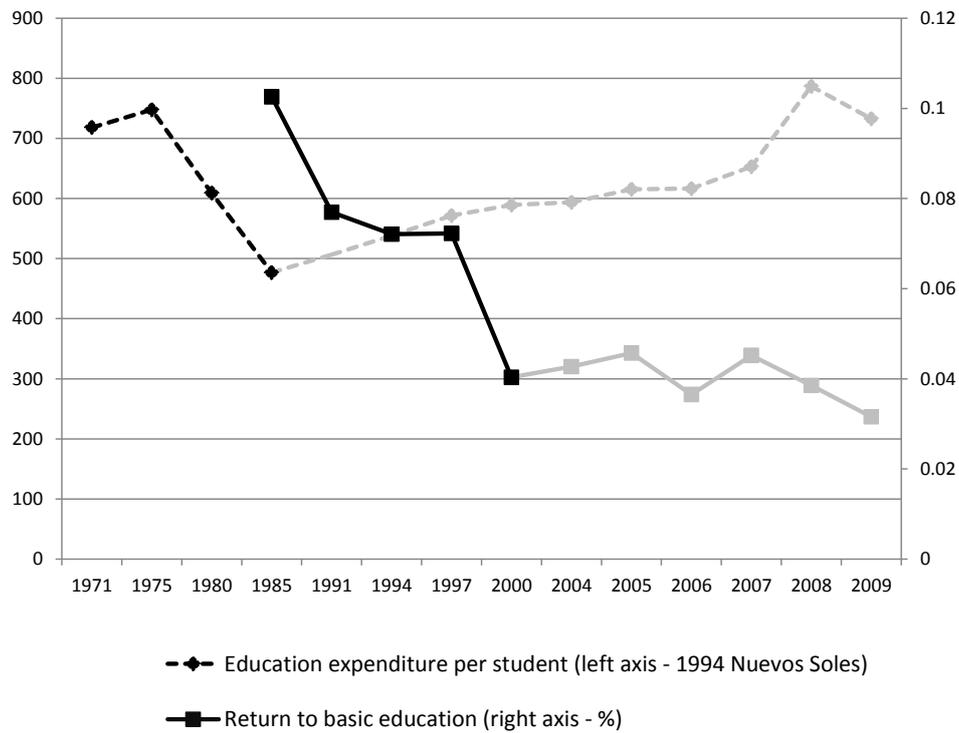


(B) Mathematics



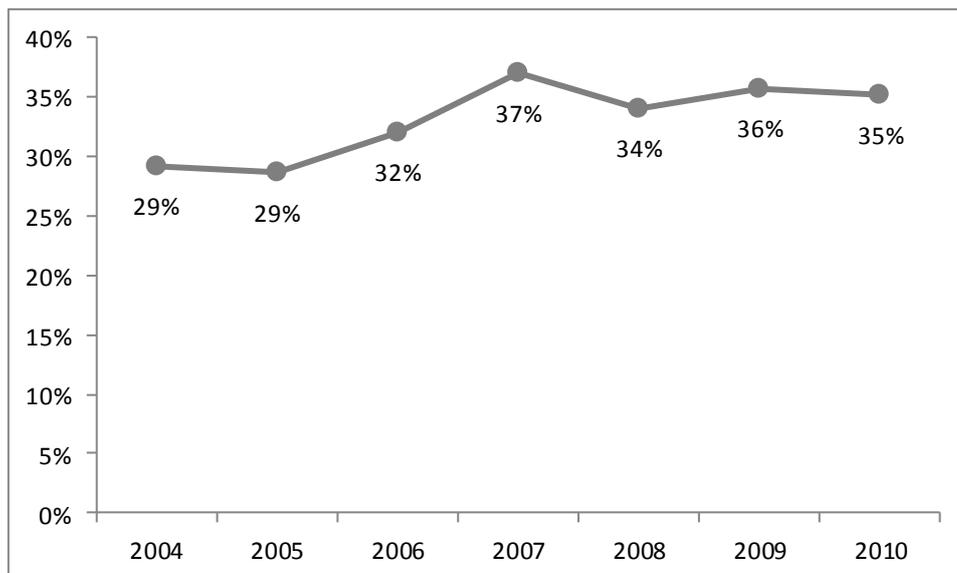
Source: OECD PISA 2009 database.

Figure 3
Public expenditure per-student in basic education
and the return to basic education



Source: UNESCO and calculations presented in Figure 1.

Figure 4
Underemployed university graduates
 (% underemployed among 24-45 year old university graduates in the workforce)



Source: Own calculations based on Clogg and Shockey (1984). University graduates are underemployed if their educational attainment is above the mean schooling in their respective occupation, plus one standard deviation.

Figure 5
Possible equilibrium outcomes for different marginal costs and marginal rate of return to schooling

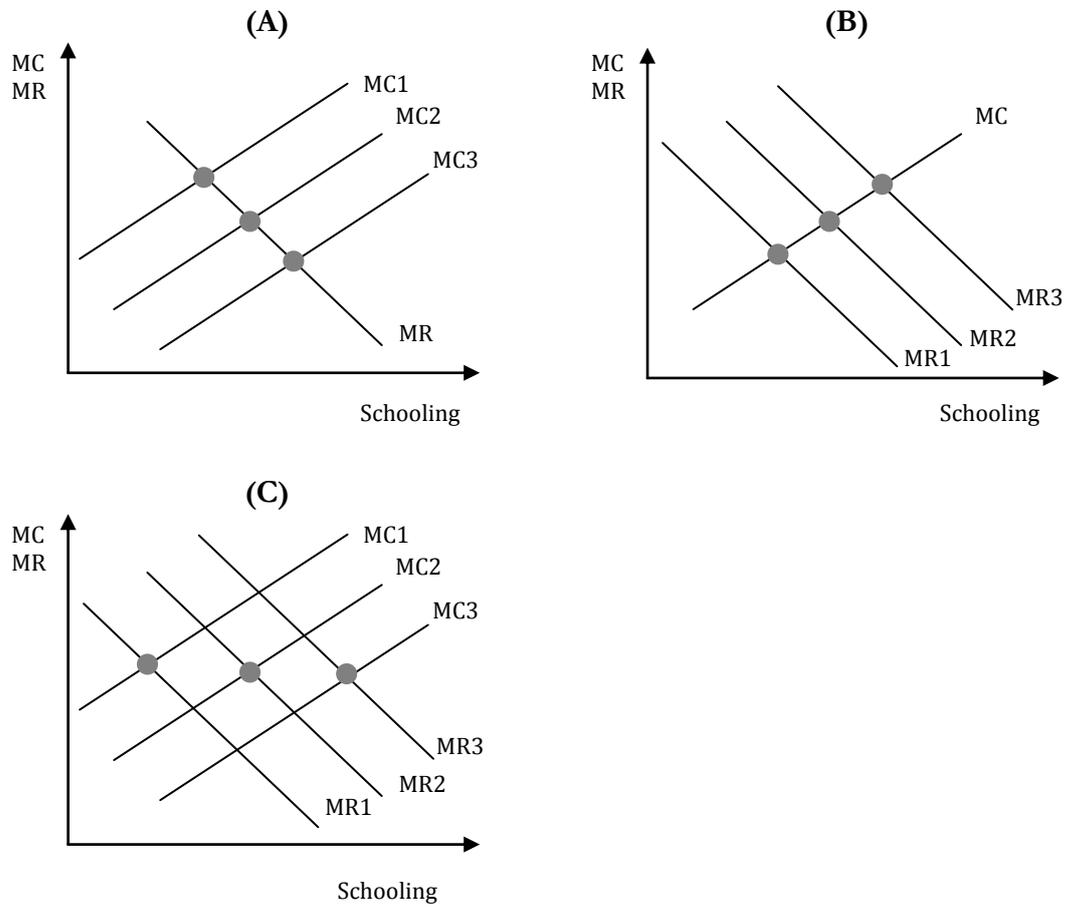


Figure 6
Effects of raising quality on the wage schedule

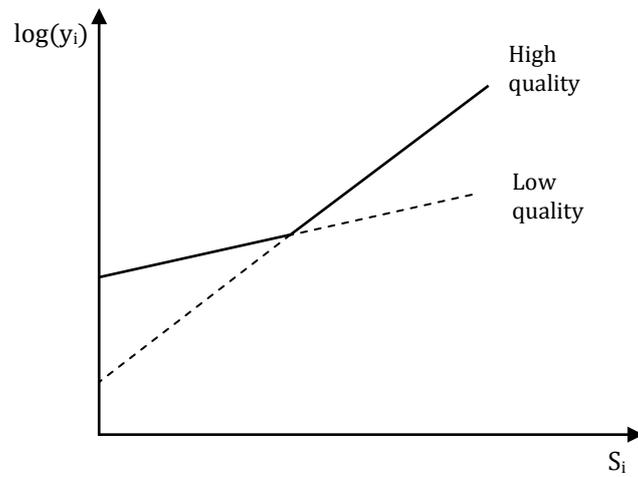


Table 1

	(A)	(B)	(C)	(D)	(E)	(F)
Schooling (S_i)	0.037*	-	0.021	0.029	0.062***	0.033***
Schooling if higher education ($S_i D_i$)	0.090**	-	0.085*	0.091**	0.078	0.144***
Higher education (D_i)	-0.916*	-	-0.974*	-0.998**	-0.857	-1.669***
Schooling if ability group 1 ($A_{1i} S_i$)	-	0.031	-	-	-	-
Schooling if ability group 2 ($A_{2i} S_i$)	-	0.078**	0.018	-	-	-
Schooling if ability group 3 ($A_{3i} S_i$)	-	0.128***	0.051	-	-	-
Schooling if ability group 4 ($A_{4i} S_i$)	-	0.090**	-0.006	-	-	-
Ability group 2 (A_{2i})	-	-0.472	-0.180	-0.010	-	-
Ability group 3 (A_{3i})	-	-0.919**	-0.437	0.132	-	-
Ability group 4 (A_{4i})	-	-0.377	0.369	0.197*	-	-
Constant	0.428**	0.506**	0.576**	0.492**	0.580**	0.379***
Wald test $H_0: -11\gamma = \delta$ (p-value)	(0.518)	-	(0.729)	(0.974)	(0.968)	(0.244)
Number of obs.	1,165	1,165	1,165	1,165	594	3,160
R-squared	0.158	0.164	0.168	0.165	0.158	0.181

Significant at: 1% (***), 5% (**), 10% (*), 15% (°)

All regressions control for experience, experience², first language, and Lima (capital city).

Ability groups were built using the quartiles of the cognitive skill distribution.

Regressions in columns (A) - (D) use data of the random subsample of individuals who answered cognitive tests. Regressions in columns (E) and (F) use the subsample of individuals who attended basic education in Lima and outside Lima, respectively.

Appendix 1

Estimated returns to basic and higher education /1

	1991	2004	2010
Schooling (S_i)	0.077** [0.045, 0.109]	0.040** [0.036, 0.049]	0.035** [0.028, 0.041]
Schooling if higher education ($S_i D_i$)	0.054 [-0.017, 0.126]	0.153** [0.138, 0.171]	0.117** [0.102, 0.132]
Higher education (D_i)	-0.694 [-1.719, 0.331]	-1.877** [-2.121, -1.632]	-1.370** [-1.573, -1.166]
Constant	-0.540**	-0.138**	0.176**
Number of obs.	2,737	19,713	23,749
R-squared	0.07	0.24	0.19

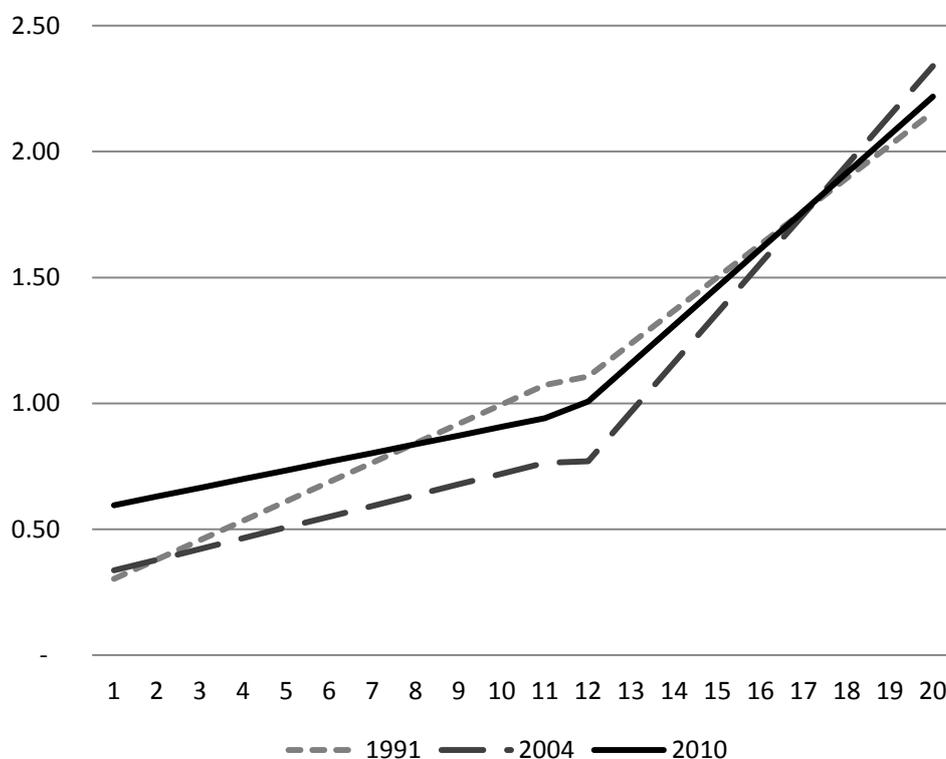
Significant at: 5% (**).

Brackets show 95% confidence interval.

/ 1 All regressions control for experience, experience², first language, and Lima (capital city).

Databases used were the ENNIV survey for 1991 and the ENAHO surveys for 2004 and 2010.

Simulated wage schedules (log of hourly wages) /1



/1 Using 1991, 2004 and 2010 coefficient estimates reported above.

Appendix 2

In columns (B), (C) and (D), ability groups correspond to the quartiles of the grit (perseverance) distribution. Columns (A), (E), and (F) are identical to those in Table 1 in the main text.

	(A)	(B)	(C)	(D)	(E)	(F)
Schooling (S_i)	0.037*	-	0.028	0.036*	0.062***	0.033***
Schooling if higher education ($S_i D_i$)	0.090**	-	0.073*	0.090**	0.078	0.144***
Higher education (D_i)	-0.916*	-	-0.764	-0.947**	-0.857	-1.669***
Schooling if grit group 1 ($A_{1i} S_i$)	-	0.063***	-	-	-	-
Schooling if grit group 2 ($A_{2i} S_i$)	-	0.051	-0.019	-	-	-
Schooling if grit group 3 ($A_{3i} S_i$)	-	0.118***	0.040	-	-	-
Schooling if grit group 4 ($A_{4i} S_i$)	-	0.131***	0.050**	-	-	-
Grit group 2 (A_{2i})	-	0.220	0.286	0.067	-	-
Grit group 3 (A_{3i})	-	-0.494	-0.343	0.105	-	-
Grit group 4 (A_{4i})	-	-0.653**	-0.452	0.130	-	-
Constant	0.428**	0.198	0.468*	0.364*	0.580**	0.379***

Wald test $H_0: -11\gamma = \delta$ (p-value)	(0.518)	-	(0.684)	(0.678)	(0.968)	(0.244)
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Number of obs.	1,165	1,165	1,165	1,165	594	3,160
R-squared	0.158	0.161	0.170	0.161	0.158	0.181

Significant at: 1% (***), 5% (**), 10% (*), 15% (°)

All regressions control for experience, experience², first language, and Lima (capital city).

Ability groups were built using the quartiles of the grit distribution.

Regressions in columns (A) - (D) use data of the random subsample of individuals that answered cognitive tests. Regressions in columns (E) and (F) use the subsample of individuals who attended basic education in Lima and outside Lima, respectively.