PERUVIAN ECONOMIC ASSOCIATION

Economic Growth and Wage Stagnation in Peru: 1998-2012

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Abstract

In the last two decades, the Peruvian economy exhibited rapid growth. Moreover, the composition of the labor force improved in terms of education and experience, two variables which are typically associated to higher human capital. The average worker in 2012 had a higher level of education and was one and a half years older than in 1998, reflecting the impact of the demographic transition. However, the average real wage was roughly constant. We show that a decline in the wage premium for education, and to a minor extent for experience, is responsible for the lack of growth in the average real wage. Had these two premia remained constant throughout the period of analysis, average labor earnings would have increased by about 2.6 percent per year, of which 0.7 percentage points are accounted for the changes in the composition of the labor force in terms of age and education. We explore the role of the relative supply of workers with different levels of human capital as an explanation for the decline in the wage premium for education. Finally, we analyze the implications of these findings for some macroeconomic variables, as earnings and wage inequality, the labor share and total factor productivity.

1 Introduction

In the last two decades, the Peruvian economy exhibited rapid growth. We focus on the period 1998-2012, in which aggregate labor productivity (measured as GDP per worker) grew at an annual rate of 2.5 percent. Moreover, in this period the labor force became more experienced and better educated, responding to demographic trends and partly to increases in the coverage of public education. The average worker in 2012 had completed a higher level of schooling and was one and a half years older than in 1998. These two trends are typically associated to increases in the average level of human capital.

However, in the same period real labor earnings per worker and the average real hourly wage remained basically constant. We document this fact using the main Peruvian household survey (ENAHO). If anything, we observe a modest growth in the average wage of 0.2 percent per year between 1998 and 2012 (or 0.6 percent between 2002 and 2012), well below the rate of growth of labor productivity. Average labor earnings actually decreased at an annual rate of -0.12 percent.[1]

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[1] See World Bank (2010) for a detailed analysis of the Peruvian labor market in this period, which is consistent with our own evidence.

This evidence leads to an obvious question: "Why does the average real wage in Peru remained stagnant in a period in which the composition of the labor force both in terms of age and education has improved and labor productivity has increased?". In this paper, we attempt to provide an explanation based on a careful analysis of the data of wages at a disaggregated level. Our analysis is mostly descriptive and to a large extent we let the data speak for itself. Still, issues of aggregation are considered in the context of an economic model, albeit a simple one.

The starting point of our investigation is the observation that there is substantial heterogeneity across age groups and educational levels in terms of the evolution of labor earnings and wages. Young and uneducated workers have experienced substantial earnings growth, while workers in the age and education categories which grew more during these years (35-44 age group, secondary and higher/non college education categories) featured either no wage growth or significant real wage losses. Therefore, the *wage premia* for education and experience decreased significantly during the period.

To assess the impact of changes in these two premia on the average wage we postulate a simple production function in which aggregate output is produced using physical and human capital. The key assumption is that the human capital of workers of different age and education are perfect substitutes. The mapping between the individual levels of human capital and the observed relative wages is derived assuming profit-maximizing firms and perfect competition in the labor market. In this setup, we show using a simple decomposition that average labor earnings and the average wage would have increased by about 2.6 percent per year had these two premia remained constant. This is roughly the rate of growth of average labor productivity; in this sense, the decline in the wage premium for education, and to a minor extent for experience, accounts for the lack of growth in average labor earnings and the average real wage.

According to our decomposition, changes the composition of the labor force in terms of age and education accounts for 0.7 percentage points of the rate of growth of the average labor earnings. The direct impact of improvements in education and the demographic trends on wages are then positive and significant. However, this impact is more than offset by the changes in the market return for these levels of experience and education whose relative supply grew more in the period. The second question that we ask in the paper is whether there is a connection between the increase in the relative supply of educated workers and the decline in the educational wage premium.

For this, we perform an alternative decomposition assuming imperfect substitutability between the human capital of workers with different levels of human capital. In this alternative setup, relative wages respond endogenously to changes in the relative supply of educated workers. Our quantitative analysis show that the observed changes the composition of the labor force in terms of education account now for a 2 percent *decrease* in the average wage, keeping the relative levels of human capital constant. Hence, a case can be made for the increase in the supply of educated workers been responsible for a large fraction of the decline in the wage premium and the gap between the growth of the average wage and the growth of aggregate labor productivity in Peru.

These findings have important implications for some macroeconomic variables, as the labor share, inequality, and total factor productivity. We show how the stagnation of the real wage in Peru is associated to a decline in the aggregate labor share of income. Also, we link the decline in the educational wage premium in Peru to an important reduction in earnings and wage inequality. Finally, we explore the impact on the growth of measured TFP (or the Solow residual) of the changes in the return to age and education. We illustrate how growth accounting exercises that consider only the changes in educational attainment (not on the wage premia) as a measure of human capital accumulation would grossly underestimate the contribution of TFP to economic growth in Peru.

Our paper contributes to a recent empirical literature focusing on the evolution of the returns to education and inequality in Latin America during the last two decades. Aedo and Walker (2012) show that in most Latin American countries the returns to schooling have decreased, reducing earnings and income inequality. Interestingly, the authors compare the experience of Latin America to the one in East Asian countries, where the increase in the coverage of education is not accompanied by a decline in the returns to education. In their view, the decline in the returns to schooling is the result of a mistmatch between the increase in the relative supply of skilled workers and the decrease in their relative demand.[2] Lustig et al. (2013) also show a decline in the returns to education for Argentina, Brazil and Mexico, relate this decline to the mistmach between supply and demand of educated workers, and analyze its impact on income inequality. None of these studies analyze the aggregate implications of these labor market developments for the average wage, the labor share, and measured total factor productivity.[3]

There is also an rich literature on the evolution of inequality in Peru in recent years. Yamada et al. (2012) show a 13.4% decline in the Gini coefficient of income inequality between 1997 and 2010. Although income redistribution through social programs is partly responsible for this decline, they also mention as an important factor the increase in the relative wages of low skilled workers. Mendoza et.al (2011) and Jaramillo and Saavedra (2011), on the other hand, give a smaller weight to labor earnings in the reduction of overall income inequality and focus almost entirely on no-labor income, including government transfers.[4] Our study highlight the importance of the wage premium for education and the relative supply of educated workers in explaining the reduction in earnings inequality in Peru.

Finally, in a related paper, Castro and Yamada (2012) analyze the evolution of the returns to schooling for different educational categories in Peru. They find a "convexification" of the wage profile during the 1990's, when individuals with no education *and* with higher education experienced wage gains at expense of workers in the middle of the distribution of years of schooling. This trend changed in the 2000's, when the returns for workers with higher education also declined. Castro and Yamada also correct for ability bias and find no significant impact of selection. Their econometric specification is consistent with a story of declining quality of education, which if supported by further direct evidence could be complementary to ours.

The paper is organized as follows. In Section 2 we introduce the data constructed from the household survey (ENAHO) and report some trends for the age and education composition of the labor force, as well as for labor earnings and wages in different age and educational categories. Section 3 performs a simple decomposition of average wage growth in changes in the composition of the labor force and changes in the wage premia, assuming perfect substitutability in human capital for different workers. Section 4 presents an alternative decomposition assuming imperfect substitutability of workers to account for the indirect impact

[2] Aedo and Walker (2012) also test for some Latin American countries the hypothesis that a negative selection into education is driving the returns to schooling down, without finding a significant impact. They also find no evidence that a decline in the quality of education (as measured by international standards as PISA tests) can account for the fall of the educational premium.

[3] In a companion paper, Infanzón and Urrutia (2014) implement the same methodology to analyze the effects of the demographic dividend and the increase in years of schooling on the average real wage in Mexico and Chile. In spite of the very different growth experiences in the last two decades, in both countries the average real wage also remained stagnant.

[4] Jaramillo and Saavedra (2011) show that inequality in labor earnings remained basically constant from 1997 to 2006, in spite of short run fluctuations related to the business cycle. However, they did not analyze the period 2006-2012 in which there is a clear negative trend for labor earnings inequality.

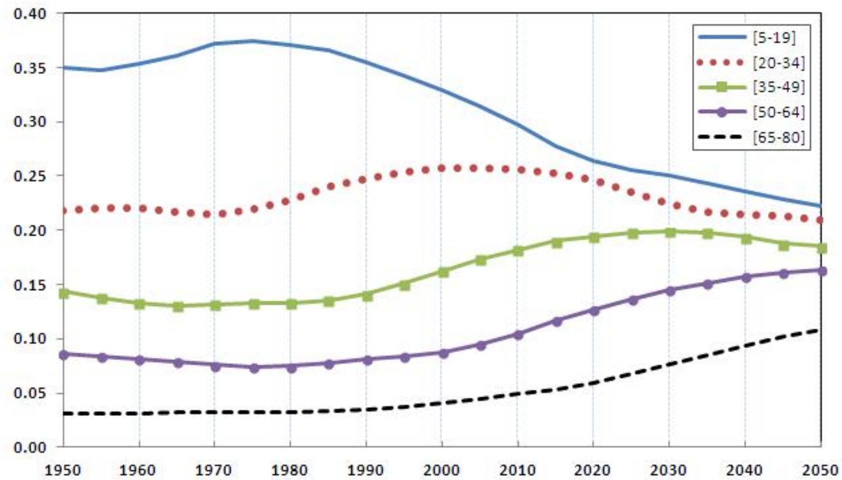

Figure 1: Estimates and Projections of Total Population in Perú, 1950-2050

of changes in the supply of educated workers on the educational wage premium. We discuss in Section 5 the aggregate implications of these findings for the labor share, earnings inequality, and total factor productivity. Finally, we conclude.

2 Data Overview

We use the main Peruvian household survey, the *Encuesta Nacional de Hogares* (ENAHO), carried on by the official statistical agency (INEI) for the period 1998-2012.[5] We select from the whole sample individuals between 14 and 64 years old, working at least 35 hours a week and receiving a positive wage. The variables that we consider are age, education, total labor earnings and hourly wage. The education variable is divided in five categories by the maximum level completed: (i) no education; (ii) primary education; (iii) secondary education; (iv) higher, non college education; and (v) college education. Since in some cases individuals report multiple activities, we focus only on earnings received from the main activity. Real earnings and wages are computed using the GDP deflator and adjusted from differences in regional price indices using a spatial deflator designed by INEI by *departamento*.

2.1 Demographic Trends and Educational Attainment

Starting in the early 1970's, the Peruvian economy exhibited a demographic transition characterized by a long-run decline in the population growth rates. As shown in Figure 1, this transition accelerated in the early 1990's and lead to a gradual shift of the age pyramid to older categories. In our sample of workers taken from the ENAHO survey we also observe this shift of the age distribution between 1998 and 2012. Table 1 compares the age distributions for our sample in 1998 and 2012. The results show an increase in

[5]Between 1985 and 1997 there was a different household survey in Peru, the *Encuesta Nacional de Medición de Niveles de Vida* (ENNIV). Unfortunately, the methodological differences between ENNIV and ENAHO do not allow for a consistent comparison of these two periods.

Age	1998	2012	Education	1998	2012
[14-24]	0.28	0.24	No-Education	0.09	0.06
[25-34]	0.31	0.30	Primary	0.25	0.19
[35-44]	0.22	0.26	Secondary	0.37	0.39
[45-54]	0.14	0.14	Higher/No-College	0.15	0.21
[55-64]	0.05	0.07	College	0.15	0.15

Table 1: Age and Education Distrbution for Sampled Workers (fraction of total)

the share of workers in the 35-44 age category, and a comparable decline of the share of workers in the 14-24 category. In addition, the average age of the sampled workers was about 32 years in 1998 and almost 34 years in 2012. These numbers are consistent with the long run aging of the Peruvian population.

The demographic trends are important because experience is an important factor in human capital. At age 40 most workers are at the pick of their productivity, so an increase in the share of workers in the 35-44 age category should be associated to an increase in the average earnings potential of the labor force. Our analysis will assess the contribution of this demographic bonus to average earnings and wages.

In parallel to these demographic transition, another important structural change in the Peruvian economy is the increase in education attainment. Between 1995 and 2010 the average years of schooling of the population (25 years old and older) increased by almost a year, from 9 to 10. As shown in the second panel of Table 1, for our sample from ENAHO the share of workers with secondary and higher (non-college) education increased significantly from 1998 to 2012, reducing the share of workers with only Primary education or none.

2.2 Trends in Real Labor Earnings and Wages

The previous two developments imply that the average worker in Peru has become older and more educated in the last two decades. Typically, more education and experience are associated to a higher level of human capital and therefore higher earnings. Moreover, labor productivity for the overall Peruvian economy increased in this period at an annual rate of 2.5 percent, reflecting both capital deepening and increases in total factor productivity.[6] However, as shown in Figure 2, average real labor earnings and the average hourly real wage in Peru have remained basically flat, with some short run fluctuations around a zero trend. If anything, there is a modest growth in the average wage of 0.2 percent per year between 1998 and 2012 (or 0.6 percent between 2002 and 2012), well below the rate of growth of labor productivity.

In the rest of the paper we attempt to shred some light on why has the average real wage in Peru not reflected the demographic, educational and productivity gains of the labor force. For now, notice that there is substantial heterogeneity across age groups and educational levels in terms of the evolution of labor earnings and wages (see Table 2).[7] Young and uneducated workers have experienced substantial earnings growth, while workers in the age and education categories which grew more during these years (35-44 age group,

[6] Labor productivity is computed from national income and product accounts as real GDP per worker. Loayza (2008) show an almost equal contribution of capital and TFP to economic growth in the 90s and a higher contribution of TFP between 2000-05 in a standard growth accounting exercise.

[7] Notice that the trends in labor earnings and hourly wages are very similar, suggesting that changes in hours per workers of different categories are not central to the explanation. Still, for completeness, in what follows we will report results for these two variables.

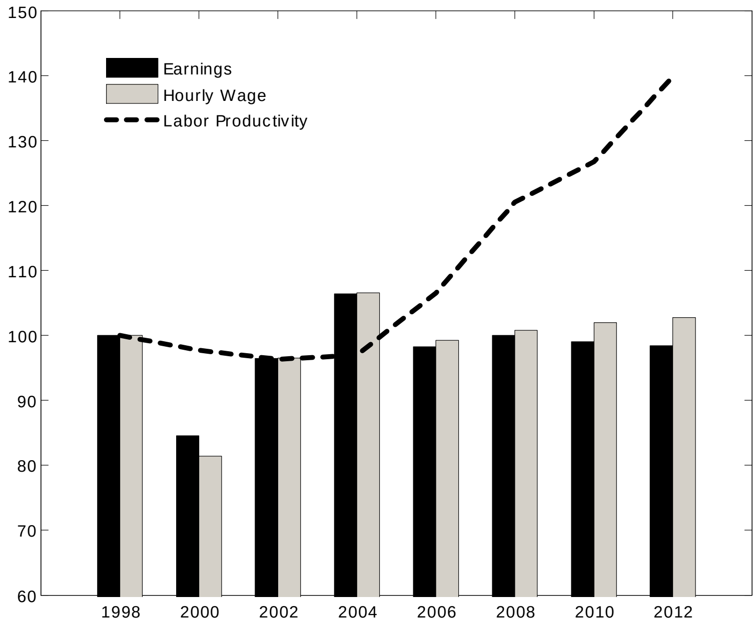

Figure 2: Average Real Labor Earnings and Hourly Wage for Sampled Workers (1998=100)

	Labor Earnings		Hourly Wage	
	1998	2012	1998	2012
Total	100	98.4	100	102.6
Age Group				
[14-24]	100	129.9	100	136.2
[25-34]	100	91.2	100	94.0
[35-44]	100	86.5	100	88.0
[45-54]	100	106.1	100	108.6
[55-64]	100	75.6	100	92.0
Education				
No-Education	100	119.3	100	125.2
Primary	100	114.0	100	118.7
Secondary	100	100.6	100	101.1
Higher/No-College	100	78.6	100	81.5
College	100	86.9	100	94.3

Table 2: Average Earnings and Wage for Sampled Workers by Age and Education (1998=100)

secondary and higher/non college education categories) experienced either no wage growth or significant real wage losses.[8]

3 Decomposing Changes in Earnings and Wages

We build a simple framework to account for changes in the average wage over time, distinguishing the impact of the composition of the labor force to the impact of aggregate labor productivity and changes in relative wages. We then use this decomposition to measure the contribution of each channel to the changes in the average wage in Peru between 1998 and 2012.

3.1 A Simple Framework

The starting point is a standard Neoclassical production function for the aggregate economy which combines physical and human capital to produce an homogenous good:

$$Y_t = A_t F(K_t, h_t L_t) \tag{1}$$

where Y_t is real output, K_t denotes the stock of physical capital, L_t the labor force and h_t the average level of human capital. The residual A_t represents total factor productivity. Assuming for now perfect substitutability between workers, total human capital is defined as the sum of individual human capital levels:

$$h_t = \sum_{a=14}^{64} \sum_{e=0}^{4} \left(\frac{L_{a,e,t}}{L_t} \right) h_{a,e,t} \tag{2}$$

where $L_{a,e,t}$ is the number of workers with age a (in years) and education e (classified in the same five categories as before), and $h_{a,e,t}$ is the human capital of workers in each particular age/education category. We rewrite:

$$h_t \equiv \sum_{a=14}^{64} \eta_{a,t} \sum_{e=0}^{4} \eta_{a,e,t} h_{a,e,t}$$

where $\eta_{a,t}$ is the share of workers with age a and, among those workers, $\eta_{a,e,t}$ denotes the share in education category e.

Firms' maximization leads to the standard first order condition

$$w_{a,e,t} = A_t F_H(K_t, h_t L_t) L_t (\partial h_t / \partial L_{a,e,t}) = \Phi_t h_{a,e,t}$$

where $\Phi_t \equiv A_t F_H(K_t, h_t L_t)$ is the marginal product of aggregate human capital. This condition, which assumes competitive labor markets, allows us to express the real wage for each type of worker as a linear function of her individual human capital. It also allows us to identify relative levels of human capital for two workers by their relative wage.

In this framework, the average real wage would then be given by:

$$w_t \equiv \sum_{a=14}^{64} \eta_{a,t} \sum_{e=0}^{4} \eta_{a,e,t} w_{a,e,t} = \Phi_t \sum_{a=14}^{64} \eta_{a,t} \sum_{e=0}^{4} \eta_{a,e,t} h_{a,e,t}$$

[8] Given our data limitations, it is hard to distinguish cohorts effects from changes in the returns to experience. Both of them would have an impact on the changes in relative wages for different age groups, as described in Table 2. Hence, in what follows, the experiments of changing the wage premia for age groups should be viewed as encompassing both effects.

	Labor Earnings		Hourly Wage	
	2012	Annual Δ%	2012	Annual Δ%
Total	98.4	-0.12	101.6	0.12
(*i*) Baseline salary	130.8	1.94	135.5	2.19
(*ii*) Composition labor force	110.5	0.71	108.7	0.60
- Age	103.0	0.21	103.1	0.22
- Education	106.8	0.47	105.3	0.37
(*iii*) Wage Premia	71.4	-2.37	71.6	-2.36
- Age	94.9	-0.37	95.6	-0.32
- Education	75.6	-1.97	75.5	-1.99
Combining (*ii*) and (*iii*)	75.1	-2.02	74.9	-2.04

Table 3: Decomposing Average Earnings and Wage (1998=100)

and, using as a baseline the salary for a worker with no education ($e = 0$) and 32 years old, we write

$$w_t = w_{32,0,t} \sum_{a=14}^{64} \eta_{a,t} \tilde{h}_{a,t} \sum_{e=0}^{4} \eta_{a,e,t} \tilde{h}_{a,e,t} \tag{3}$$

where the relative human capital ratios $\tilde{h}_{a,t} \equiv \frac{h_{a,0,t}}{h_{32,0,t}}$ and $\tilde{h}_{a,e,t} \equiv \frac{h_{a,e,t}}{h_{a,0,t}}$ can be identified by the corresponding wage premia $\frac{w_{a,0,t}}{w_{32,0,t}}$ and $\frac{w_{a,e,t}}{w_{a,0,t}}$.

The resulting expression allows us to decompose changes in the real average wage in: (i) changes in in the baseline salary $w_{32,0,t}$, reflecting changes in the marginal product of aggregate human capital; (ii) changes in the composition of the labor force, measured by changes in $\eta_{a,t}$ for age and $\eta_{a,e,t}$ for education; and (iii) changes in the wage premia relative to the baseline worker, captured by $\tilde{h}_{a,t}$ for age and $\tilde{h}_{a,e,t}$ for education.

3.2 Accounting for Earnings and Wage Changes

There are a few issues that need to be addressed before performing the previous decomposition with our dataset. One practical problem is that for some age/education categories there are very few observations. Related to this, idiosyncratic earnings shocks make the information on average wages noisy if the sample size is small.[9] To smooth out the data, we first run the following regressions of earnings or wage on age a (in years) and age squared, for each educational level e (classified in the same five categories as before) and each period t,

$$w_{e,t} = \beta_{0,e,t} + \beta_{1,e,t} a + \beta_{2,e,t} a^2 + \epsilon_{e,t}$$

and obtain an estimated earnings or wage $\widehat{w}_{e,t}$. We use these estimates instead of the original data to perform the decomposition in Equation 3, changing one of the components at a time. The results are presented in Table 3.

[9] These problems could be adressed by grouping years of age into five or ten years intervals, as we did in Section 2. In order to minimize the loss of information, we chose to estimate age-earnings profiles using years of age.

The decomposition highlights the positive role of the productivity of human capital (as measured by the baseline salary) and the composition of the labor force in raising labor earnings in Peru. These two factors combined, keeping relative wages constant, would have implied a 2.6 percent annual increase in the average labor earnings between 1998 and 2002. However, the effect of changes in the wage premia by education and, to a minor extent by experience, offset this positive impact. The results in terms of hourly wages are similar: The increase due to the baseline salary and the composition of the labor force would have been of about 2.7 percent per year, and most of these gains are offset by the changes in the wage premia by education and experience.

4 Relative Supply and Education Wage Premium

From the previous analysis it transpires that understanding why real wages have remained stagnant in Peru requires to understand the changes in the wage premia for different education levels. In the introduction we discussed several possible explanations, including technological change, selection and quality of education. We now examine the role of the relative supply of each type of worker. Can the increase in the supply of more educated and more experienced workers account for the decline in the wage premia for these type of workers?

4.1 An Alternative Framework

Obviously, to analyze this hypothesis we need to abandon the assumption of perfect substitutability between different types of human capital, implicit in Equation 2. An alternative structure for aggregating human capital would be

$$h_t = \sum_{a=14}^{64} \eta_{a,t} \left(\sum_{e=0}^{4} (\eta_{a,e,t} h_{a,e,t})^{\rho} \right)^{\frac{1}{\rho}} \tag{4}$$

where, for each age, the human capital of individuals with different education levels are imperfect substitutes. Therefore, from firm's maximization, individual wages satisfy

$$w_{a,e,t} = \Phi_t \left(\sum_{i=0}^{4} (\eta_{a,i,t} h_{a,i,t})^{\rho} \right)^{\frac{1-\rho}{\rho}} (h_{a,e,t})^{\rho} (\eta_{a,e,t})^{\rho-1}$$

with $\Phi_t \equiv A_t F_H(K_t, h_t L_t)$ as before. In this alternative setup, we compute the average wage as

$$w_t = \Phi_t \sum_{a=14}^{64} \eta_{a,t} \left(\sum_{i=0}^{4} (\eta_{a,i,t} h_{a,i,t})^{\rho} \right)^{\frac{1-\rho}{\rho}} \sum_{e=0}^{4} (\eta_{a,e,t} h_{a,e,t})^{\rho}$$

or, using again the baseline salary for a worker with no education and 32 years old,

$$w_t = w_{32,0,t} \sum_{a=14}^{64} \eta_{a,t} \left(\frac{\sum_{i=0}^{4} \left(\eta_{a,i,t} \tilde{h}_{a,i,t} \right)^{\rho}}{\sum_{i=0}^{4} \left(\eta_{32,i,t} \tilde{h}_{32,e,t} \right)^{\rho}} \right)^{\frac{1-\rho}{\rho}} \tilde{h}_{a,t} \sum_{e=0}^{4} \eta_{a,e,t} \left(\frac{\eta_{a,e,t}}{\eta_{32,0,t}} \right)^{\rho-1} \left(\tilde{h}_{a,e,t} \right)^{\rho} \tag{5}$$

for the relative human capital ratios $\tilde{h}_{a,t} \equiv \frac{h_{a,0,t}}{h_{32,0,t}}$ and $\tilde{h}_{a,e,t} \equiv \frac{h_{a,e,t}}{h_{a,0,t}}$.

$\rho = 0.5$	Labor Earnings 2012	Labor Earnings Annual Δ%	Hourly Wage 2012	Hourly Wage Annual Δ%
Total	98.4	-0.12	101.6	0.12
(*i*) Baseline salary	130.8	1.94	135.5	2.19
(*ii*) Composition labor force	74.2	-2.11	78.6	-1.71
- Education	72.9	-2.23	77.2	-1.83
(*iii*) Relative Human Capital	93.6	-0.47	88.9	-0.84
- Education	86.8	-1.01	91.4	-0.64
Combining (*ii*) and (*iii*)	75.1	-2.02	74.9	-2.04

Table 4: Alternative Decomposition of Average Earnings and Wage (1998=100)

In the previous decomposition, the shares of workers of different ages and in different education categories ($\eta_{a,t}$ and $\eta_{a,e,t}$) can be obtained directly from the data. However, the mapping between the relative human capital ratios ($\tilde{h}_{a,t}$ and $\tilde{h}_{a,e,t}$) and relative wages is now more complicated, with

$$\tilde{h}_{a,e,t} = \left(\frac{w_{a,e,t}}{w_{a,0,t}}\right)^{\frac{1}{\rho}} \left(\frac{\eta_{a,e,t}}{\eta_{a,0,t}}\right)^{\frac{1-\rho}{\rho}} \tag{6}$$

and

$$\tilde{h}_{a,t} = \left(\frac{w_{a,0,t}}{w_{32,0,t}}\right) \left(\frac{\eta_{a,0,t}}{\eta_{32,0,t}}\right)^{1-\rho} \left(\frac{\sum_{i=0}^{4}\left(\eta_{a,i,t}\tilde{h}_{a,i,t}\right)^{\rho}}{\sum_{i=0}^{4}\left(\eta_{32,i,t}\tilde{h}_{32,e,t}\right)^{\rho}}\right)^{\frac{\rho-1}{\rho}} \tag{7}$$

4.2 An Alternative Accounting for Earnings and Wage Changes

To compute the human capital ratios under the alternative framework we need a value for ρ. Estimates in the literature range from $\rho \in (0, 0.5)$, implying an elasticity of substitution between workers with different educational levels in the range of $(1, 2)$ (see Katz and Autor, 1999). Notice, though, that these estimates only consider two levels of skills and use mostly information for developed countries. Jones (2011) uses a more general structure with different human capital levels and cross country data and obtains an estimate of the elasticity of substitution of almost 2, implying $\rho \approx 0.5$. In our analysis, we use this estimate for ρ and perform some sensitivity analysis around it.

Given ρ, we use Equations 6 and 7 to construct the relative levels of human capital in our dataset and perform the decomposition in Equation 5. The results are reported in Table 4. By construction, total changes and the contribution of the baseline salary are the same as in Table 3. However, the contribution of the composition of the labor force includes now the indirect impact on the wage premia, via the relative supply of each type of human capital. The contribution of the relative human capital, on the other hand, represents changes in the wage premia that cannot be attributed to changes in relative supply. .

As expected, in this alternative setup the contribution to the average wage growth of changes in the composition of the labor force becomes negative, while the negative contribution of changes in the relative human capital is reduced significantly. In particular, the implied contribution of changes in relative human capital by educational categories is between half and one third of its value in Table 3, since the other half is accounted for the endogenous response to the relative supply of educated workers.

	Annual $\Delta\%$ in Labor Earnings, 1998-2012			
	$\rho = 0.2$	$\rho = 0.4$	$\rho = 0.6$	$\rho = 0.8$
(*ii*) Composition labor force	-3.51	-3.17	-1.62	-0.62
- Education	-3.62	-3.29	-1.75	-0.77
(*iii*) Relative Human Capital	0.66	-0.09	-0.85	-1.61
- Education	20.7	0.60	-1.64	-1.94

Table 5: Sensitivity Analysis for the Alternative Decomposition

Table 5 shows the sensitivity of this alternative decomposition to changes in the elasticity of substitution between workers of different educational levels. We only focus on labor earnings since the results with respect to hourly wages are very similar. As expected, increasing the elasticity of substitution reduces the negative impact on the average wage of the supply of educated workers. The limit case with perfect substitution is obtained with $\rho \to 1$. On the other hand, reducing this elasticity ($\rho \to 0$) increases the negative impact of the composition of the labor force in terms of education, implying a positive impact of the relative levels of human capital by education, which is obtained as a residual.

In summary, with a reasonable elasticity of substitution we can explain an important fraction of the decline in the wage premium for education and its impact on the average wage as the result of the relative increase in the supply of educated workers.

5 Some Macroeconomic Implications

We conclude this exploratory analysis by highlighting two macroeconomic implications of the evolution of wages in Peru in this period: A declining labor share and a reduction in earnings and wage inequality. While some empirical literature have already mentioned these two facts in a more general context, our analysis helps to link them, at least for the case of Peru, to the observed changes in the wage premia for education and experience. We also analyze the impact of the changes in relative wages for growth accounting and the calculation of the contribution of total factor productivity.

5.1 Declining Labor Share

One obvious implication of real wages growing at a slower rate than labor productivity (see again Figure 2) is a decline in the labor share of income. Figure 3 plots the time series for the aggregate labor share in Peru, obtained from National Income and Product Accounts as *Remuneraciones Totales* over GDP. As expected, there is a sharp decline starting in 2002, from 24 percent to almost 20 percent in 2012.[10]

The decline of the labor share seems to be a global trend. Karabarbounis and Neiman (2013) report a comparable fall in the U.S. and other advanced economies starting in 1980. Rodriguez and Jayadev (2010) show a similar trend for most regions in the world, in particular for Latin America where the decline in the labor share significantly accelerated starting in 1995. Our framework relates the decline of the labor share to changes in the wage premia for education and experience.

[10] The *level* of the labor share is controversial in an economy with a high incidence of self-employment, as discussed by Gollin (2002). Notice though that we are interested not so much in the level as in the time trend for this variable. In fact, for the growth accounting exercise which follows we use a more conventional labor share of 0.6.

5.2 Earnings and Wage Inequality

The observed changes in relative wages have also implications for inequality. Figure 4, constructed using our original database in Section 2, shows an important reduction in the cross–sectional Gini coefficients for both labor earnings and the real hourly wage. These trends are a natural consequence of the decline in the wage premia for secondary and higher education, as discussed by Aedo and Walker (2012) in the general context of Latin America and Lustig et al. (2013) for Argentina, Brazil and Mexico, in particular. Younger workers with low education experienced the highest gains in the period, contributing to a reduction in earnings inequality.

In the case of Peru, different studies show a reduction in the overall income inequality during this period.[11] This is remarkable considering the decline in the labor share, which would suggest higher polarization between workers and capital income earners. However, the impact of the reduction in wage disparity *among workers* seems to be the key factor to understand the evolution of inequality.

5.3 Human Capital and Total Factor Productivity

Consider the production function postulated in Equation 1, with a constant capital share α. Standard growth accounting exercises decompose the growth of output per worker in three components: the rate of growth of total factor productivity (TFP); the contribution of capital deepening; and the contribution of the growth of the average human capital per worker:

$$\widehat{Y/L} = \widehat{A} + \alpha\widehat{K/L} + (1-\alpha)\,\widehat{h}$$

Considering the period 1998-2012, the left hand side is about 2.5 percent per year, while the rate of capital deepening $\widehat{K/L}$ is about 1.1 percent.[12] Therefore, estimates of the growth rate of TFP clearly depend on the measures of the labor share and the growth rate of human capital used in constructing the residual:

$$\widehat{A} = 2.5\% - \alpha \times 1.1\% - (1-\alpha)\,\widehat{h} = 2.1\% - 0.6 \times \widehat{h}$$

using $\alpha = 0.4$. Growth accounting exercises that ignore human capital changes would attribute the whole 2.1 percent to changes in TFP. We want to explore the impact on the TFP contribution of the changes in the return to age and education.[13]

For this, notice that using the measure of human capital per worker postulated in Equation 2 and the corresponding notation thereafter, we can write:

$$1+\widehat{h} = \left(1+\widehat{h}_{32,0}\right)\left(\frac{\sum_{a=14}^{64}\eta_{a,2012}\sum_{e=0}^{4}\eta_{a,e,2012}\tilde{h}_{a,e,2012}}{\sum_{a=14}^{64}\eta_{a,1998}\sum_{e=0}^{4}\eta_{a,e,1998}\tilde{h}_{a,e,1998}}\right)$$

where $\widehat{h}_{33,1}$ is the rate of growth of human capital for workers which are 32 years old and have no education. As a raw calculation, let's assume that $\widehat{h}_{32,0} = 2.5\%$ so that all wage gains for these individuals represent

[11] See for instance Mendoza et.al (2011), Jaramillo and Saavedra (2011), and Yamada et al. (2012). These studies also highlight the role of public transfers in accounting for the changes in the overall income inequality.

[12] We compute the capital stock using the perpetual inventory method and investment data from 1950 onwards and a 3 percent depreciation rate. Loayza (2008) shows a slightly negative (-0,6 percent) growth rate of capital per worker in Peru between 2001 and 2005. Ledesma (2010) estimates a less than 0.2 percent growth rate of capital per worker between 2000 and 2009. Our estimated contribution for capital deepening is larger because of the latest years in our sample.

[13] An interesting question that we ignore is the impact of changes in the labor share over time for growth accounting.

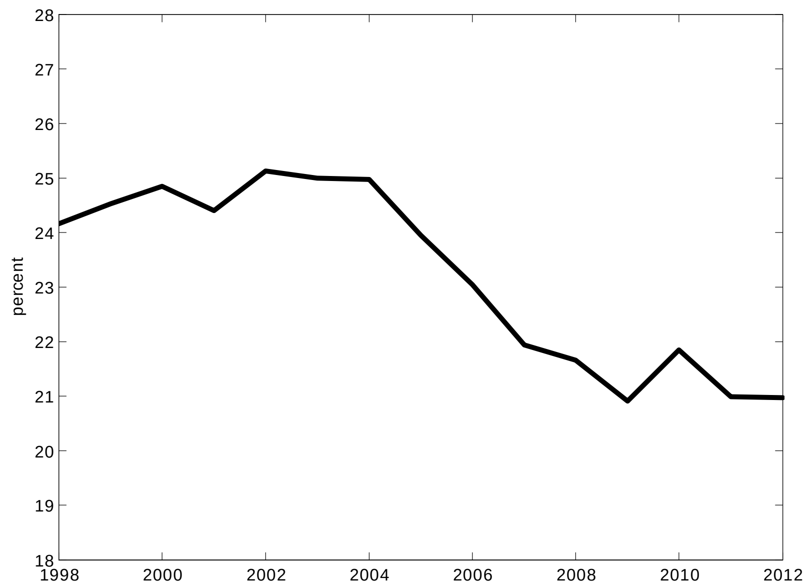

Figure 3: Evolution of the Aggregate Labor Share of Income in Peru, 1998-2012

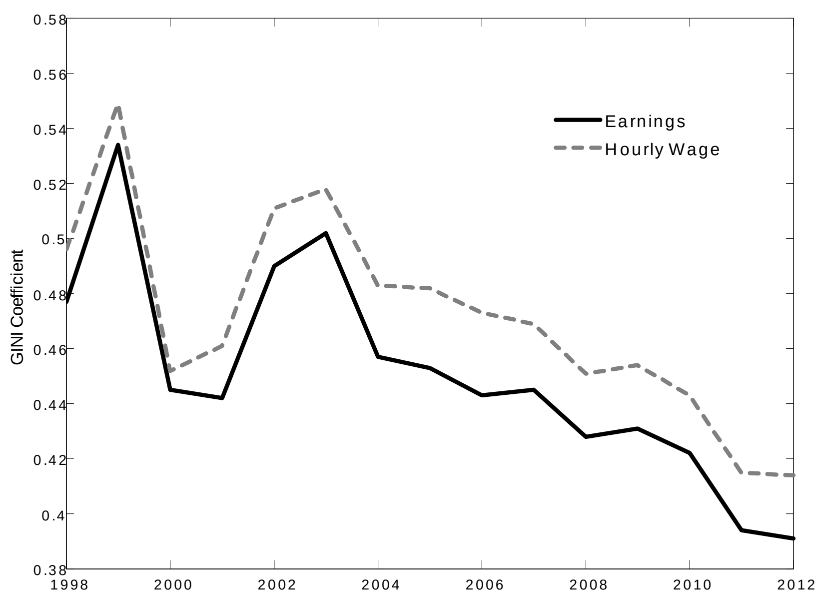

Figure 4: Evolution of Earnings and Wage Inequality in Peru (Gini coefficient), 1998-2012

aggregate productivity gains. Then, using the numbers in Table 3 for labor earnings, $\widehat{h} \approx 2.5\% - 2.02\% = 0.48\%$, so that the implied rate of growth of TFP would be about 1.8 percent per year.

Notice, though, that the results change significantly if we ignore the evolution of the *relative* levels of human capital, reflected in the wage premia for different age and category:

$$1 + \widehat{h^*} \equiv \left(1 + \widehat{h}_{32,0}\right) \left(\frac{\sum_{a=14}^{64} \eta_{a,2012} \sum_{e=0}^{4} \eta_{a,e,2012} \tilde{h}_{a,e,1998}}{\sum_{a=14}^{64} \eta_{a,1998} \sum_{e=0}^{4} \eta_{a,e,1998} \tilde{h}_{a,e,1998}} \right)$$

This alternative measure of the growth of human capital only consider changes in the composition of the labor force, in particular changes in educational attainment. Using again the numbers in Table 3 for labor earnings, we would obtain $\widehat{h^*} \approx 2.5\% + 0.71\% = 3.21\%$ and hence an implied rate of growth of TFP of about 0.18 percent per year.

The bottom line is that considering only the changes in educational attainment as a measure of human capital growth would grossly underestimate the contribution of TFP.[14] Changes in the relative productivity of different types of workers, reflected in their relative wages, implies in the case of Peru a much smaller growth in the aggregate human capital (in spite of the educational gains) and hence a higher growth rate of the TFP residual.

6 Conclusions

We started this investigation by asking the question: "Why does the average real wage in Peru remained stagnant in a period in which the composition of the labor force both in terms of age and education has improved and labor productivity has increased?" We have shown that a significant part of the explanation lies in the observed changes in relative wages, especially in the decline of the returns to education. Average labor earnings and the average real wage would have grown at a rate of about 2.6 percent per year, roughly corresponding to the rate of growth of aggregate labor productivity, had these returns remained constant during the period.

The next question is, or course, how to account for the decline in the relative wage of educated workers. We show that the observed increase in the supply of educated workers could be partly responsible for cannibalizing the returns to education. However, a deeper analysis is required to disentangle these effects from changes in the demand for workers with different levels of education arising from technological change, sectoral shifts of production, and so on.

Answer to these questions are key to understand the evolution of inequality and the decline in the labor share, and to measure properly the contribution of total factor productivity to economic growth. Moreover, the empirical literature shows that some of these developments are common to a wider set of Latin American countries, hence the relevance of this topic for economic development in general.

[14] This concern applies to studies which use a Mincerian specification for human capital as a function of years of schooling and a constant return to education over time. An example is Daude and Fernandez-Arias (2010), which find in the context of Latin American growth experience a relative large contribution of human capital and hence a low contribution of TFP. Our analysis favors growth accounting exercises which use "aggregate labor quality indices" constructed from micro data (following for instance Jorgenson et al.,1987).

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