What Can Explain the Rising Wage Share of Skilled Labor in Developing Countries? Evidence from Peru

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Abstract

Using data from Peru for the 1990s, we study the factors behind the increase in the relative demand for skilled workers. We use a translog cost function for *gross* output to incorporate the effects of materials, both domestic and imported, in addition to capital. This is different from the literature in this area, which has relied on cost functions for *value added* and has not incorporated the role of materials in a completely satisfactory manner. We find that capital accumulation has a strong positive effect on the relative share of skilled workers indicating capital-skill complementarity. There is some evidence that imported materials decrease the relative demand for skilled labor. Trade either in final goods or in material inputs is unable to explain the increased demand for skilled labor.

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I. Introduction

Contrary to the predictions of international trade theory, many developing countries have experienced an increase in the relative wages of skilled workers following trade liberalization (See Robbins (1996), Wood (1997), and Hanson and Harrison (1999)). One explanation for this phenomenon is the argument of skilled biased technological change.[1] According to this framework, an increase in the relative demand for skilled workers could come from a reallocation of resources *between* or *within* sectors. The distinction between *between* and *within* sectors points out the different sources of the increase in the relative demand for skilled labor. Trade liberalization effect is associated with the explanation of an increase in the relative demand for skilled labor *between* sectors. If this increase takes place *within* sectors, it is associated with a technological change effect. A common way to demonstrate that skilled biased technological change *within* industries has taken place is to show that the share of skilled workers in the wage bill *within* industries has increased over time (e.g., Berman, Bound, and Griliches 1994 and Berman and Machin 2000).[2]

In Peru, we observe an increase in the share of skilled workers in the wage bill. The objective of this paper is to document this increase in the wage share of skilled labor and to explore the factors that could be behind this change. Changes in the wage share of

[1] Other explanations include Davis (1996) and Feenstra and Hanson (1996). Davis argues that middle-income countries may be competing with low-income countries in a world with multiple cones of specialization, and so trade could reduce relative wages in these middle-income developing countries. According to Feenstra and Hanson, capital flows from the North to the South could increase the relative demand for skilled labor in both regions.

[2] Berman and Machin show that this share has increased for a number of developing countries.

skilled labor within industries can be a good measure of shifts in relative demand. An increase in the wage share of skilled labor in the face of a rising skilled wage premium will indicate a shift in favor of this type of labor if we assume that the elasticity of substitution between skilled and unskilled labor is greater than 1.

Besides technological change, within industry shares of labor can be driven by inputs such as capital and materials. Skilled labor could be more complementary with physical capital than unskilled labor. Griliches (1969) formalized the hypothesis for such capital-skill complementarity and provided evidence for it. Increases in capital and skill intensity have been observed even in low income countries following market oriented reforms. According to Howell and Kambhampati (1999), competitive pressures in the textile sector in India following reforms drove some firms to engage in modernization efforts that involved importing machinery and increasing both their capital intensities and skill requirements. It is also possible for materials to affect the share of skilled labor. For example, material imports could substitute for unskilled labor in industrialized nations, as Feenstra and Hanson (1999) show in their paper. In developing countries, material imports could substitute for *skilled* labor. The effect of material imports in that case would be to decrease the wage share of skilled labor. On the other hand, it is possible that material imports embody new technology that is unskilled labor saving, in which case such imports would increase the wage share of skilled labor.

We conduct a detailed analysis of the factors behind the changes in skilled labor wage share. We use disaggregated industry level data and take into account the effect of capital and imported and domestic materials. We use a gross output framework to take into account the role of materials. This is different from the rest of the literature that uses a value added framework. The latter is appropriate only if materials are not likely to affect the relative shares of skilled and unskilled labor. Few studies take into account imported materials, and when they do this variable is introduced in a value added framework in an ad-hoc fashion to explain changes in the share of skilled labor in the wage bill.[3] However, if imported materials are considered to be another input then the gross output framework, where imported materials affect the share of skilled labor in payments to *all* variable factors (including domestic materials etc.), is the appropriate one to use.

Our main results are as follow. We find that increases in capital intensity are strongly and positively related to increases in the wage share of skilled workers. There is some evidence that imported materials act as *substitutes* for skilled labor. Capital intensity does not have a significant effect if we use a value added framework. Tariff rates are negatively related to the share of unskilled workers, as expected in a developing country.

The remainder of the paper is organized as follows: Section II gives a brief history of reforms in Peru in the early 1990s. Section III presents the basic theoretical framework

[3] There are only a few studies in this literature that takes materials into account. Berman, Bound, and Griliches (1994), using US data, try to take into account the effect of materials, without making a distinction between domestic and imported, and find it to be unimportant. Feenstra and Hanson (1999) find that their outsourcing variables, which are based on imported intermediate inputs, are positively related to the non production wage share in the US in a regression that is based on the value added framework. Pavcnik (2003) also looks at the effect of imported materials in a share equation based on the value added framework using Chilean data. It is interpreted, however, as an indicator of foreign technology.

that provides the main determinants of the shares of skilled and unskilled workers in factor payments. Changes in these shares are interpreted as measures of relative demand shifts. The equation to be estimated and the estimation method are discussed in this section. Section IV describes the data and the results. The last section contains our conclusions.

II. Reforms overview

Reforms in Peru

Like many other developing countries during the last two decades, Peru implemented drastic reforms in early 1990s. President Alberto Fujimori came to power in 1990 and implemented wide ranging structural reforms. His government eliminated price controls, subsidies, and foreign exchange restrictions. A flexible exchange rate was adopted in August 1990. There was a significant liberalization of the foreign trade regime and the average level of tariffs was reduced sharply, from 66 percent in 1989 to 15 percent in 1995 and to 12 percent in 1997. Import prohibitions, which were extensively used in the 1970s and the late 1980s, were gradually abandoned. Export restrictions were eliminated for most exports in 1991. There was also a substantial privatization drive and tax reform. After a recession in 1992, the country experienced GDP annual growth rates of more than 7 percent in the following five years. Inflation was much lower (with an average annual rate of around 20 percent) during this period.

Along with these reforms, Peru was one of the few countries in Latin America to implement significant reforms in the labor markets.[4] These reforms were focused on lowering worker dismissal costs, facilitating temporary hiring, and introducing flexibility in formal employment.

Prior to labor reform, labor legislation was extremely complex and included a wide range of regulations, such as binding minimum wage policies, extremely high dismissal costs, administrative controls, and specific compulsory benefits, which introduced a series of distortions in labor markets. Peruvian labor legislation was modified through successive steps. The Law of Employment Promotion (Ley de Fomento al Empleo) of 1991 along with a new constitution in 1993 introduced several measures to reduce labor market rigidities. Later in 1995, new regulations followed to deepen the flexibility in labor markets. Consequently, workers' dismissal costs declined sharply through the progressive elimination of job security regulations, the introduction of temporary contracts, and changes in the severance payment structure (see Saavedra and Torero 2000).

In our paper, we focus on the period 1995–2000 after the major labor market reforms of 1991 had already taken place so that we may abstract from their effects. Focusing on this period also has the advantage that labor markets are closer to being competitive, which is the basis of our conceptual framework.

[4] According to the 2004 Inter-American Development Bank report, only six countries imp lemented significant labor reforms between the mid-1980s and 1999: Argentina (1991), Colombia (1991), Guatemala (1990), Panama (1995), Peru (1991), and Venezuela (1998).

Trends in wages and employment

The dataset we use (described in greater detail in Section IV) has data on white- and blue-collar workers for the manufacturing sector. White-collar workers (empleados) and blue-collar workers (obreros) will be interpreted as skilled and unskilled labor, respectively. Table 1 reports data on wages and employment of both types of workers for the manufacturing sector in Peru during 1995–2000. The relative wages of skilled workers increase from 2.24 to 2.53 over this period, approximately 13 percent. The ratio of employment of skilled workers to unskilled workers shows a slight decrease, from 0.69 to 0.675. The share of skilled workers in total wages increased from 0.61 to 0.63 over this period. The real wages of unskilled workers actually declined over this period while that of skilled workers increased.

The data on white and blue collar workers that we use includes permanent workers only. In the survey, the total wages paid to temporary workers are reported but their employment numbers are not reported. In addition, there is no information regarding whether they are white or blue collar workers. This could lead to a potential problem with the shares that we report since the use of temporary workers increased after the labor reforms due to the introduction of independent contracts. If temporary workers are mainly blue collar workers then the increase in wage share of white collar workers could be the result of a smaller fraction of permanent blue collar workers. To see the magnitude of the possible overestimation of wage share of white collar workers, we assume that all temporary workers are blue collar workers and recalculate the wage shares of skilled workers. These adjusted shares are reported in the second row from the bottom in the table. We still observe an increase in the wage share from 0.56 to 0.58 during this period.[5]

Effect of trade liberalization

One factor to consider is the effect of the elimination of tariffs and quotas. It has been observed that even developing countries provide higher levels of protection to *unskilled* labor intensive industries. Hanson and Harrison (1999), for example, find that unskilled labor intensive industries in Mexico had higher pre-trade reform tariff levels. Also, reductions in tariff were larger for unskilled labor intensive industries. Interestingly, unskilled labor intensive industries like apparel and food products enjoyed some of the highest rates of effective protection before the 1990 reforms in Peru also. These sectors also suffered the largest decreases in protection rates after the reforms were implemented.[6] However, as discussed below, we do not find that unskilled labor intensive industries suffered more losses during the period under consideration. Since our sample period starts a few years after the reforms were implemented, it is possible that the reallocations among industries had already taken place by 1995.

We look at changes in the employment shares of industries to see if there is any evidence that unskilled labor intensive industries suffered more during this period as a result of the trade reforms. Table 2 provides information on the top 10 industries in terms

[5] As we will see later, the time trend is significantly positive in regressions involving wage shares of skilled labor at the 4-digit industry level as the dependent variable. This is true for both, the shares that adjust for temporary workers and those that do not.

[6] Effective protection rates decreased from 261.6% to 87.6% for the apparel industry and from 197.2% to 62.6% for the beverage and tobacco industry between July 1990 and December 1990 (Boloña and Illescas 1997).

of employment in the manufacturing sector in Peru in 1995. These industries together accounted for more than 80 percent of manufacturing employment. Therefore, it will be useful to look at these industries because their impact on employment is likely to be significant. As we can see from the first column in the top panel, food products and beverages and textiles and apparel account for close to 40 percent of employment. The skill intensity in these sectors, as measured by the skilled to total employment ratio or the skilled labor share in the wage bill (last two columns of top panel), is lower compared to chemicals or publishing/printing, as one would expect.

As we can see, there is no clear pattern between skill intensity and changes in the shares in employment (the latter reported in the first column in the bottom panel) during the 1995–2000 period. Some unskilled labor-intensive industries like apparel have expanded, which is consistent with our expectations. However, other unskilled intensive industries like food and beverage have contracted. Also, some skilled labor-intensive industries like publishing or rubber and plastics have increased their shares while other industries, with a high skill ratio such as chemicals, have experienced a decrease. So, the increase in the demand for skilled labor cannot be explained by changes in industrial composition resulting, perhaps, from trade liberalization. This will be confirmed below by our more formal between-within decompositions. On the other hand, as we can see from the second column in the bottom panel, the within industry share of skilled labor in the wage bill has increased for most industries. This suggests that the increase in the demand for skilled labor is a result of increases in skill intensity that occurred within industries.

Between and within decomposition

As Berman, Bound, and Griliches (1994) point out, changes in the wage bill share of skilled labor are a good measure of relative demand shifts as long as the elasticity of substitution is greater than 1. We will focus on this measure in this paper. We perform a between-within decomposition of the wage bill share of the manufacturing sector to see if changes in the overall wage share of skilled labor are due to shifts across industries or changes within industries. We conduct this analysis using all 4 digit ISIC industries in the manufacturing sector. The standard way to decompose these changes is as follows:

$$\Delta S' = \sum \overline{S'}_i \Delta P_i + \sum \overline{P_i} \Delta S'_i$$

where S' is the wage share of skilled workers for the manufacturing sector as whole, S'_i is the skilled wage share in industry i, P_i is the share of industry i in total wages. A bar over a variable denotes the mean over the time period.

According to the results, the entire change in the overall skilled labor wage share is due solely to within-industry changes. The within-industry is 0.03 and the between-industry change is actually negative, -0.01. That is, it will be worthwhile to explore the factors behind these within-industry changes in order to understand the relative demand shifts.[7]

[7] The fact that between industry changes have not played a role suggest that trade in final goods was not a factor behind the changes in the wage shares in the manufacturing sector. If final goods trade was the reason then we would expect to see decreases in the shares of unskilled labor intensive industries in employment. The correlations between skill intensity (measured as the ratio of white to blue collar employment) and other variables during this period are also not consistent with the story that final goods trade is decreasing the demand for unskilled workers. Skill intensity is negatively correlated with employment growth, positively correlated with changes in the import share of value added and negatively correlated with output price changes during this period. The correlations are -.06, .01 and -.08, respectively, and insignificant at the 5% level.

As mentioned before, it is possible that the changes in these shares are driven by measured factors such as capital and materials. Figure 1 shows the trends in these factors (at 1994 prices) over time for the manufacturing sector in Peru. It is clear that capital stock has grown at a much faster rate compared to the other variables. Capital intensity, as measured by the capital to value added ratio, increased from 1.24 to 1.67 between 1995 and 2000. The increase in capital intensity in Peru could, therefore, also be responsible for the increase in the wage share of skilled workers.

III. Conceptual Framework

Our estimation is based on a quasi-fixed cost function for gross output. We use the cost function for gross output to take into account the effect of materials, which could also influence labor shares. The cost function is used to derive equations involving shares of skilled and unskilled workers in *factor payments* (all variable factors). The estimates from these equations will then be used to make predictions about changes in shares in the *wage bill*. The quasi-fixed cost function assumes that some of the inputs are fixed and the quantities of the variable inputs are chosen to minimize costs. We will assume that the quasi-fixed or variable cost function takes the translog form (see Brown and Christensen 1981) such as the following:

$$
\begin{aligned}
\ln CV = {} & a_0 + a_Y \ln Y + \sum_{i}^{l} a_i \ln P_i + \sum_{i}^{m} \text{ß}_i \ln Z_i + \frac{1}{2} ?_{YY} (\ln Y)^2 + \\
& \frac{1}{2} \sum_{i}^{l} \sum_{j}^{l} ?_{ij} \ln P_i \ln P_j + \frac{1}{2} \sum_{j}^{m} \sum_{j}^{m} d_{ij} \ln Z_i \ln Z_j + \sum_{i}^{l} ?_{Y_i} \ln Y \ln P_i + \\
& \frac{1}{2} \sum_{i}^{l} \sum_{j}^{m} ?_{ij} \ln P_i \ln Z_j + \sum_{i}^{m} ?_i \ln Y \ln Z_i + a_A \ln A + \frac{1}{2} a_{AA} (\ln A)^2 + \\
& a_{AY} \ln A \ln Y + \sum_{i}^{l} a_{AP_i} \ln A \ln P_i + \sum_{i}^{m} a_{AZ_i} \ln A \ln Z_i
\end{aligned} \qquad (1)
$$

where Y is gross output, P_i is price of variable input i, Z_i is the quantity of fixed input i, and A measures the level of technology.

We assume that there are four variable inputs and one fixed input. The variable inputs are skilled labor, unskilled labor, domestic materials, and imported materials. The fixed input is capital.

Using Shephard's duality theorem, the derivative *dln CV/dln* P_i will equal the share (S_i) of the variable factor i in variable cost. Therefore we have

$$
S_i = \frac{\partial \ln CV}{\partial \ln P_i} = a_i + ?_{Y_i} \ln Y + \sum_{j}^{l} ?_{ij} \ln P_j + \sum_{j}^{m} ?_{ij} \ln Z_j + a_{AP_i} \ln A \qquad (2)
$$

where S_i is the share of factor i in total payments to variable factors. The first equality in (2) comes from the assumption of cost minimization while the second equality comes from taking derivatives of equation (1).

We need to assume $g_{ij} = g_{ji}$ so that the cross partials of the translog cost function with respect to the log of prices are the same. We also need $\sum_{j}^{l} g_{ij} = 0$ for the cost function to be homogeneous of degree one in input prices. If we impose constant returns to scale then we will have $r_{Y_i} + \sum_{j}^{m} r_{ij} = 0$.

We will assume that *ln A* takes the form

$$\ln A = b_k + b_h t + e_{kt} \tag{3}$$

where *k* denotes industry, t denotes a time trend and e_{kt} is a random error term. A is, therefore, assumed to depend on both industry and time. The technology term has industry, time, and random components. We will assume that b_h is positive, i.e., technology improves over time. Equation (2) can then be rewritten as

$$S_i = a_i + r_{Y_i} \ln Y + \sum_{j}^{l} g_{ij} \ln P_j + \sum_{j}^{m} r_{ij} \ln Z_j + (a_{AP_i} b_k + a_{AP_i} b_h t + a_{AP_i} e_{kt}) \tag{2'}$$

Let us look at the expression for the error term (within parentheses) in equation (2') above (the industry and the time subscripts have been omitted from the other variables for the sake of clarity). The first term is an industry specific term. The second term is a function of time and will be negative if $a_{AP_i} < 0$. A negative a_{AP_i} will imply that technological change is biased against factor *i*. The last term within parentheses is a random term.

Equation (2') can therefore be estimated using an industry fixed effect, a time trend, log of price indices of the variable inputs, and the log of capital and gross output. The actual equation to be estimated (after imposing all necessary constraints) takes the form

$$S_i = a_i + g_{iS}\, ln\left(\frac{w_S}{p_D}\right) + g_{iU}\, ln\left(\frac{w_U}{p_D}\right) + g_{iM}\, ln\left(\frac{p_M}{p_D}\right) + r_{iK}\, ln\left(\frac{K}{Y}\right)$$

$$+ industrydummy + time\ trend + error\ term, \qquad (2'')$$

where w denotes wage, the subscripts S and U denote skilled and unskilled labor, respectively; p denotes price of materials, the subscripts D and M denote domestic and imported, respectively; and K denotes capital.

We have an equation for each of the four variable factors: skilled labor, unskilled labor, imported materials, and domestic materials. These equations will be estimated as a system. Only three of these equations will be linearly independent. We will drop the share equation involving domestic materials and estimate the remaining three using iterative Seemingly Unrelated Regressions (SUR). Since the iterative procedure is used, the estimates will not be sensitive to the equation being dropped. One point to note is that we assume that there is no correlation between capital and shocks affecting factor shares. This is reasonable since the capital stock for year T does not include investment in year T. While the latter could be correlated with year T shocks, the capital stock should not. Also, investment may not respond to year-to-year shocks since the planning horizon for new investment is likely to be longer than a year.

IV. Data and Results

Data

Our data come from the Annual Survey of Manufactures for Peru collected by *Ministerio de Industria, Turismo, Integración y Negociaciones Comerciales Internacionales* (MITINCI). The data are available at the four-digit ISIC (Rev. 3) level and includes information on employment, wages, value added, materials, investment, and capital stock for firms with five or more workers. The data are available from 1994 to 2000.[8] The survey covers approximately 90 percent of the gross value of production of 1994, the base year.

The survey has information on white-collar and blue-collar workers and, as mentioned before, we interpret these as skilled and unskilled labor, respectively. To compute payments to these two types of workers, we take into account both wage and non-wage payments. The wage payments are available for each type of worker. The non-wage payments are not available separately for the two types of workers and so are allocated to each type according to their share in the wage bill. Non-wage payments include health plan payments, accident insurance payments, manufacturing training fund payments (SENATI), contributions to the national housing fund (FONAVI), tenure bonus payments, and Christmas and national holiday bonuses.

Using this information, we compute the shares of skilled and unskilled workers in total payments to variable factors. Given the lack of distinction between skilled and

[8] Previous surveys cover the period from 1988 to 1992. However, the data from these years are not easily comparable to that of the latter period because of changes in industry classification.

unskilled workers among temporary employees, we assume that their shares in total payments to temporary employees are the same as their shares in total payments to permanent employees. Adjusting the payments to the two types of workers under this assumption would leave their shares unchanged. [9]

We constructed price indices for materials, both domestic and imported, used in each industry. We were able to obtain these indices only at the level of input-output (IO) industries for Peru. Both domestic and import price indices (base year 1994) for the IO sectors in Peru were available from the *Compendio Estadístico,* published by the National Institute of Statistics and Information (INEI). These were then used to calculate the price index for all intermediate goods used by an IO sector industry using the IO table for Peru. The price index for materials used was calculated as follows

$$P_j = \sum_i p_i \left(\frac{v_i}{\sum_i v_i} \right)$$

where P_j is the price index for materials used in IO industry j, p_i is the price index for IO commodity i (obtained from the *Compendio*) and v_i is the value of commodity i used as an intermediate in industry j (obtained from the 1994 IO table). $\sum_i v_i$ is, therefore, the total value of intermediate goods used in industry j. The price index for materials used in an industry is, therefore, a weighted average of the price indices of IO commodities with the 1994 shares of each commodity in total value of intermediate goods used in that industry as weights.

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[9] In previous section, we have observed already that results do not change much by assuming that all temporary workers are unskilled.

The 1994 IO table for Peru reports separately the flows of domestically produced commodities and imports into each industry. So, we were able to obtain separate price indices for domestic and imported materials using these data and the price indices. The import price indices take into account tariff and exchange rate changes. The nominal values of domestic and imported materials used in an industry were considered to be the payments to these two factors.[10] The shares of these two factors in total payments to variable factors were calculated using these data on payments.

We employed the perpetual inventory method to obtain estimates of the capital stock. That is, the beginning of period capital stock in period t, K_t, is given by

$$K_t = (1-d)K_{t-1} + I_{t-1},$$

where δ is the depreciation rate and I is investment (at base year prices). The depreciation rate used for equipment was 12.3 percent and for structures was 3.6 percent (based on United States data from Jorgenson, Gollop, and Fraumeni 1999, ch. 4). The initial capital stock used was the one available for 1994 from the survey with some adjustment since we do not have the investment data for previous years by industry.[11]

[10] These also include taxes on fuels. Taxes on fuels were allocated to domestic and imported materials according to their shares in total material use.

[11] The survey reports the end-of-year capital stock and investment during that year. The beginning-of-year capital stock for 1994 was estimated using the end-of-year capital stock, and investment data for 1994, and the depreciation rates. The capital stock for subsequent years was estimated using the perpetual inventory method mentioned before. One problem with the capital data for 1994 is that the survey reports the capital stock data at book value. The stock may be understated since investment acquired in years prior to 1994 will be valued at the prices of the years they were acquired instead of 1994 prices and prices tend to

The wage rates on the right hand side of equation (2") were calculated at the level of manufacturing sector as whole for each year (obtained as total wage payments divided by total employment). The assumption here is that wages are the same across industries due to mobility of both types of labor, which has been the standard practice in the literature.[12] Wages, therefore, vary only across time (however, the wage shares, which are the dependent variables in the system of equations, *do* vary across both industry and time). The wage variables used in the regression are indices with 1994 as the base year.

Estimation

The sample period for all regressions is 1995–2000.[13] Before we estimate equation (2") we run a regression involving the share of skilled workers in the total wage bill as the dependent variable. This has been the standard way to analyze the determinants of the changing share of skilled workers (see, for example, Berman, Bound, and Griliches 1994 and Pavcnik 2003). The equation takes the form

$$S' = a + b_1 \, ln\left(\frac{w_S}{w_U}\right) + b_2 \, ln\left(\frac{K}{V}\right) \tag{4}$$

where S' is the share of skilled workers in total wage bill; w_S and w_U are wages of skilled and unskilled labor, respectively; K is capital; and V is value added.

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increase over time. We estimated the total stock in the manufacturing sector using investment data from 1950 for Peru as a whole. This was about twice the total manufacturing sector capital stock reported in the survey. We multiplied the capital stock in 1994 obtained from the survey by 2 to get the initial capital stock for each industry. The possible mismeasurement problem with the initial capital stock will be alleviated by the fixed effects.

[12] Since observed wages do differ across industries, the implicit assumption here is that such variations arise from differences in quality and that the *quality adjusted* wage is the same across industries. Actual industry wages cannot be used in the regression since they are endogenous.

[13] We do not include 1994 in our sample since the mismeasurement problem is likely to be more severe with the capital stock data for 1994.

The theoretical basis of the equation is a quasi-fixed translog cost function for value added with the usual homogeneity restrictions and constant returns to scale assumption imposed. Capital is taken to be the fixed input while the two types of labor are variable. The results of this estimation are reported in Table 3b. Regression 1 reports the results of running the skilled labor share in the wage bill on just the time trend. The time trend is positive and significant. Regressions 2 and 3 report the results of estimating equation (4) with and without the time trend. The capital to value added ratio is positive but not quite significant at the 10% level. The time variable is still positively related to the skilled share in wage bill but is not significant.

One problem with this specification could be that the production function is not separable between labor and capital variables on one hand and materials on the other. The equation could, therefore, be misspecified. We will show later that the null hypothesis of separability is rejected by the data when we include imported materials in our regression.

We now go back to the share equations based on our framework involving a gross output cost function. Equation (2") gives us a system of equations, one for each variable factor of production. Before we estimate the entire system of equations, we estimate an equation involving the difference in the share of skilled workers and unskilled workers in payments to variable costs using equation (2"). That is, we estimate an equation of the form

$$S_S - S_U = (a_S - a_U) + (g_{SS} - g_{US})\ln\left(\frac{w_S}{p_D}\right) + (g_{SU} - g_{UU})\ln\left(\frac{w_U}{p_D}\right)$$
$$+ (g_{SM} - g_{UM})\ln\left(\frac{p_M}{p_D}\right) + (r_{SK} - r_{UK})\ln\left(\frac{K}{Y}\right) \quad (5)$$
$$+ industrydummy + timetrend + error\ term.$$

The results are reported in the first column of Table 4b. The coefficient of the capital-output ratio is positive and highly significant indicating capital-skill complementarity. Figure 2 shows the strong positive relationship between capital intensity and skilled labor share. It plots the change in the difference between skilled and unskilled share against change in the log of capital to gross output ratio over the period 1995–2000. There is a very clear positive relationship between these two variables.

The relative price of imported materials is positively related to the share differential. Although the coefficient is not quite significant at the 10% level, the p-value is close to 0.10.[14] This indicates that an increase in material imports will decrease the difference in the shares of skilled and unskilled workers. Imported materials, therefore, seem to act as substitutes for *skilled* labor. This makes sense in light of the fact that skilled labor is the scarce factor in Peru. Material imports could be embodying skilled labor. Feenstra and Hanson (1999) found that imported intermediate goods act as

[14] There could also be an econometric issue arising from the fact that our price indices for materials are at the IO level while we are looking at a more disaggregated ISIC level data. Since several industries within an IO sector share the same characteristic, this could lead to an underestimation of the standard errors in OLS, as was demonstrated by Moulton (1990). We can correct for this by allowing for correlation of standard errors between industries belonging to same IO sector. This correction actually decreases the standard error for relative price of imported materials (from .024 to .022) so that the coefficient becomes significant at the 10% level.

substitutes for unskilled labor in the US. The opposite could be true for developing countries.

We use a measure of the quantity of material imports instead of prices in our next regression to explore this result a little more. Our measure is the share of imported materials in gross output. The results are reported in the next column of table 4b. As expected, we find that the share of imported materials on gross output is negatively related to the share difference between skilled and unskilled labor. The coefficient is significant at the 10% level.[15] It supports the results of our earlier regressions. This result goes against the assumption of the value added function that materials do not affect the relative shares of skilled and unskilled labor. Moreover, a test of separability rejects the null hypothesis that the separability restrictions hold, showing that using the gross output framework and incorporating the role of materials make a difference.

One issue that needs to be addressed is the role of policy change since this was a period of reforms. While the most dramatic reforms, e.g., trade liberalization and changes in the labor market legislation preceded the years of our study we are looking at, there were smaller changes in trade and labor regulations towards the beginning of our sample period. It is also possible that the effects of policy reforms take place with a lag and

[15] This is interesting since other studies have found imported materials in developing countries to be positively related to the demand for skilled labor (imported materials is interpreted as an indicator of technology in these studies). Hanson and Harrison (1999), using plant level data for Mexico, find relative employment of skilled labor to be positively related to the share of imported materials in total material use. Pavcnik (2003), using plant level data for Chile, also finds that the wage share of skilled labor is positively related to the imported material share. However, the coefficient becomes insignificant and negative once plant level dummies are included in the regression. It is not clear why the results for Peru are different but it does imply that trade could not have led to the higher inequality via this mechanism.

responses of the firms occurred during this period. Therefore, we also include tariff rates and year dummies (instead of the time trend) to capture the effects of these policy changes. The tariff rates capture the effects of trade legislation. The year dummies are meant to capture the effects of changes in labor market legislation since they are economy wide changes and are not industry specific. The year dummies can also capture trade policy changes that are not industry specific. The two wage variables, included in the previous regressions as controls, are the ratios of the wage to price of domestic materials for skilled and unskilled workers. The wages do not vary across industries in a given year, as mentioned before, and therefore would be perfectly collinear with the year dummies. However, the prices of domestic materials do vary across industries and this was included as a control instead of the wage variables in the regressions with year dummies. As we can see from equation (2”), the coefficient for the price of domestic materials in these regressions should be interpreted as the negative of the sum of the coefficients of the two wage variables.

The results are reported in the third regression in table 4b. The capital variable is still strongly significant. The coefficient stays about the same in size. The coefficient of the price of imported materials decreases and it is not significant. The tariff rate is positively related to the difference between white and blue collar shares but it is not significant. The positive effect of tariff rates on the gap between white and blue collar share indicates that trade liberalization may increase the share of unskilled labor. This could be because more skilled labor or capital intensive activities in the production process can now be done abroad and these skilled labor/capital intensive inputs can now be imported under the more liberal trade regime. Feenstra and Hanson (1996) point out that such “outsourcing” activity can have an impact on measured productivity (an increase in A in terms of equation 2) and such productivity improvements will behave like factor biased technological change[16]. Our price index of imported materials may not adequately capture the effects of these changes since they are based on 1994 shares of various inputs and these shares may changed subsequently due to lower trade barriers.

One potential problem with our analysis could be endogeneity of our capital stock variable. It is possible that productivity shocks that are industry and time specific could be correlated with investment (shocks that are purely industry specific or purely time specific have been controlled for with the industry and year dummies). As mentioned before, the capital stock is beginning of the year capital and therefore should be independent of any shocks during the course of the year. However, if there is serial correlation in these shocks then there might be contemporaneous correlation between the capital stock and the error term.

In order to take account of this possibility we use instrumental variable estimation in the last regression of this table. Good instruments are not easily available. It is realistic, however, to assume that capital accumulation in an industry depends on the general availability of capital in the economy. Therefore, the total capital stock in Peru would be a reasonable instrument. It is also unlikely to be correlated with shocks that are industry specific. In order to introduce industry variation in the instrument, we multiply total

[16] In their case, outsourcing would decrease the share of unskilled workers and increase the share of skilled workers since they were looking at the US, which should be skilled labor abundant.

capital with the 1994 shares of each industry in Peru's total capital stock. 1994 is the year preceding our sample period. The idea is that industry shares in Peru's capital should not change much and total capital in a given year should be allocated among industries according to these shares approximately. That is, total capital multiplied by these shares should be a good predictor of the actual capital stock in an industry. Ideally we would take these shares from a year or period many years prior to our sample period so that it would be very unlikely that, even in the presence of serial correlation, shocks during the years in our sample would be correlated with shocks in the year from which the shares were obtained (since these shocks could influence these shares). This is not possible for us since 1994 is the first year of data that we have. However, the fixed effects in our model should take care of any correlation between shocks in 1994 and shocks during our sample period.

The results from the IV estimation are reported in the last column of table 4b. As we can see, the coefficient and standard errors change little. Capital continues to be significant.

We next run the system of equations described by (2") using iterative SURE. We include year dummies and the tariff rate. The results for the skilled and unskilled wage share equations are reported in the first two columns of Table 4c. Both skilled and unskilled wage shares are positively related to the capital to output ratio. However, the coefficient is not significant in the case of the unskilled wage share and the point estimate is higher in the skilled wage share regression. The difference in the estimates between the skilled and unskilled wage share is a little more than 0.01, which is consistent with the results of estimation of equation (5) involving the difference in shares reported in table 4b. The relative price of imported materials is positively related to shares of both types of labor but the coefficients are similar in size. This is again consistent with results reported in the third regression in table 4b where price of imported materials is not significantly related to the difference in shares. The tariff rate has no significant effect on the white collar share but it does have a significant and negative effect on the share of blue collar workers. This again is consistent with the hypothesis that, in developing countries, trade liberalization allows the outsourcing of activities in an industry that are intensive in factors other than unskilled labor (such as capital or skilled labor) and therefore increases the share of unskilled labor.

The last two columns report the results with instrumental variables using three stage least squares. The coefficients and standard errors change very little. The capital to output ratio is now significant in the unskilled wage share regression but the coefficient continues to be much smaller than that in the skilled wage share regression. Tariffs have a negative effect on unskilled labor share confirming previous results.

V. Conclusion

We show in this paper that there has been a significant shift in demand in favor of skilled workers in Peru during the latter half the 1990s. We find that trade in final goods or changes in the share of temporary workers resulting from reforms are not able to explain this shift. We show that *within* industry changes explain the increase in the demand for skilled labor. We analyze the determinants of these *within* industry changes in the share of skilled labor. We use a gross output framework to incorporate the role of materials. Capital intensity is positively related to the share of skilled labor. There is some evidence that increased availability of imported materials decreases the relative demand for skilled workers, perhaps because materials that are imported into a developing country such as Peru embody skilled labor. Our main results are robust even after we introduce tariff rates and year dummies to capture trade and labor reforms. In addition, we use an industry-weighted capital stock as instrumental variable to correct for endogeneity. Tariffs rates are negatively related to the unskilled labor share.

One implication of our results is that trade either in final goods or in material inputs is unable to explain the increased demand for skilled labor. However, if the higher accumulation of capital was partly due to trade liberalization then that could be one mechanism via which trade may have led to higher skilled labor demand.

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Table 1

	1995	**1996**	**1997**	**1998**	**1999**	**2000**
Skilled to unskilled wage ratio	2.24	2.18	2.35	2.34	2.48	2.53
Skilled to unskilled employment ratio	0.69	0.689	0.678	0.669	0.678	0.675
Skilled share in wage bill	0.607	0.601	0.615	0.611	0.627	0.630
Skilled real annual wages (1994 nuevos soles)	17865	17473	18535	18616	19065	19552
Unskilled real annual wages (1994 nuevos soles)	7973	7985	7869	7941	7699	7741
Skilled share in wage bill adjusted for temporary workers	0.567	0.557	0.576	0.572	0.585	0.581
Share of temporary workers in wage bill	.067	.075	.064	.063	.067	.079

Table 2

		1995		
ISIC	**Sector**	**Employment Share (%)**	**Skill Intensity (skilled labor/total employment)**	**Skilled Labor Share in Wage Bill (%)**
15	Food products and beverages	23.0	0.41	59.5
24	Chemical and chemical products	9.7	0.51	74.3
18	Apparel	8.0	0.36	48.3
28	Fabricated Metal Products	7.6	0.39	54.3
26	Other non metallic mineral products	6.3	0.34	51.3
17	Textiles	6.1	0.35	53.7
22	Publishing, printing and reproduction	5.8	0.47	66.8
25	Rubber and plastic products	5.7	0.42	61.9
36	Furniture	5.4	0.38	54.6
27	Basic Metals	2.5	0.38	56.5

ISIC	**Sector**	**Change in Employment Share 1995-2000 (%)**	**Change in Skilled Labor Share in Wage Bill 1995-2000(%)**
15	Food products and beverages	-0.3	3.8
24	Chemical and chemical products	-1.2	6.2
18	Apparel	3.2	-0.7
28	Fabricated Metal Products	-0.3	0.4
26	Other non metallic mineral products	-0.8	2.9
17	Textiles	1.9	-3.4
22	Publishing, printing and reproduction	0.2	2.5
25	Rubber and plastic products	0.1	1.6
36	Furniture	0.1	2.2
27	Basic Metals	-0.6	5.6

Table 3a. Descriptive Statistics

	Mean	Standard Deviation	Minimum	Maximum
Skilled share in wage bill	0.58	0.11	0.27	0.92
Skilled to unskilled workers relative wage	0.87	0.04	0.81	0.94
Ln(capital/value added)	0.22	0.81	-6.1	4.23

Table 3b.

Dependent Variable: Skilled Labor Share in Wage Bill (with Industry Dummies)			
	Reg. 1	**Reg. 2**	**Reg. 3**
Relative wage		0.11* (0.06)	0.008 (0.117)
Ln(capital/value added)		0.009 (0.006)	0.009 (0.006)
Time	.004*** (.001)		0.003 (0.003)
R^2 (adjusted)	0.77	0.77	0.77
N	552	552	552

Note: Numbers in parentheses are standard errors.
* significant at 10 percent level. *** significant at the 1 percent level.

Table 4a. Descriptive Statistics

	Mean	Standard Deviation	Minimum	Maximum
Skilled share – unskilled share in payments to variable factors	0.027	0.048	-0.18	0.28
Skilled share in payments to variable factors	0.093	0.046	0.008	0.32
Unskilled share in payments to variable factors	0.067	0.039	0.011	0.29
Imported materials share in payments to variable factors	0.18	0.15	0	0.62
Ln (skilled wage/ price of domestic material)	0.22	0.09	-0.16	0.44
Ln (unskilled wage/ price of domestic material)	0.087	0.074	-0.365	0.292
Ln (price imported mat./price domestic mat.)	0.023	0.08	-0.347	0.53
Ln (capital/gross output)	-1.13	0.76	-6.9	0.52
Imported materials share in gross output	0.11	.10	0	.49

Table 4b.

	OLS	OLS	OLS (includes year dummies)	IV (includes year dummies)
	Dep var: Skilled - unskilled share in payments to variable factors	**Dep var**: Skilled - unskilled share in payments to variable factors	**Dep var**: Skilled - unskilled share in payments to variable factors	**Dep var**: Skilled - unskilled share in payments to variable factors
Ln(Skilled wage/ price of domestic material)	-0.029 (0.052)	-0.016 (0.05)		
Ln(Unskilled wage/ price of domestic material)	-0.004 (0.052)	0.003 (0.05)		
Ln(price domestic materials)			0.004 (0.04)	0.005 (0.04)
Ln(price imported mat./ price domestic mat.)	0.039 (0.024)		0.006 (0.03)	0.008 (0.03)
Imported materials share in gross output		-0.049* (0.026)		
Ln(capital/gross output)[a]	0.011*** (0.003)	0.011*** (0.003)	0.012*** (0.003)	0.01*** (0.003)
Tariff			0.002 (0.001)	0.002 (0.001)
Time	0.001 (0.001)	0.0007 (0.001)		
R squared	0.77	0.778	0.81	0.83
N	552	552	546	544

Note: Numbers in parenthesis are standard errors.
***, ** and * significant at 1, 5 and 10 percent levels respectively.
[a] Instrumental variable for regression in column 4.

Table 4c.

	Iterative SUR		**Iterative Three Stage Least Squares**	
	Dep var: Skilled share in payments to variable factors	**Dep var**: Unskilled share in payments to variable factors	**Dep var**: Skilled share in payments to variable factors	**Dep var**: Unskilled share in payments to variable factors
Ln(price domestic materials)	-0.002 (0.03)	-0.007 (0.03)	-0.002 (0.03)	-0.007 (0.03)
Ln(price imported mat./ price domestic mat.)	0.036 (0.03)	0.03 (0.02)	0.037 (0.03)	0.03 (0.02)
Ln(capital/gross output)	0.016*** (0.003)	0.004 (.003)	0.016*** (0.003)	0.005* (0.003)
Tariff	-0.0001 (.001)	-0.002** (0.001)	-0.0001 (.001)	-0.002** (.001)
R squared	0.8	0.79	0.8	0.79
N	546	546	544	544

Note: Numbers in parenthesis are standard errors.
*** and * significant at 1 percent and 10 percent levels respectively.

Figure 1. Evolution of Factors of Production (1994=1)

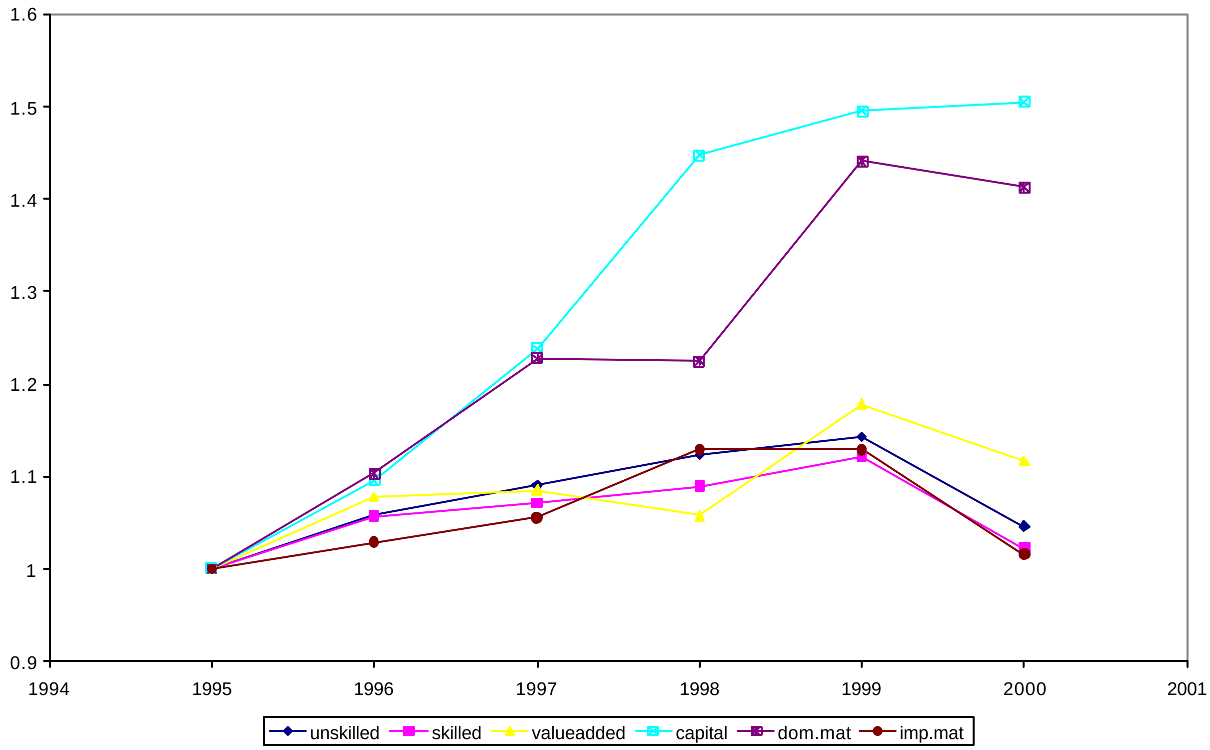

Figure 2. Correlation Between Skilled and Unskilled Wage Share Difference and Capital Intensity