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**The Role of Intermediate Goods and Some Evidence from Peru**

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# Trade and the Skill Premium in Developing Countries: The Role of Intermediate Goods and Some Evidence from Peru

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**Abstract:** The rise in income inequality in developing countries after trade liberalization has been a puzzle for trade theory, which predicts the opposite effect. The authors present a model with imported intermediate goods in which the relative wages of skilled labor can rise due to higher imports of inputs or due to skill-biased technological change. The evidence from Peru in the post-liberalization phase in the early 1990s supports the skilled-biased technological change hypothesis. The authors find that most of the decrease in the blue-collar wage share in the manufacturing industries can be explained by the increase in machinery imports that followed liberalization, suggesting that the skilled-biased technology is embodied in imported machinery.

JEL classification: F16, J31, 033, 054, 015

Key words: income distribution, machinery imports, trade liberalization, wage differentials, Peru

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**Trade and the Skill Premium in Developing Countries:**
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## 1. Introduction

Since the 1980s, the occurrence of increasing wage inequality along with rising volume of trade in developed countries has led to a debate about the impact of international trade on the changing wage structure. While economists argue about the quantitative impact of trade, they agree that trade can lead to higher income inequality in a high-income nation (the Stolper-Samuelson theorem). On the other hand, conventional trade theory predicts that trade will lead to lower income inequality in developing countries. Unfortunately, that prediction has not been borne out. Studies of developing countries find that trade liberalization episodes have been accompanied by rising wage inequality.

There are fewer studies of developing countries compared to the literature on developed countries. Robbins (1996) in a study of developing countries in Latin America, East and South-East Asia finds that wage differentials have risen in many developing countries with high trade exposure. Using household data, he finds that trade liberalization has been accompanied by rising relative wages and demand for skilled-labor in Argentina, Chile, Costa Rica, Colombia, Malaysia, Mexico, the Philippines, Taiwan and Uruguay, contradicting the predictions of traditional trade theory. Robbins suggests that adoption of skill intensive technology via capital goods imports is responsible for rising inequality and finds some evidence for this using data on aggregate machinery imports.

Wood (1997) compares the experience of Latin America since the mid-1980s with that of East Asia in the 1960s and 1970s. He points out that while the wage gap between skilled labor and unskilled labor narrowed in the four tigers (Hong Kong, the Republic of Korea, Singapore, and Taiwan) in the initial decades of export-oriented industrialization, wage differentials have risen in many of Latin American countries following their trade liberalization episodes. He suggests that the difference in experience is due to the entry of China and other large developing countries into the world market and the introduction of skilled-biased technology since the 1980s. Davis (1996) makes a similar argument and shows in a model with multiple diversification cones that local factor abundance, instead of global factor abundance, is central to determining the income distributional effects of trade liberalization. Also, Hanson and Harrison (1999) provide evidence suggesting that rising wage inequality in Mexico may have been due to import competition in low skill intensive industries.

There are other possible explanations for this phenomenon. Feenstra and Hanson (1996, 1997) hypothesize that activities transferred from the north to the south are more skilled-labor intensive than those formerly produced in the south, but less skilled-labor intensive than those in the north. They argue that capital flows from the north to the south increase the relative demand for skilled labor in both the north and the south. They find evidence for this using regional data for Mexico.

One mechanism that has been relatively unexplored is the role of imported machinery and more generally of imported intermediate goods (with the exception of Robbins, discussed above). This is a bit odd since the bulk of world trade is in intermediate goods. One straightforward way in which imported machinery (or intermediate goods) could increase the skill premium in developing countries is if they embody a technology that is biased in favor of skilled labor. There is some evidence in favor of skill biased technological change in industrialized countries. Moreover, as Berman and Machin (2000) point out there is evidence for this in middle-income countries too. Using data on employment ratios they provide evidence for a shift in favor of non-production workers. There has also been an increase in the wage bill share of non-production workers. Also, changes in the wage bill share of industries are correlated across countries indicating that skill biased technological change tends to take place in the same industries globally.

However, imported intermediate inputs can affect the skill premium even if the skill bias of the technology does not change. For example, if only the skilled labor intensive sector has access to imported intermediate inputs and the imports of these increase after trade liberalization, then the skill premium could increase. The conventional predictions in trade theory regarding the effects of trade on the prices of different factors of production (e.g., skilled labor, unskilled labor, etc.) assumes a simple framework with only final goods and no impediments to trade. However, if production uses intermediate goods and all intermediate goods are not traded freely, then both the pattern of trade and the effect of trade on skilled and unskilled labor become difficult to predict. Deardorff (1979) made this point with the help of an example. In this case the effect of trade on the wages of skilled and unskilled workers may be contrary to what we expect from more conventional models. For more recent analyses of the case with intermediate goods trade see, for example, Deardorff (2001) and Jones (2000a).

In this paper we present a simple framework for analyzing the effects of intermediate goods imports both when it leads to skilled biased technological change and when it does not. It is important to distinguish between these two scenarios because they have different implications for what happens to the real wage of unskilled labor. While the skill biased technology story implies that imports of intermediate goods could reduce real wages, the simple imported inputs story has the implication that real wages of unskilled labor would rise although not as much as that of skilled labor. This has implications for how we view the inequality associated with globalization and how undesirable we think this trend in skill premium is.

We take into account the fact that the majority of unskilled labor is not in manufacturing but in traditional non-tradeable sectors, which are in general more unskilled labor intensive. The bulk of unskilled labor in developing countries is employed in family farms (some in rural non farm) and the urban informal sector (see World Development Report 1995)[1]. Rural employment is engaged mostly in food production either for subsistence or for sale in the domestic market. The bulk of urban informal employment falls in the category of the self employed, which includes mostly non-tradeable labor intensive activities (see World Employment Report 1998-99)[2]. Also, as one would expect, the average level of education is lower in the urban informal sector than in the formal sector[3].

We assume a developing country with two sectors - a traditional sector (e.g., labor intensive services) that is unskilled labor intensive and a modern sector (e.g., manufacturing) that is skilled labor intensive. The traditional sector does not use any (tradeable) inputs. This is a reasonable assumption for labor-intensive activities in the urban informal sector. We also assume that the traditional good is not tradeable (based on the discussion in the previous paragraph). The modern sector uses inputs that embody technology. The developing country cannot produce the tradeable intermediate goods because of lack of technological know-how.

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[1] In poor countries, almost 83% of the labor force is in this sector; in middle-income countries, the corresponding proportion is about 50.

[2] These activities include domestic help, shoe shining and repair, street vending, rickshaw pulling (in some countries), haircutting, electronic repair services, meat preparation etc. In 1996, about 65% of the urban informal employment in Peru was in the self employed category (see ILO, World Employment Report 1998-99); about 86% of the self employed were ``own-account" workers, i.e., persons engaged in a business but who did not hire any employees (see ILO, 1999). A relatively small fraction of the urban labor force (about 16%) was engaged in the informal "micro enterprises" that could potentially be producing tradeable goods. Urban informal employment was 50% of total urban employment (the proportion for unskilled labor is likely to have been higher).

[3] Studies of the informal sector in Thailand, Paraguay and Tanzania show the concentration of poorly educated in this sector (see World Employment Report, 1998-99).

The paper is organized as follows. Section 2 describes the basic model in which intermediate imports lead to an increase in the skill premium without involving a skill biased technological change. It also explores the effects of a skill biased technological change within the same framework. The implications for the real wage under the two assumptions are also discussed. Section 3 describes developments in Peru in the 1990s and the trends in relative wages. Section 4 describes the data and the estimation results. Section 5 concludes.

## 2. The Model

Consider the following simple model. Assume there are two final goods - a traded good X (the modern industry) and a non-traded good Y (the traditional industry) and a traded intermediate good T (traded). All of T is imported in the developing country. The assumption here is that the developing country lacks the factor to produce the intermediate goods. There are two primary factors of production - S (skilled labor) and L (unskilled labor). We will assume that these factors are also exogenously given. We assume that X is the skilled labor intensive good and Y is the unskilled labor intensive good. Unskilled labor is mobile between the two sectors.

We will assume that there are trade barriers on the import of the intermediate good and a movement towards free trade will increase these imports[4]. Let the production functions be of the following form:

$$X = A_x T^a S^b L_x^{1-a-b}$$

and

$$Y = A_y L_y$$

where $L_x$ and $L_y$ are the labor employed in the $X$ and $Y$ industry, respectively.

[4] In the real world a rationale for these barriers could be balance of payments concerns.

We assume that utility is homothetic with share γ spent on *Y* and the rest spent on *X*. We will assume that $\gamma'(p_x/p_y)>0$. Using the fact that production has to equal consumption in the non-traded sector, we get (for the developing country)[5]

$$\frac{p_x X}{p_y Y} = \frac{1-g}{(1-a)g} \tag{1}$$

Using the unskilled labor shares in the two industries and equation (1) above, we get

$$\frac{L_x}{L_y} = (1-a-b)\frac{1-g}{g(1-a)} \tag{2}$$

Using the fact that the marginal revenue product of unskilled labor in the two sectors will equal its wage, we get

$$\frac{p_x}{p_y} = \frac{1}{1-a-b}\frac{A_y}{A_x}\left(\frac{L_x}{T}\right)^a\left(\frac{L_x}{S}\right)^b \tag{3}$$

Using the shares of skilled and unskilled labor in the *X* industry we get

$$\frac{w_S}{w_L} = \frac{b}{1-a-b}\frac{L_x}{S} \tag{4}$$

Equations (3) and (2) imply a positive and negative relationship between $L_x$ and $p_x/p_y$, respectively (shown in figure 1).

**Intermediate imports without skill biased technological change**

An increase in *T* shifts the curve (implied by (3)) downwards leading to a decrease in $p_x/p_y$ and an increase in $L_x$ as shown in figure 1. This leads to an increase in $w_S/w_L$ as is obvious

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[5] The corresponding expression for the developed country would be $\frac{p_x X}{p_y Y} = \frac{1-g}{g}$. The difference comes from the fact that in the developing country only $(1-a)p_x X$ accrues as income to factors in the *X* industry. The rest is used to pay for the imports of the traded intermediate good that is obtained from the developed nation.

from equation (4). However, since $w_L = A_y p_y$, a decrease in $p_x/p_y$ will mean an increase in $w_L/p_x$, that is, an increase in the real wage in terms of the X good.

Note that intermediate imports behave like sector biased technological change[6]. It leads to an increase in the relative wages of the factor that is employed more intensively in the sector that experiences the technological improvement.

It can be shown that trade liberalization in this scenario will lead to a rise in the relative income of skilled workers in the (small) *developed* nation also (see Appendix A.1). That is, increased trade leads to higher inequality in both countries.

**Intermediate imports with skill biased technological change**

We can also analyze the effects of skill biased technological change within the same framework. We will assume that this new technology is embodied in imported inputs so that this change takes place only in the *X* sector. In order to contrast the effects of skill biased technological change from simple input imports of the previous sub-section, we will keep the quantity of input imports constant (i.e., *T* stays the same). In reality, and as we will assume for the empirical section, skill biased change is likely to be accompanied by increase in intermediate goods imports.

A skill biased technological change is said to have occurred if at the same relative wage the ratio of unskilled labor to skilled labor decreases. This implies that $\beta$ will have to increase (see equation (4)). Also, there should be a reduction in cost at initial factor prices. The reduction in costs in the *X* industry at initial factor prices is given by $q_{TX}\hat{b}_{TX} + q_{SX}\hat{b}_{SX} + q_{LX}\hat{b}_{LX}$ where $q$

[6] Jones (2000b) provides a lucid analysis of the effects of the sector biased and skill biased technical change in a general model with only traded goods. The analysis does not, however, incorporate intermediate goods imports or discuss explicitly the effects on the real wage. See also Xu (2001).

denotes factor share and $\hat{b}$ denotes the relative reduction in unit factor requirements at initial factor prices (see Jones 2000). This can be shown to equal $-\hat{b}b\ \log(L_x / S)$. This expression has to be positive implying a cost reduction (that is, $L_x/S$ has to be less than 1).

The effects of skill biased technological change are shown in figure 2. As is clear from equation (2), the AA curve shifts to the left. The BB curve could shift either way. If the BB curve shifts to the right then $p_x/p_y$ falls and we get the same effects on the real wage of unskilled labor as in the previous section. However, it is also possible for the BB curve to shift to the left. If the shift in BB to the left is large enough then $p_x/p_y$ will rise and the real wage of unskilled labor will fall. This will occur when the horizontal shift of the BB curve is greater in magnitude than the horizontal shift in AA (the positively sloped line in figure 2 between BB and B'B' shows the position of BB if the horizontal shift was the same as in AA - in this case $p_x/p_y$ would stay unchanged). This will be the case if the following condition is satisfied (see appendix A.2).

$$-\log(L_x / S) < \frac{L_x}{L}\frac{a+b}{1-a-b}+1 \tag{5}$$

A sufficient condition for the inequality to hold is if $-\log(L_x/S) < 1$. Since changes in the value of $A_y$, $A_x$ and $T$ change the equilibrium value of $L_x$ (at the same level of S), $p_x/p_y$ will rise for values of these three parameters that lead to values of $-\log(L_x/S) < 1$. A greater horizontal shift in BB leads to a rise in $p_x/p_y$ and a fall in $L_x$.

The inequality (5) can also be derived using the Jones (1965) methodology. It can be shown using the Jones framework that $p_x/p_y$ will increase (or $\hat{p}_x - \hat{p}_y > 0$, where the ^ denotes growth rates) if the following condition holds

$$\frac{d_L + d_S}{1-q_{LX}} < -\frac{[(\Pi_s - A)-(\Pi_L - B)]}{(\Pi_X - C)} \tag{6}$$

where,

$$d_L \equiv l_{LX} q_{SX} s_{SLX} + l_{LX} q_{TX} s_{TLX}$$

$$d_S \equiv q_{LX} s_{SLX}$$

$$\Pi_S \equiv \hat{b}_{SX}$$

$$\Pi_L \equiv l_{LX} \hat{b}_{LX}$$

$$\Pi_X \equiv q_{TX} \hat{b}_{TX} + q_{SX} \hat{b}_{SX} + q_{LX} \hat{b}_{LX}$$

$$A \equiv l_{LX} q_{TX} (s_{TLX} / s_{STX})(\hat{b}_{SX} - \hat{b}_{TX})$$

$$B \equiv q_{TX} s_{STX} (\hat{b}_{SX} - \hat{b}_{TX})$$

$$C \equiv (q_{TX} / s_{STX})(\hat{b}_{SX} - \hat{b}_{TX})$$

$$l_{LX} \equiv L_x / L$$

and $s_{ijX}$ denotes the elasticity of substitution between factors *i* and *j* in sector *X*.

$P_S$ and $P_L$ have the same interpretation as in Jones - they are measures of overall factor (S and L, respectively, in this model) saving features of technological change. $P_X$ is a measure of the technological change in the *X* industry (same as Jones). The inequality above is not exactly analogous to the corresponding expression in Jones because of the presence of three factors and other special features of this model. The condition above is more likely to hold if the technology is more unskilled labor saving than skilled labor saving and if the overall technological improvement (or cost saving at initial factor prices) in the *X* industry is small. It can be shown that the condition (6) will hold if the inequality (5) is satisfied.

It can be shown that an increase in $p_x/p_y$ will also lead to an increase in the skill premium or $w_S/w_L$ (see appendix A.3). Also, a rise in $p_x/p_y$ will lead to a fall in the real wages of unskilled labor in terms of the $X$ good (since $w_L=A_yp_y$). Therefore, the implications of skill-biased change for the welfare of unskilled labor are different from the simple intermediate goods imports story described in the previous subsection. While the latter story implies that unskilled labor suffers a wage decline in relative terms but an *improvement* in absolute terms, the skilled biased story could imply a wage decline in both absolute and relative terms. Other empirical implications are also different. Skill biased technological change should be accompanied by a decrease in the ratio of unskilled to skilled workers while the simple intermediate goods story would imply an increase in this ratio. Also, the former implies that unskilled labor share of the wage bill should decrease while the latter story implies no changes in wage shares. We will use these implications to distinguish the two hypotheses.

## 3. The Peruvian Experience

Peru was a relatively open economy in the 1950s and 1960s with exports mostly consisting of primary goods. It experienced more or less steady growth from 1950s to mid 1970s. It implemented import substitution policies in the 1970s. From the mid 1970s onwards there was a steady decline in per capita GDP so that per capita GDP in 1990 was no higher than in 1960. It suffered the debt crisis in the 80s and hyperinflation between 1988 and 1990.

Fujimori came to power in 1990 and implemented wide-ranging structural reforms including trade liberalization. His government eliminated price controls, subsidies, and foreign exchange restrictions. A flexible exchange rate was adopted in August 1990, and foreign exchange surrender requirements and foreign currency restrictions were abandoned in March 1991. At the same time, the average level of tariffs was reduced sharply, from 66 percent in 1989 to 15 percent in 1995 and 12 percent in 1997. Tariff reform in September of 1990 led to three tariff rates – 15 percent on inputs without domestic substitutes (e.g., basic steel industry capital goods for industry, metal-mechanic, medical equipment, some medicines, parts for vehicles and tires); 25 percent for the rest of the capital goods and inputs with domestic protection and also for agricultural goods intended for final consumption and 50 percent for the rest of the consumption goods, inputs and capital goods (these included goods which previously enjoyed tariff rates greater than 50 percent). Import prohibitions, which were extensively used in the 1970s and the late 1980s, were gradually abandoned. The only import prohibitions that remained were for public health and security. Export restrictions were eliminated for most exports in 1991.

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 (average annual rate of around 20 percent) in the following five years. Both imports and exports showed dramatic increases after the liberalization. Intermediate goods imports also rose sharply (see figure 3).

There were other important changes associated with the stabilization program that are relevant for our study. Fujimori introduced dramatic changes in labor legislation and passed a labor law in 1995 that abolished the right to job security and also reduced severance payments that had to be paid to a worker upon dismissal. Also, there was a substantial privatization drive in the 1990s especially in 1995 and 1996. Most of the privatizations were in mining, fishing, banking and utilities (electricity and telecommunications).

The trends in relative wages are shown in table 1 and figure 4. Salaries and wages in figure 4 are the payments to white and blue-collar workers respectively. Table 1 reports the average annual wages in real terms of different categories of workers in 1991, 1994 and 1997 that have been computed using the labor survey described below. The increase in executive salaries was around an average of 22 percent per year while that of white-collar and blue-collar workers was around 8 and –4 percent, respectively, on average per year during this period.

**4. Data and Estimation**

We use data from the Labor Survey in Metropolitan Lima by the Labor Ministry in Peru. Lima accounts for 85 percent of the industrial sector in Peru and the Labor Survey covers all formal firms in Metropolitan Lima. In this sense, the sample is quite representative of Peru. The Labor Ministry conducts the Labor Survey 4-5 times each year. All formal firms in metropolitan Lima are required to respond and turn in reports about their total employment and payroll. We have used the surveys for 1991, 1994 and 1997.

The survey reports wage and employment information for the three categories of workers - executives (ejecutivos), white collar (empleados) and blue collar (obreros). Since the total working hours and extra (overtime) working hours are recorded for blue collar employees, the hourly wage is computed as the total payment divided by the sum of total working hours and extra working hours. The monthly wage is obtained by multiplying the average hourly wage by 192 (assuming a 48 hour work week). For white-collar employees and executives, the monthly wages are simply the total payments to the two categories of workers divided by the total number of employees respectively. The annual wages are obtained by multiplying the monthly wages by 12. We will interpret the executive to blue-collar wage ratio and white to blue-collar wage ratio as the ratio of wages of skilled workers to unskilled workers.

One can get a few clues regarding what is happening if one looks at the data on the two broad sectors - manufacturing and services. There was a sharp decrease in the share of manufacturing in blue-collar employment in Peru between 1991 and 1997, as we show in table 2A.The shares of manufacturing in white collar and executives employment do not exhibit any definite trend. The fall in share of manufacturing in blue-collar employment did not occur because of a decrease in the overall importance of the manufacturing sector in the economy. We can see from this table its share in the total wage bill or its share in GDP (first two rows of numbers) did not change much. Since the share of blue-collar employment in manufacturing fell without a significant decrease in the share of manufacturing in total wage bill, we would expect the blue-collar share in the wage bill to fall in manufacturing. In fact, that is what we observe (see second row of table 2B). The blue-collar share in the wage bill in this sector shows a substantial decline of 18 percentage points between 1991 and 1997. We would also expect the ratio of blue-collar employment to white collar and executive employment to fall in manufacturing. This ratio declines substantially (34 percent) as one can see from the same table.

The blue-collar share in the wage bill in the service sector, on the other hand does not show much change (there is a small decrease). The ratio of blue to white-collar employment shows a substantial rise of more than 100 percent in the service sector during the same period. This suggests that the service sector is absorbing the excess unskilled labor displaced from the manufacturing sector. A rise in blue-collar employment with a small decrease in their wage share would suggest that the average wages of blue collar in the service sector should fall or (at least not rise too much). That is what we observe. Blue-collar wages in the service sector actually show a decline in real terms of 52 percent, during this period. The picture that emerges from this table is the following. Although manufacturing did not lose its importance during this period, there was a biased shift in favor of skilled labor, perhaps due to technological change. The excess supply of unskilled labor created by this shift was absorbed in the service sector, depressing wages in this sector.

We now explore changes at the industry level. We use the data from 1994-1997 in order to do this. This is because there was a change in the industry classification system in 1991, which makes it difficult to compare data from 1991 with the other years. The classification for 1994 and 1997 is the same and corresponds to ISIC (Revision 3). We will use the data from 1994 and 1997 only for all subsequent analysis as well as the regressions. We believe that the study of the 1994-1997 period would still shed light on the processes that started in 1991 as a result of liberalization. This is because the trends in blue collar employment in manufacturing and the blue collar wage share in this sector that started in 1991continued during the 1994-1997 period, as is clear from tables 2A and 2B.

Since it is the manufacturing sector that has experienced a big drop in blue-collar share, we focus our attention on industries in this sector only for all subsequent analysis[7]. Some of the highest growth rates in white collar and executive wages during the 1994-1997 period were to be found in the manufacturing industries. In fact, real executive wages increased at a faster rate in the manufacturing sector compared to the services sector. The industries that show very high white-collar wage growth rates are ISIC 1513 (processing of fruits and vegetables), 2422 (paints, varnishes. coatings, printing ink), 2694 (cement, lime and plaster), 2922 (machine tools), and 5239 (other retail sale in specialized stores). Some of the same industries like 2422, 2694, and 2922 also show large growth in executive wages.

Industries at the input-output (IO) category level that have experienced large changes in the blue-collar wage share (greater than 5 percentage points) in the manufacturing sector are shown in table 3. The top half includes industries that have experienced increases in the share

[7] We included electrical power and water and construction in our sample although they may not be considered strictly manufacturing because these sectors are likely to use blue-collar workers intensively. All mining sectors were excluded because workers in these sectors who work in Lima are unlikely to be representative of the mining industry as a whole.

such as textiles and footwear, which are unskilled labor-intensive industries. As is clear from the table, the largest decreases in the blue-collar wage share have occurred in the less unskilled labor-intensive industries like paper and paper products, pharmaceuticals and machinery industries. The correlation between changes in the blue-collar wage share over this period and the initial (i.e., 1994) white to blue employment ratio is –0.51 suggesting that skill biased technological change (as measured by changes in the blue collar share) occurred in the more skill intensive industries. This is interesting and contrary to what we would expect if we thought that competition from very low-income countries in Asia in labor-intensive industries was behind the decreasing blue-collar relative wage in Latin America. In fact, the garment industry, which is perhaps most likely to face competition from cheap Asian labor (and accounted for 7 percent of the blue collar work force in the sample), experienced an increase in its blue-collar employment of about 15 percent in the 1994-97 period.

The decrease in real wages of unskilled workers, the drop in their share in the wage bill in manufacturing and the decline in the blue to white employment ratio provides evidence for skill biased technological change, according to our theory. Machinery imports are most likely to be the driving force behind such change since they are likely to embody new technology. If the skilled biased technological change were taking place via machinery imports then we would expect changes in the blue-collar wage share and white to blue employment ratio to be correlated with machinery imports at the industry level. We explore this relationship further using data on machinery imports. The data on imported machinery by industry was not available for Peru for all years. It was available for 1994 at the IO level industries from Peru's 1994 input-output table. We used this data to form estimates for 1997 using trade data available from the UN International Trade Statistics by assuming that the share of industry *i*'s imports of machinery in total machinery imports stays constant over time. We also form estimates of total intermediate good usage for 1997 by assuming that the use of any good in any industry increases in the same proportion as the value added in that industry. The data for value added by industry comes from the Compendio Estadistico published by INEI (Instituto Nacional de Estadistica Informatica).

We focus our analysis on three variables - the blue-collar wage share, the ratio of white-collar employment to blue-collar employment and the ratio of white-collar wages to blue-collar wages. Table 4 gives a few correlations at the IO industry level. It gives the correlations of changes in these variables with changes in the share of imported machinery in total intermediate goods usage. Two thirds of total machinery imports went to the manufacturing sector in 1994. Blue-collar wage share is negatively correlated with imported machinery while the white-collar to blue-collar employment ratio is positively correlated. The positive correlation suggests that skill-biased technological change is at work here. The decrease of the real wage of unskilled workers (shown in table 1) is also consistent with this hypothesis. The changes in the wage ratio are very weakly correlated with changes in the share of imported machinery. This may be due to labor mobility across industries that would tend to dampen wage differences across industries for the same category of workers.

We use panel regression with fixed effects to test the relationship of our key labor variables with our trade variables. Specially, we regress our three variables of interest, the blue collar wage share, white to blue employment ratio and the white to blue collar wage ratio on the share of imported machinery in total intermediate goods. The control variables in the regression attempt to capture the effect of other variables that may affect the blue-collar wage share (and the other dependent variables of interest). These include unionization variables for blue- and white-collar workers, export and import share, investment and privatization.

The unionization variable is the proportion of firms in an industry that have some collective bargaining arrangement. This data comes from the labor survey. The export and import shares are the ratios of exports and imports of the good produced by an industry to total value added of that industry. Import penetration can potentially have an effect on the premium if there is competition from countries with lower wages and larger pools of unskilled labor (see, for example, Hanson and Harrison 1999). Skill premium may also be related to exports. Bernard and Jensen (1997) provide some evidence for this.

We follow studies of the skill premium in industrialized nations (see, for example, Berman, Bound and Griliches (1994), Machin and Reenen (1998) and Krusell, Ohanian, Rios-Rull and Violante (2000)) and try to control for capital skill complementarities in our regressions. The investment share in total intermediate goods at the industry level is used to capture this effect. Since we do not have data on investment by industry we have to rely on estimates. We have data on total machinery investment for the economy as a whole for our sample period from the Compendio Estadistico. We assume that the proportion of total machinery investment in any year that is allocated to an industry is the same as the share of machinery used by that industry in total machinery used at the intermediate stage in 1994 (this data is obtained from the input-output table of 1994). The investment share is this estimated amount of investment in an industry divided by total value of intermediate goods used by that industry[8].

We use two measures of imported machinery in our regression. One is the share of imported machinery in total intermediate goods. The second measure is the share of imported machinery in total machinery investment in that industry (the latter is estimated as mentioned above). The privatization variable is total sales since 1991 divided by the value added in that industry. This data also comes from the Compendio Estadistico. This variable is included to capture wage cuts and layoffs, especially of blue-collar workers, that may accompany privatization. Data on the imported machinery share, investment share and the privatization share are at the level of IO industries.

Table 5 gives the mean values of the variables to be used in our regression. Note the decrease in the blue-collar wage share and the increase in the ratio of white- to blue-collar wages and dramatic rise in executive to blue-collar wages between 1994 and 1997. Also note the steep fall in the ratio of firms with unions (both white and blue collar) during this period. The high mean values of import and export shares are being driven by a few industries. The large values in the case of the imports are due to high level of imports compared to domestic value added (this is true for more sophisticated goods). In the case of exports the high values in some industries arise due to the fact that export is a gross concept and includes the value of intermediate goods (produced by other industries) used in the production of value added in an industry.

Table 6 reports the results of the regressions. The top row shows the dependent variables in each regression while the first column shows the independent variables. As we can see from the first and second regressions, the share of imported machinery in total intermediate usage has a negative and statistically significant effect on the blue-collar wage share. The point estimate is also very high. It implies that a 1-percentage point increase in the share of imported machinery will decrease the blue-collar wage share by more than 7 and 10 percentage points respectively. This would imply that the increase in the share of imported machinery could explain the entire decrease in the blue-collar wage share over this period. The other variables in the regression are not significant. The blue-collar unionization rate has a positive effect; the white-collar unionization rate has a negative effect. The coefficient for privatization is positive but not

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[8] The results did not change much when we used investment as a fraction of value added.

significant. The investment share is positively related to the blue collar wage share implying that there are no capital skill complementarities and that unskilled workers actually gain relatively more from capital accumulation. This is different from the results of studies for developed countries where capital intensity is correlated with the share of skilled workers. This suggests that a different process may be at work in developing countries. Capital accumulation in these countries may be geared towards utilizing the more abundant factor - unskilled labor. The second regression introduces export and import shares. The imported machinery variable continues to be significant.

The third and fourth regressions use the share of imported machinery in investment as the independent variable. The investment share itself is a control in the regression. Therefore, this regression tests whether the composition of investment (imported machinery vs. domestic machinery) has an effect on the blue-collar wage share controlling for the investment share itself. This imported machinery variable again turns out have a negative coefficient. That is, a higher proportion of imported machinery in total investment does seem to reduce the blue-collar wage share. However, the coefficient is not significant when export and import shares are present (the fourth regression), although it has the correct sign.

Regressions 5 through 8 have the white-collar to blue-collar employment ratio as the dependent variable. If there were indeed a skill-biased technological change, we would expect this ratio to be positively related to imported machinery. As is clear from regressions 5 and 6, the share of imported machinery in total intermediate goods usage is positively and significantly related to the white to blue-collar employment ratio. Note that white-collar unionization has a negative effect on white-collar employment ratio in all these regressions. This could imply that unionization tends to reduce employment for white-collar workers. In regression 5, investment share is significant and negative supporting the idea that there are no capital skill complementarities and that unskilled workers actually gain relatively more from capital accumulation. Regressions 7 and 8 have the composition of investment as the independent variable. Again, the share of imported machinery in investment is positively related the white to blue employment ratio and the coefficient is significant at the 5 percent level. This variable is not significant when import and export shares are included.

The third dependent variable of interest is the white-collar to blue-collar wage ratio. The last two regressions in table 6 report the results of the regressions with the white-collar to blue-collar wage ratio as the dependent variable and the share of imported machinery in intermediate goods as the independent variable. The coefficient for the imported machinery variables is not significant in these regressions. We also ran the regressions (not reported) with the share of imported machinery in total machinery investment as the independent variable. The coefficient was not significant. The coefficients of the imported machinery variables are not significant in these regressions perhaps because inter industry labor mobility is dampening wage differentials across industries.

## 5. Conclusion

We present a model of a developing country in which the traditional sector is unskilled labor intensive and the modern sector is skilled labor intensive and also has access to imported intermediate goods that embody technological knowledge. The skill premium can rise either because imports of inputs in the skilled labor intensive sector increase or if imported inputs lead to skill-biased technological change. We test some of the implications of our theory using data from Peru and find that machinery imports are related to declining blue-collar wage shares and the decreasing ratio of blue collar to white collar employment. This provides support for the claim that skill biased technological change has taken place in Peru. The implication of this is that rising inequality has been accompanied by declining real wages for unskilled workers. In fact this is what we observe since the growth in wages of unskilled workers has not kept up with inflation. What is also interesting is that the skill-biased change seems to have taken place in industries that are less intensive in unskilled labor. This runs counter to the claim that such change in Latin America has been due to low wage competition from poorer Asian nations in unskilled labor-intensive industries.

## APPENDIX

*A.1 The Effects of Trade in a Small Developed Country*

The effect of a movement from autarky to free trade for a small-developed nation will imply a rise in $p_t/p_x$. The developed country will have endowments of the factor that can produce the traded intermediate good. Let us assume that one unit of this factor produces one unit of the intermediate good and gets paid $w_t$ $(= p_t)$.

A decrease in $T$ will lead to a rise in $p_x/p_y$ and a fall in $L_x$, i.e., labor employed in the $X$ industry (using the logic of the previous section). This will lead to a rise in $w_t/w_L$ and a fall in $w_s/w_L$ (since $L_x$ falls, equations (3) and (4) imply that $L_x/S$ has to fall and $L_x/T$ has to rise). In order to look at income distribution between the different groups we will assume that the factor required to produce the traded intermediate good is also skilled labor (of a different kind from $S$). The relative income between skilled labor and unskilled labor is therefore $(w_sS+w_tT)/w_LL$, where $T$ is the total endowment of the second skilled labor. Taking logs of this expression and totally differentiating we get,

$$d\log\frac{w_sS+w_tT}{w_LL}=\frac{w_sS(\hat{w}_s-\hat{w}_L)+w_tT(\hat{w}_t-\hat{w}_L)}{w_sS+w_tT} \tag{7}$$

where $\hat{w}_j = dw_j / w_j$

Using the fact that $S$ and some of $T$ is used to produce $X$ domestically, we can express

$d\log\frac{w_sS+w_tT}{w_LL}$ as follows

$$d\log\frac{w_sS+w_tT}{w_LL}>\frac{p_xX[b(\hat{w}_s-\hat{w}_L)+a(\hat{w}_t-\hat{w}_L)]}{w_sS+w_tT} \tag{8}$$

Using the profit maximizing conditions of the firm we get,

$$\hat{p}_x - \hat{w}_L = b\,(\hat{w}_s - \hat{w}_L) + a\,(\hat{w}_t - \hat{w}_L) \tag{9}$$

We know $\hat{p}_x - \hat{w}_L$ is positive as a result of trade liberalization. Therefore, the right hand side of the inequality (8) is positive.

That is, the income of skilled labor relative to unskilled labor increases as a result of trade.

A.2 *To derive the conditions under which the horizontal shift in BB is larger in magnitude than horizontal shift in AA*

The horizontal shift in AA is the change in $L_x$ keeping $p_x/p_y$ constant using equation (2). Taking logs and differentiating, we get

$$\left|\hat{L}_x\right| = \frac{\hat{b}b}{1-a-b}\frac{1}{\left(1+\dfrac{L_x}{L_y}\right)} \tag{10}$$

Similarly, taking logs and differentiating equation (3), assuming $p_x/p_y$ constant to get the horizontal shift in BB we get

$$\left|\hat{L}_x\right| = \frac{1}{a+b}\left[\frac{\hat{b}b}{1-a-b} + \hat{b}b\,\log(L_x/S)\right] \tag{11}$$

It can be shown easily that if the r.h.s. of equation (11) is greater than the r.h.s. of equation (10) then

$$-\log(L_x/S) < \frac{L_x}{L}\frac{a+b}{1-a-b} + 1 \tag{12}$$

A.3 *To show that an increase in $p_x/p_y$ is a sufficient condition for $w_S/w_L$ to rise*

Using the first order conditions in sector *X*, we get

$$\frac{w_S}{w_L} = b\ \frac{p_x}{p_y}\frac{A_x}{A_y}\left(\frac{T}{S}\right)^a \left(\frac{L_x}{S}\right)^{1-a-b} \qquad (13)$$

Taking logs and differentiating and substituting $L_x$ using equation (4), we get,

$$(a+b)(\hat{w}_S - \hat{w}_L) = (\hat{p}_x - \hat{p}_y) + \hat{b}[a - b\log(L_x / S)] \qquad (14)$$

Since $\hat{b}$ >0 and $-b\log(L_x / S) > 0$, $w_S/w_L$ will rise if $p_x/p_y$ increases.

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**Table 1. Average Annual Wages (in 1994 Nuevos Soles)**

| | 1991 | 1994 | 1997 | %1994-91 | %1997-94 |
|---|---|---|---|---|---|
| Blue Collar | 11490 | 11247 | 8712 | -2.1 | -22.5 |
| White Collar | 16415 | 24899 | 24452 | 51.7 | -1.8 |
| Executive | 51324 | 90788 | 140163 | 76.9 | 54.4 |

**Table 2A. Wages and Employment in Manufacturing**

| | 1991 | 1994 | 1997 |
|---|---|---|---|
| Share of manufacturing in total wage bill | 0.24 | 0.32 | 0.25 |
| Share of manufacturing in GDP | 0.32 | 0.36 | 0.35 |
| Share of manufacturing in total employment | 0.28 | 0.33 | 0.27 |
| Share of manufacturing in blue collar employment | 0.65 | 0.53 | 0.45 |
| Share of manufacturing in white collar employment | 0.15 | 0.22 | 0.17 |
| Share of manufacturing in executive employment | 0.21 | 0.30 | 0.26 |

**Table 2B. Wages and Employment in Manufacturing (Man.) and Services (SS.)**

| | 1991 | | 1994 | | 1997 | |
|---|---|---|---|---|---|---|
| | Man. | SS. | Man. | SS. | Man. | SS. |
| Share in blue collar employment | 0.65 | 0.34 | 0.53 | 0.45 | 0.45 | 0.53 |
| Share of blue collar workers in wage bill | 0.45 | 0.11 | 0.33 | 0.09 | 0.27 | 0.08 |
| Blue collar average wage* | 9882 | 14510 | 13349 | 8225 | 10743 | 6967 |
| Employment Ratios: | | | | | | |
| Blue / White + Executive workers | 1.58 | 0.15 | 1.16 | 0.31 | 1.04 | 0.31 |
| Wage Ratios: | | | | | | |
| White / Blue collar workers | 1.71 | 1.12 | 2.05 | 2.85 | 2.56 | 3.32 |
| Executive / Blue collar workers | 6.09 | 3.34 | 6.88 | 10.59 | 13.92 | 18.38 |

* in 1994 Nuevos Soles

**Table 3. Industries Showing Large Changes in Blue-Collar Wage Share***

Industries showing **increase** in blue-collar wage share:

Textiles, Footwear, Nonferrous Metallic Products.

Industries showing **decrease** in blue-collar wage share:

Fishmeal, Paper and Paper Products, Pharmaceutical Products, Other Chemical Products, Other Metal Products, General (Non-electrical) Machinery, Electrical Power and Water.

* A change that is greater than 5 percentage points in absolute value is defined as "large".

**Table 4. Correlations of Some Key Variables***

| | Share of machinery imports in total intermediate goods |
|---|---|
| Blue collar wage share | -0.27 |
| Ratio of white to blue-collar employment | 0.60 |
| Ratio of white to blue-collar wages | 0.007 |

* All variables are expressed in changes.

**Table 5. Mean Values of Key Variables**

| | 1994 | 1997 |
|---|---|---|
| Blue collar wage share | 0.43 | 0.33 |
| Share of imported machinery in total intermediate goods | 0.06 | 0.08 |
| White to blue collar wage ratio | 1.6 | 1.9 |
| White to blue employment ratio | 1.3 | 1.8 |
| Executive to blue collar wage ratio | 5.6 | 8.9 |
| Share of firms with blue collar unions | 0.39 | 0.26 |
| Share of firms with white collar unions | 0.17 | 0.11 |
| Privatization (sales/value added) | 0.04 | 0.16 |
| Imported machinery/total machinery investment | 0.25 | 0.29 |
| Share of investment in total intermediate goods | 0.22 | 0.26 |
| Share of imports in value added | 2.60 | 3.41 |
| Share of exports in value added | 1.28 | 2.06 |

**Table 6. Panel Regressions with Fixed Effects (all manufacturing industries)**

| | Blue collar wage share (1) | Blue collar wage share (2) | Blue collar wage share (3) | Blue collar wage share (4) | White/ Blue empl. Ratio (5) | White/ Blue empl. Ratio (6) | White/ Blue empl. Ratio (7) | White/ Blue empl. Ratio (8) | White/ Blue wage ratio (9) | White/ Blue wage ratio (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| Share of imported machinery | -7.26** (2.77) | -10.30* (5.29) | | | 87.52** (35.62) | 115.99* (64.11) | | | 41.23 (32.75) | |
| Import investment ratio | | | -1.98** (0.96) | -1.79 (1.10) | | | 27.77** (12.01) | 19.20 (13.52) | | 8.86 (6.78) |
| Blue union share | 0.089 (0.07) | 0.095 (0.08) | 0.058 (0.08) | 0.084 (0.08) | -0.55 (0.83) | 0.09 (0.92) | -0.024 (0.90) | 0.27 (0.96) | -0.58 (0.47) | -0.49 (0.48) |
| White union share | -0.08 (0.08) | -0.09 (0.09) | -0.07 (0.08) | -0.08 (0.09) | -0.32 (1.01) | -0.67 (1.06) | -0.54 (1.04) | -0.91 (1.08) | 0.36 (0.54) | 0.27 (0.54) |
| Investment share | 1.35 (0.90) | 1.63 (1.20) | -0.49 (0.54) | 0.67 (1.09) | -25.35** (11.65) | -12.10 (14.95) | -3.23 (6.84) | -0.97 (13.66) | -5.90 (7.64) | -2.03 (6.85) |
| Export share | | -0.006 (0.02) | | -0.013 (0.02) | | -0.35 (0.25) | | -0.28 (0.26) | 0.16 (0.13) | 0.19 (0.13) |
| Import share | | 0.04 (0.07) | | -0.059 (0.05) | | -0.94 (0.87) | | 0.16 (0.57) | -0.42 (0.45) | -0.04 (0.29) |
| Privatization share | 0.005 (0.06) | 0.10 (0.16) | 0.024 (0.06) | 0.036 (0.15) | 1.25* (0.73) | 2.52 (1.99) | 1.00 (0.74) | 3.34* (1.88) | -1.76* (1.01) | -1.59* (0.94) |
| Number of observations | 79 | 79 | 79 | 79 | 82 | 82 | 82 | 82 | 82 | 82 |
| R square | 0.290 | 0.302 | 0.239 | 0.278 | 0.285 | 0.336 | 0.273 | 0.313 | 0.117 | 0.120 |

** and * denote significance at least at 5 and 10 percent levels.

Figure 1. Intermediate Imports Without Skill Biased Technological Change

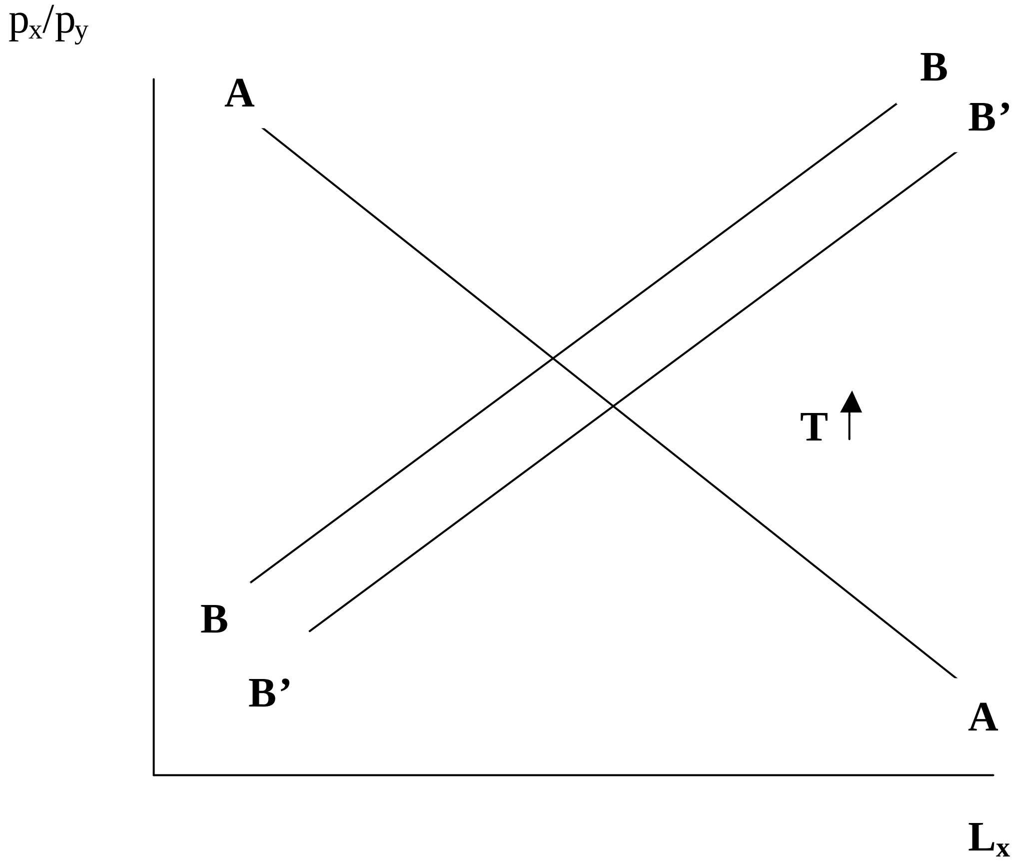

Figure 2. Intermediate Imports With Skill Biased Technological Change

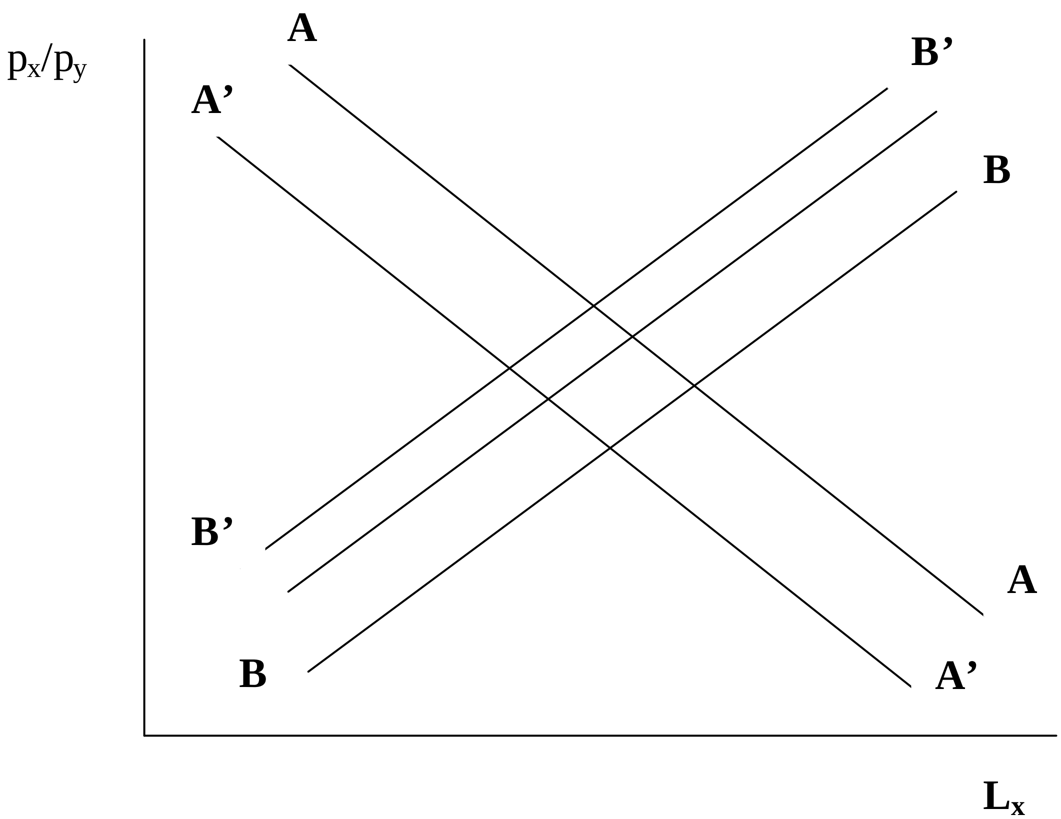

Figure 3. Imports of Intermediate Goods as % GDP

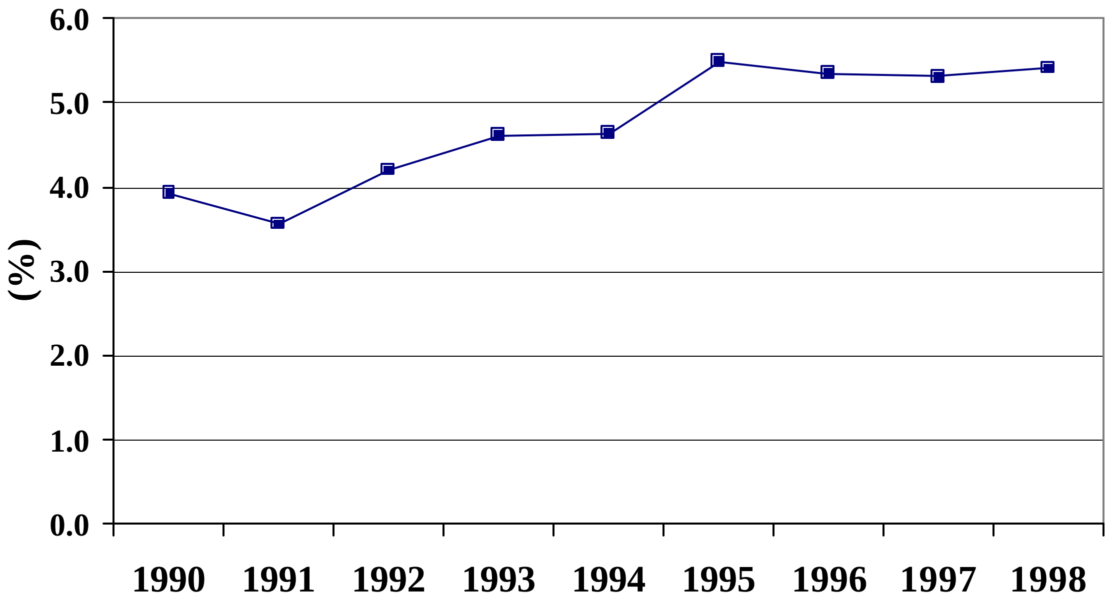

Figure 4. Annual Salaries and Wages (average)