TECHNOLOGICAL CHANGE, HUMAN CAPITAL ACCUMULATION, WAGE STRUCTURE AND THE GROWTH OFREAL WAGES*

—THE DEEP ROOTS OF COLOMBIA'S CRISIS OF GROWTH AND ACCUMULATION—

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ABSTRACT

This study examines the pattern and causes of changes in average real wages in Bogotá, Colombia (1976-1999) using repeated household surveys. Changes in average real wages are a central measure of welfare. They may be the result of diverse causes, mainly changes in the levels of human capital, the structure of returns to human capital, or orthogonal shifts in wage levels. Colombia experienced a rapid growth of real wages until 1985 but thereafter, such growth slowed down and then ceased. This study argues that these shifts largely reflect technological change; the slowed-down growth of Colombian average real wages after 1985 suggests a near halt in technological progress. Since 1985 real wages have grown only for a few individuals who enter into labor market with more human capital than their predecessors: real wages did not grow for those already working since 1985 and certainly fell between 1995 and 1999. These findings show that the Colombian economic growth crisis is very profound, and its roots go back to 1985. The study also proposes simple estimates of technological change using wage data that may track more sophisticated estimates surprisingly well; these may be used to corroborate estimates that are more sophisticated where available or to supplant them where reliable information on physical and human capital is unavailable.

Key Words: Real salary, economic growth in Colombia, technological change, labour feminine participation.

RESUMEN

Este estudio examina el patrón y las causas de los cambios en el salario real promedio en Bogotá, Colombia(1976-1999), usando repetidas encuestas de hogares. Los cambios en el salario real promedio son una medida importante del bienestar. Pueden ser el resultado de diferentes causas, principalmente los cambios en los niveles de capital humano, la estructura de retornos al capital humano o los cambios ortogonales en los niveles salariales. Colombia tuvo un crecimiento rápido del salario real hasta 1985, pero de ahí en adelante el crecimiento del salario real disminuyó y luego se detuvo. Este estudio argumenta que dichos cambios, en su mayoría, reflejan transformaciones tecnológicas y que la disminución en el crecimiento del salario real promedio en Colombia después de 1985 sugiere el estancamiento del progreso tecnológico. Desde 1985, el salario real ha aumentado solamente para algunos individuos que ingresan al mercado laboral con un mayor capital humano que sus predecesores: el salario real no creció para aquellos que estaban en el mercado laboral en 1985, y disminuyó entre 1995-1999. Estos resultados muestran que la crisis de crecimiento económico que atraviesa Colombia es muy profunda, y que sus raíces se remontan a 1985. El estudio también propone cálculos simples del cambio tecnológico usando datos sobre salarios que podrían emplearse para corroborar estimaciones más sofisticadas o suplantarlas cuando no haya información confiable sobre el capital físico o humano.

Palabras Claves: Salario Real, crecimiento económico en Colombia, cambio tecnológico, participación laboral femenina.

Introduction

This study examines the pattern and causes of growth in average real wages in Bogotá, Colombia (hereafter "Colombia¨) over 1976-1999. Colombia initially experienced rapid average real wage growth, with wages rising 43 percent between 1976-1989. Subsequently, however, the annual rate of growth of average real wages fell consistently. Over 1985-1999 average real wages in Colombia grew at 1.5 percent, falling further to (0.6) percent over 1990-1999, with no growth after 1995.

Changes in real average wages may be ascribed to three principal sources. First, changes in the returns to human capital or price effects have same-signed effects upon average real wages. Changes in returns to schooling may derive from factors shifting demand such as trade liberalization [e.g. Gindling and Robbins (1997, 2000, 2001); Robbins (1994, 1995, 1996a-b, 1997a-b, 1999, 2000a, 2000b, 2000d)], or from the equalizing impact of educational expansion upon returns to schooling [e.g. Knight and Sabot (1983), Robbins (1996a, 1996b, 1997, 2000)]. Second; increases in the accumulation of human capital raise real wages for a given wage structure. These effects are sometimes referred to as quantity effects. The third potential source of changes in the average real wage is shifts in wage levels orthogonal to human capital, or "intercept effects". In the theoretical and empirical studies of economic growth, technological change has long been identified as a core source of rising output per capita and real wages —e.g. Jones (1998)—. This paper employs a simple, robust, technique to decompose changes in average real wages into these three dimensions.

The remainder of this paper is organized into four sections. Section 1 presents the methodology used to decompose changes in average real wages into price effects, quantity effects, and "intercept" effects. Section 2 presents the principal findings. In Colombia, the slowdown of real wage growth was due to initially falling returns to schooling and slower, declining, increases in "intercept" effects. Section 3 examines the intercept effects and relates them to technological change. Section 4 discusses the possible causes and cures of the technological slowdown. In Colombia, the rise and subsequent slowdown and cease of average real wage growth was due to rising then stagnant or falling intercept effects reflecting the complete stagnation of technological and dramatic change. Section 5 concludes briefly.

1. Methodology

Real wages are decomposed into three major components: human capital price effects, human capital quantity effects, and shifts in wage levels orthogonal to human capital, or intercept effects. The decomposition employs information of changes in the means of human capital variables in combination with estimates of earnings functions for multiple years in each country.

1.1 *The Decomposition Technique*

The decomposition technique follows that of Clark and Leslie (1994). Changes in average wages can be attributed to two broad effects: changes in wage structure holding

quantities constant, and quantity effects, due to changing average levels of worker characteristics holding wage structure constant. The wage structure effects are further decomposed into intercept and price effects.

Suppose that y_0^i is log earnings for individual 'i' in the base year 0, then;

$$y_0^i = \Sigma_{j=1}^k b_{0j} x_{0j}^i , \quad (1)$$

Similarly for year "1" may be written:

$$y_1^i = \Sigma_{j=1}^k b_{1j} x_{1j}^i , \quad (2)$$

where x_{0j}^i is the jth characteristic for the individual 'i' and b_{0j} is the associated return for one unit of the characteristic. Thus, the change in the average earnings would be:

$$Y_1 - Y_0 = \Sigma_{j=1}^k b_{1j} (X_{1j} - X_{0j}) + \Sigma_{j=1}^k (b_{1j} - b_{0j}) X_{0j} \quad (3)$$

or

$$Y_1 - Y_0 = \Sigma_{j=1}^k b_{0j} (X_{1j} - X_{0j}) + \Sigma_{j=1}^k (b_{1j} - b_{0j}) X_{1j} \quad (4)$$

where X_{0j} is the average level of the jth characteristic for the population under consideration.

The first term in equation (4) gives us the quantity or composition effect and the second term is the effect reflecting changes in the wage structure. Changes in wage structure are then separated into intercept and price effects.

The parameters estimated for this decomposition are based on OLS estimates of a robust specification of the earnings function, where log hourly wages are regressed onto education, experience, experience-squared and dummy variable for gender.

2. Empirical Findings

2.1 *The Data*

This study uses household survey data for Bogotá, Colombia, from 1976 to 1999. The data sources are the National Statistical Department (DANE) annual household surveys for metropolitan Bogotá. These household surveys include information on earnings, hours worked, demographic characteristics as education, gender and age and, labor force status among others. Our samples are restricted to the full-time employees in the formal sector for comparability of hourly wage estimates. All tables and figures that follow refer are based on the sub-population and data source.

Table 1 presents summary statistics for Bogotá, Colombia for the period studied. In Colombia, average real wages grew quickly over 1976-1985, but thereafter grew very slowly and were stagnant over 1995-1999 (see also Figure 1). Mean educational levels grew rapidly over the period studied. In Colombia, mean experience rose gradually from 16.8 to 19.84 years.

2.2 *Estimated Earnings Functions*

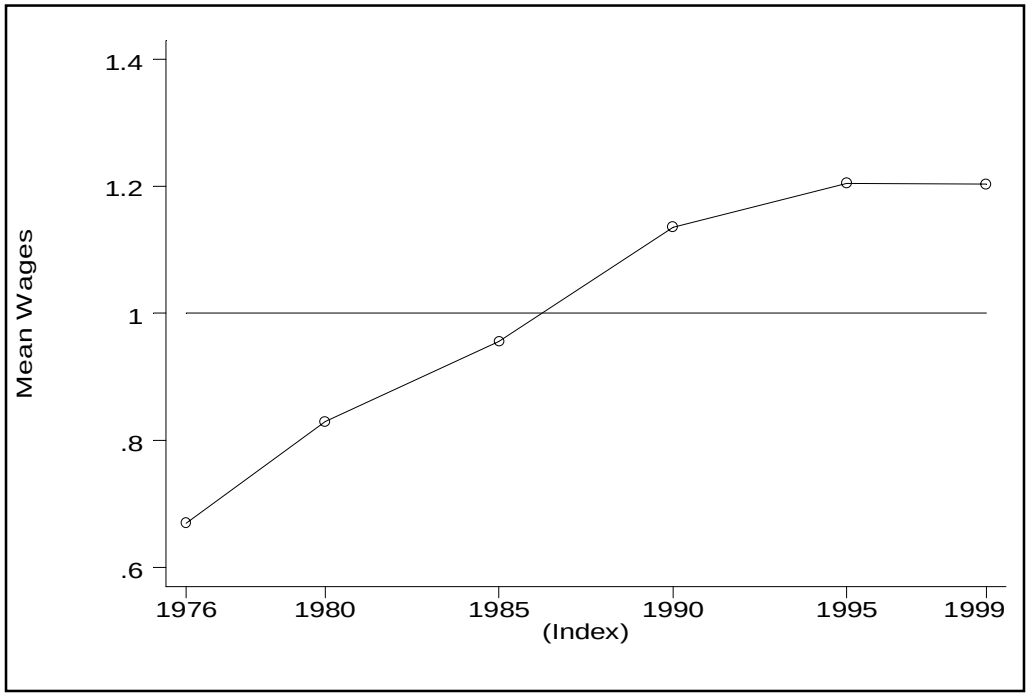
Table 2 reports representative results for the estimated earnings function coefficients. A variety of specifications and techniques were explored, including pooling data over three year intervals, spline regressions, and Heckman selectivity corrections for female workers, etc.

Table 1
Bogotá, Colombia: Sample Means (1)

Variable	1976	1980	1985	1990	1995	1999
Schooling	6.63	6.88	7.55	8.86	9.04	9.85
Experience	16.80	17.70	18.44	19.02	19.53	19.84
Experience squared	518.90	566.90	622.30	532.22	556.96	565.17
Percent men	0.50	0.51	0.53	0.53	0.53	0.53
Real wage	90.00	111.49	128.29	152.50	161.79	161.56

(1) Full time workers in the formal sector.
Schooling and experience in years. Real hourly wage in constant values of 1984.
Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

Figure 1



Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

The results were robust across specifications, and representative OLS estimates are reported. Decompositions calculated for different specifications yielded similar results.

The wage structure in Colombia changed dramatically over the period studied. First, the intercepts only rose over the 1976-1985 period in Colombia. Second, the returns to education and experience declined sharply in Colombia through 1990, with returns to education rising slightly thereafter. The causes of changes in the wage structure are beyond the scope of this paper and are the subject of several earlier studies. Those studies suggest that in Colombia the fall in returns to education over 1976-1999 was due to the downward pressure from rising educational attainment, while the rise in returns to schooling after 1990 may have been due to trade liberalization (Robbins, 1995, 1996a-b, 1997a, 2000d). The estimated coefficient on the gender dummy in Colombia varies somewhat but shows no trend.

Table 2
Bogotá, Colombia: OLS Estimation Results / Dependent variable: log household earnings

Variable	**1976**	**1980**	**1985**	**1990**	**1995**	**1999**
Schooling	0.161	0.136	0.119	0.118	0.119	0.132
	(48.3)	(43.8)	(49.2)	(52.16)	(56.38)	(35.581)
Experience	0.051	0.043	0.039	0.032	0.028	0.022
	(16.9)	(15.5)	(17.1)	(14.13)	(14.64)	(6.09)
Experience squared	-0.001	-0.001	0.000	0.000	0.000	0.000
	(-12.6)	(-10.3)	(-10.7)	(-8.10)	(-8.05)	(-3.03)
Gender	0.215	0.235	0.144	0.234	0.211	0.153
	(8.2)	(9.7)	(7.5)	(12.84)	(12.97)	(5.23)
Constant	2.831	3.191	3.435	3.430	3.510	3.390
Adj. R^2	0.46	0.42	0.34	0.34	0.33	0.32
F - statistic	634	523	625	735.34	862.00	337.25
Obs.	3046	2913	4812	5688	6982	3083

Note: absolute value t-statistics in parenthesis. Gender is a dummy variable equaling 1 if male.
Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

2.3 *Wage Decompositios*

The estimates obtained from these regressions and the means of human capital variables were used to compute equation (7). We identify three components of the total change in the real average wages. First, the changes in the constant, or intercept effects. Second, the price effect, which is divided into, schooling, experience and gender effects. Finally, we calculated the composition or quantity effects that are similarly subdivided into schooling, experience and gender components.[1] The

[1] The table 3 reports total price and quantity effects, and their component parts. The total explained difference is the sum of total price and quantity effects.

total difference is the total explained difference plus the intercept or constant effect.

Table 3 presents the decompositions. Table 4 presents decompositions for 1976-1999 and 1985-1999. Price and quantity effects were dominated by schooling prices. The falling returns to education had a large negative effect upon average real wages over 1976-1990, averaging 90 percent of the total difference. After 1990, the rise in returns to education had a small positive impact upon average real wages. Quantity effects were dominated by schooling throughout the 1976-1994 period that averaged 58 percent of the total difference. The decline in the estimated wage-gender gap, or the estimated coefficient on the gender dummy, were reflected in an overall increase of real average wages, though the rising percent of women in the labor force exercised a modest depressing effect upon average real wages, due to the continued existence of an estimated wage-gender gap. Intercept effects were positive and large over the 1976-1985 period. However, after 1985 intercept effects were negative or small.

The decompositions reveal that Colombia's growth and experience in real average wages over 1976-1985 was lowered by falling returns to schooling, while but this was not the result of intercept effects, which were strongly positive. In this period, the slower increase in real wages in Colombia was due to falling returns to education and experience.

After 1985, the pattern of average real wage growth fell sharply due principally to intercept effects. Intercept effects after 1985 became zero or negative. Rising educational levels continued to contribute modestly to increasing real wages. Returns to education and experience were fairly stable after 1985. Returns to education in Colombia had a small positive effect upon average real wages in this period, while continued declines in the returns to experience had a small depressing effect on average real wages.

Table 3
Colombia: Decomposition of Log Real Wage Change

Variable	1976-80	1980-85	1985-90	1990-95	1995-99	1976-99	1985-99
Total Difference	0.21	0.15	0.20	0.07	0.01	0.75	0.24
Change in constant	0.36	0.24	-0.01	0.08	-0.12	0.56	-0.04
Explained difference	-0.15	-0.10	0.21	-0.01	0.13	0.19	0.28
Total price effect	-0.21	-0.19	-0.01	-0.04	0.03	-0.46	-0.07
Schooling	-0.17	-0.12	-0.01	0.01	0.11	-0.19	0.10
Experience	-0.05	-0.03	-0.05	-0.04	-0.06	-0.24	-0.17
Gender	0.01	-0.05	0.05	-0.01	-0.03	-0.03	0.00
Total quantity effect	0.06	0.10	0.22	0.03	0.10	0.65	0.35
Schooling	0.04	0.09	0.16	0.02	0.10	0.52	0.27
Experience	0.01	0.00	0.06	0.01	0.01	0.12	0.08
Gender	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

Table 4
Decomposition-Bogotá, Colombia

Variable	1976-99	1985-99
Total Difference	0.75	0.24
Change in constant	0.56	-0.04
Explained difference	0.19	0.28
Total price effect	-0.46	-0.07
Schooling	-0.19	0.10
Experience	-0.24	-0.17
Gender	-0.03	0.00
Total quantity effect	0.65	0.35
Schooling	0.52	0.27
Experience	0.12	0.08
Gender	0.00	0.00

Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

3. The Impact of Technology on Wages

Changes in the intercept of the earnings function may derive in part from changes in the rate of technological change. To relate our intercept to changes in technology, we begin with an aggregate production function, summarizing the basic augmented Solow model of Mankiw, Gregory, Romer, and Weil (1992) and relate those results to the estimated earnings function's intercept. The same result of this section generalizes to optimizing growth models such as (Cass-Koopmans, 1965) and the Ramsey growth model presented by Barro and Sala-I-Martin (1995, Chapter 2). This model employs the aggregate of human capital rather than the number of workers as the labor input, L, where L is the number of workers, N, times their average human capital, H, L = NH. Subsequently we will incorporate the labor force participation rate, p, as well, so that L = NHp.

We specify aggregate output with Harrod-neutral technical change and human capital. In this formulation, changes in the average real wage reflect changes in the level of human capital and the level of labor-augmenting technology. Where Q is output, Ld is aggregate demand for human capital, Ls is the aggregate supply of human capital, H is human capital, N is the economically active population and A is labor-augmenting technical change we have the aggregate production function:

$$Q = K^{(1-a)} (Ld\ A)^{a}.$$

Labor supply, Ls, is equal to the number of workers times their average human capital:

$$Ls = NH,$$

where $H = e^{bS}$, where b is the average return to education, and S is the average level of education. Thus, setting supply equal to demand we have:

$$Q = K^{(1-a)} (NHA)^{a}.$$

Rewriting in per capita terms, we have per capita output, q, in terms of per capita capital, k, times a term in labor-augmenting technology and average human capital:

$$q = k^{(1-a)} (AH)^{a}.$$

It is convenient to define our state variables by dividing these per capita variables by the product of labor-augmenting technology and average human capital, AH. Thus, where $q \tilde{} \tilde{}\, Q/(NAH)$ and $k \approx K/(NAK)$, we can rewrite the production function as:

$$\tilde{q} = \tilde{k}^{(l-a)}$$

The capital accumulation equation is:

$$\dot{\tilde{k}} \cong sq - (n + g + d + h)k$$

where s, n, g, d and h are respectively the savings rate, and the growth rates of population, technology, the rate of depreciation and the rate of human capital accumulation. The steady state values of $q \tilde{}$ and $k \tilde{}$ are found by setting the time derivative of $k \tilde{}$ equal to zero. This leads to the following steady-state value of the output-technology ratio, $q \tilde{}$:

$$\tilde{q}^{*} = \left(s/(n + g + d + h)\right)^{(l-a)/a}$$

Solving for the level of per capita output, q, we see it is proportional to the product of the level of human capital, H, times the level of labor-augmenting technology, A:

$$\tilde{q}^{*} = \left(s/(n + g + d + h)\right)^{(l-a)/a} H A$$

Thus, the growth rate of per capita output, unconditioned upon human capital accumulation, is the sum of the growth rate of human capital and the growth rate of technology:

$$\hat{\tilde{q}}^{*} = \hat{H} A$$

Alternatively, the rate of growth of the level of output per capita conditional upon the level of human capital is equal to the rate of technological change:

$$\hat{Q}/(HN) = \dot{A}$$

3.1 *Linking the Aggregate Production Function to the Earnings Function*

First, we relate the steady state growth result to the marginal product of an additional unit of human capital, Q_{HN} , and its steady state growth rate. Let L' denominate NH, the aggregate of human capital. Then the marginal product with reference to a the aggregate of human capital, or in equilibrium with the price of a unit of human capital, is:

$$Q_{HN} = a\ (Q/NH).$$

To relate this price of a unit of human capital to the steady-state equilibrium, note that $q \tilde{}$ (or/Q/ANH). Therefore, the marginal product of HN, or the price of a unit of hu-

man capital can be expressed in terms of the steady-state outcome as follows:

$$Q_{HN} = a\,A\,(q^{\sim *}),$$

and, as 'a' and $q^{\sim *}$ are constants, the growth rate of Q_{HN} is equal to the growth rate of technology, $\dot{A}$.

Next we relate the steady state price of a unit of human capital to the earnings function:

$$W_i = .H_i = e^{o} H_i = e^{o+bSi},$$

where $. = e^{o}$, and o is the intercept in the empirical earnings function.

Here the key point to emphasize is that . and hence ?? o ??are determined in the aggregate market by ? H_i. In addition, we have shown that this price grows at the rate of technological change, ?.

This formulation is modified only slightly if we consider labor force participation, P, explicitly, then the aggregate woman input is NHP. We would then be interested in Q/N*P, or q*' and, where p is the growth rate of labor force participation, we would have:

$$q^{*\prime}/H = (s/(n + g + d + h + p))^{(1-a)/a} \cdot A.$$

The estimated intercept of the earnings function will also change if the sum of growth rates of population, human capital and labor force participation changes. Such changes in growth rates would imply movement between, not along, steady state paths. Increases in the sum of the growth rates of labor supply variables would depress the average real wage per unit of human capital. Because for these relatively short periods and for these particular countries and periods the growth rates of these labor force factors were relatively constant, we interpret the changes in the estimated intercepts to substantially reflect changes in labor-augmenting technology.

Table 5
Estimated Labor Augmenting Technical Change (?) and Total Factor Productivity (TFP)
(Percent annual growth rates)

Colombia				
			Constant Female Labor Force Participation	
	1	2	3	4
Period		TFP		TFP
1976-1985	4.58	2.98	9.00	5.87
1985-1990	-0.76	-0.49	0.74	0.48
1990-1995	1.6	1.00	2.60	1.69
1995-1999	-0.50	-0.30	-0.50	-0.30
1990-1999	-3.10	-2.00	-2.10	-1.36

Notes: ?, is estimated as the exponential growth rate of the level of the real wage conditional upon education and experience, or exp (α_0) where $á_0$ is the estimated intercept in the log wage earnings function. TFP is calculated as the labor share times. For Colombia the labor share used was (.65), from Greco (1999).
Source: Figures calculated by the author on the basis of Encuesta Nacional de Hogares data.

Table 5 presents the estimated rates of labor-augmenting technical change, and corresponding estimates of total factor productivity (TFP). The TFP estimates are equal to the rate of labor-augmenting technical change times the labor share.[2]

The estimates of technical change discussed thus far are approximate. Various factors may cause observed data to deviate from the assumptions in the human-capital augmented growth model. This method of measuring technological change requires that the economy be, roughly, in steady state equilibrium. Robbins (1998, 1999) present a model and evidence for Bogotá, Colombia where the female labor force participation rate responds endogenously to exogenous components of economic growth, particularly for the period 1980-1994. If women in the potential labor force have similar underlying reservation wages, then their participation rate will tend to increase, depressing the average wage conditional upon human capital downward towards that reservation wage. Exogenous components of economic growth will tend to induce rising female labor force participation rates and observed real wages will grow at a lower rate than were female labor force participation constants. To the extent that the growth of female labor force participation rates are accelerating, the economy may be out of the steady state, with output per unit of human capital rising more slowly than the steady state values. Under these circumstances, using observed wages would understate technological change.

To reflect this possibility the implied rates of Harrod-neutral technological change and total factor productivity were recalculated under the assumption that the female labor force participation rates were constant after 1976. Simulated wage series are calculated as follows. Begin with a simple Cobb-Douglas production function $Q = L^{a}K^{(1-a)}$, where the wage equals (aQ/Ld). In equilibrium labor demand equals labor supply, Ls, or w = aQ/Ls. Labor supply is the number of potential workers, N, times their average human capital, H, times the labor force participation rate, g. Distinguishing between men and women we have

$$Ls = N_m H_m g_m + N_f . H_f . gf,$$

where the subscripts 'm' and 'f' refer to males and females, respectively. H, human capital, equals e^{bs}, where s is average education and b is the average rate of return to education. We would like to calculate the wage that would have occurred with constant female labor force participation, or W*. To do so define Ls* as the labor supply for constant gf. This is calculated directly. The percent change between the simulated and observed wage, ((W* - W)/W), simplifies to (Ls/Ls* - 1), so the simulated wage for constant labor force participation is W* (Ls/Ls*). An advantage of this method is that it does not require series on physical capital or prior values of technological change. The same result holds for more complicated production functions of the sort used in Lucas (1988) and Mankiw, Romer and Weil (1992) where output is specified as $Q = (AHL)^{a} K^{(1-a)}$. (See Bils y Klenow (1996) for a similar formulation).

Columns 3 and 4 of Table 5 report the modified estimates of Harrod-Neutral and Total

[2] Re-writing the production function we have $Q = A^{(a)}K^{(1-a)}L^{(a)}$, where dln (A^{a}) / dt = a? corresponds to the usual TFP term.

Factor Productivity (TFP) change. These figures almost surely overestimate TFP, but provide an upper bound and provide corroborating information on the pattern of TFP over time. In combination with the prior estimates, we get the following ranges of TFP for Bogotá, Colombia. Over 1976-1985 TFP estimates are high and range from 2.98 to 5.9 percent. This short interval with high growth rates likely reflects cyclic factors or movement from below the steady-state level of per capita output towards the steady state level. Over 1985-1990 TFP estimates range from -.5 to .5 percent; over 1990-1994 TFP estimates range from .5 to 1.3 percent; and over the 1985-1994 period TFP estimates range between 0 and .83 percent. Thus, all these TFP estimates portrait a situation of significant productivity slowdown for Colombia over the 1976-1994 period. This pattern of falling productivity is broadly consistent with estimates by Pontón, Posada and Urrutia (1999), or "Greco?.[3]

4. Interpretation and Policy Recomendations

To understand the past and affect the future, three dimensions of wage behavior - human capital price effects, human capital quantity effects and shifts in wage levels orthogonal to human capital - require explanation. Thorough examination of the causes of these factors is beyond the focus of this study and has been the subject of extensive prior research.

Causes of changing wage structure - Earlier work documented and analyzed the fall of relative wages and returns to schooling[4] over 1976-1990 and subsequent rise, showing that the fall was due to the impact of the rising relative supply of more educated workers upon relative wages [e.g. Robbins (1996a, 1996b, 1997 and 2000b)].[5] That work also showed that the modest upturn in relative wages and returns to schooling after 1990 reflected skill-biased relative demand shifts that may have been associated with Colombia's modest trade liberalization, and that rising relative wages in other countries were associated with trade liberalization.

Causes of changing educational attainment —Other work examines the causes of growth

[3] A caveat is warranted concerning the Greco estimates. Though the Greco study initially discusses a production function with human capital along the lines discussed in this paper, their actual estimates do not include human capital. This is because they wish to estimate productivity growth over a very long period, beginning in 1925, when measures of human capital are not available. The consequence of omission of human capital in their estimates of technological change appears to be to upward bias in their technological change estimates, due to omission of the human capital variable that would be positively correlated with the time trend variable they use to capture technological change. The TFP estimates associated with the Greco estimates are not reported here, as they are not presented explicitly in that study.

[4] Relative wages are the ratio of wages of workers with higher education to wages of workers with primary-complete education. This measure is monotonically related to returns to education and hence I refer to them interchangeably.

[5] Robbins (2000b) presents evidence that shifts in domestic relative supply have first order impacts upon relative wages in small open economies, in contravention to the Rybczynski theorem.

in education in Bogotá, Colombia as well as five other Latin American countries (Robbins, 1998, 2000c, 2000d). That work finds that the principal cause of rising educational attainment is the rising opportunity costs for women, originating in per capita growth in GDP, and only secondarily returns to education and public spending on education.

Causes of changes in the level of wages contingent on education and experience - Above it was shown that the stagnation in the growth of the intercept of the earnings function, controlling for the increase in the female participation rate, may significantly reflect stagnation in productivity growth. If so, what causes may underly such stagnation in productivity growth and what policies may be proposed to remedy that stagnation? According to a study by the Greco group of the Banco de la República (1999), Colombia experienced reasonable productivity growth prior to 1976 but productivity growth slowed substantially in the 1980s. Those findings are broadly consistent with the interpretation of this paper. Nonetheless, the causes of the stagnation of Colombia's productivity growth are less understood.

One important candidate to explain the stagnation in productivity growth could be high and rising industrial and financial concentration, particularly where such concentration was not due to returns to scale. The absence of competition can lead to low growth rates, and the lack of incentives for technological innovation. Unfortunately, it has not been possible to reliably study industrial and financial concentration in Colombia. This is because Information on industrial concentration derives from the National Statistical Institute (DANE), which only reveals information at the plant, not the firm, level. Thus, for example, while today there is only one firm producing beer in all of Colombia, the data from the DANE on beer plants would lead to a low and entirely misleading index of industrial concentration. In the absence of objective information on industrial concentration is its perhaps useful to note that there is a widespread perception that ownership in Colombia is highly concentrated in a few economic groups, consisting of financial-industrial conglomerates. If industrial concentration is high, and even more-so if such concentration has grown in recent decades, this would have likely contributed to low rates of technological change.[6,7]

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[6] According to many authors, the National Front coalition helped stabilize national political and economic policy but was also an agreement among elite groups to exclude popular participation. [e.g. Rudolf Hommes: "The National Front permitted a certain continuity and consensus regarding economic management which continued until the end of the 1980's. ... The pact was essentially an agreement between two competitive factions from the same elite that colluded to exclude from the political process the vast majority of the population and divide the resources that derived from their management of the State." (Rudolf Hommes, Former Minister of the Treasury; El Portafolio, May 16, 2000)]. It is plausible, therefore, that the National Front contributed to rising economic concentration.

[7] The experience of Chile serves as an example. After 1973, industrial and financial sector concentration grew dramatically. The concentration was so severe that the international debt crisis of the early 1980's shook the Chilean financial system to its foundations and led to 40 percent unemployment. The government took over the banking sector and subsequently implemented an intelligent, far-reaching system of financial sector and industrial and anti-trust regulation which

Another potential contributor to productivity stagnation is the rising share of government spending on GDP. Since 1990 public spending rose from 9 to 20 percent of GDP. Crowding-out of the private sector, however, since the roots of the productivity crisis pre-date 1990 this is likely not the only cause. Yet another possible cause could be the very high real interest rates since the mid-1980's. Though there are potentially many different interest rates, a central lending rate reported by Colombia's central bank, in real terms, rose from roughly zero in the mid-1970's to approximately twenty-percent and remained at that level through 2001.

4.1 *Policies for the Future*

Average real wages can rise due to an acceleration in technological change, to increases in the returns to schooling, or to increases in the average level of education or experience. Thus, policies that foster these outcomes will contribute to increasing real wages. Nonetheless, related work comparing the sources of increases in average wages between Bogotá, Colombia and Taiwan, finds that average real wages rose much more rapidly in Taiwan than in Bogotá, despite similar increases in educational attainment, due to the much faster rise in the intercept of the earnings function there that corresponded to much faster growth in technological change [Robbins (2000e)]. Thus, growth in educational attainment alone is not enough. Furthermore, as emphasized in Robbins (1998, 2000c y d), growth in educational attainment is linked to growth in per capita economic output and hence technological change, so that policies directed to affect educational attainment without encouraging technological change and economic growth are unlikely to achieve great success. And, as regards policies that might be directed towards increasing the returns to education, the negative impact this would have upon the distribution of earnings would likely be too high a price to pay to marginally increase average real wages. Thus, priority should be given to policies that lead to accelerating technological change and per capita economic growth.

4.2 *Accelerating Technological Change*

To the extent that excessive industrial concentration is an important cause of stagnation of productivity growth, two paths suggest themselves to remedy this situation. The direct path would be the forceful implementation of anti-monopolistic regulation policies. A second path often suggested is trade liberalization. Among trade liberalization's virtues is its power to act as a surrogate to anti-trust policies. Trade liberalization imposes competitive pressures upon domestic producers of tradeable goods, though these competitive pressures do not extend to sectors producing non-tradeable goods. Moreover, while it is commonly accepted that full trade liberalization

has been fundamental to Chile's economic efficiency and growth ever since. Elsewhere, in the United States the recent actions of the United States Justice Department against the Microsoft Corporation are evidence of the same preoccupation for guaranteeing competitiveness. Competition through anti-trust regulation has been a pillar of capitalism's successes and its absence a recipe for capitalism's disasters of stagnation, inefficiency and inequality.

has been implemented in Colombia, this is not clear. If trade liberalization were consisted only in the reduction of nominal tariffs, then it would appear that Colombia had fully liberalized in he 1990's. However, real trade liberalization involves many other factors, including explicit and implicit non-tariff barriers. Satisfying academic studies of this do not exist.[8] Apparently in Colombia, in sectors such as transport, many exceptions and barriers exist that have limited the scope of trade liberalization, suggesting that further competitive pressures could be brought to bear through a more thorough trade liberalization that eliminated remaining non-tariff barriers.

A second channel through which full trade liberalization can affect technological change is through induced technology transfer. This was early proposed and empirically supported as part of the Skill-Enhancing Trade hypothesis of Robbins [Gindling and Robbins (1997, 2000, 2001); Robbins (1994, 1995, 1996a-b, 1997a-b, 1999, 2000a, 2000b, 2000d)], and has been subsequently supported by extensive empirical and theoretical literature. Trade liberalization induces competitive pressures that induce domestic producers to modernize and, particularly where combined with real devaluation, permits great exports and greater imports of equipment of recent vintage. At the same time, trade liberalization is not a panacea and its potential short and medium-run costs in terms of worsening distribution need be considered [e.g. Gindling and Robbins (1997, 2000, 2001); Robbins (1994, 1995, 1996a-b, 1997a-b, 1999, 2000a, 2000b, 2000d)].[9]

Conclusion

This study has examined the sources leading to initially rapid growth in average real wages followed by rapidly decelerating and then stagnating real wage growth in Bogotá, Colombia over 1976-1999. Over 1976-1985 average real wages grew rapidly due to increases in intercept terms, aided by growth in human capital. Real wage growth was moderated by falling returns to schooling and experience. After 1985, the sharp fall in average real wage growth was due to a dramatic slowdown of intercept effects in Colombia, likely due to the virtual disappearance of technological change.

[8] In the author's opinion full trade liberalization has not been implemented, as is evidenced through casual comparison with countries that have done so such as Chile, where a plethora of cheap imported goods are available in all sectors, and where quality and prices of domestic production are in line with international standards.

[9] Findings (Robbins, 1996a-b,1997a-b, 1999, 2000a, 2000b, 2000d) that the Rybczynski theorem is not valid in Colombia and other LDCs offer an antidote to trade liberalization's distributional side effects. Had the Rybczynski theorem been valid, raising educational levels would not affect wages. But they do. Over 1976-1990 the near doubling of relative supply led to a nearly 50 percent fall in relative wages: a vast, equalizing force. Colombia could accelerate educational expansion by redoubling its efforts to effectively invest in public education, especially through financial support for education to low and middle-income groups. Accelerating educational expansion would provide greater pressure lowering wage dispersion or relative wages and counter-acting the skill-biased demand growth that would occur with aggressive trade liberalization. The growth-augmenting effects of trade liberalization would work in the same direction so that average real wages would begin to climb while the dispersion of wages would be held in check by the efforts to support educational attainment. Rising educational attainment would further foment productivity and growth.

Falling returns to education through 1990 suggest that the wage compression effects of educational expansion dominated any relative demand shifts. After 1990 in Bogotá, Colombia, the wage compression effects associated with rising educational levels continued and largely neutralized modest skill-biased demand shifts. Trade liberalization was associated with skill-biased demand shifts. As rising returns to education for a given distribution of human capital have a clear unequalizing effect, the positive link between returns to education and average real wages, given constant or rising levels of human capital, offers a counterpoint to the negative relation between returns to education and income equality.

This paper has interpreted changes in the estimated intercepts as reflecting substantially the pace of technological change.[10] In Colombia there appears to have been a sharp productivity slowdown after 1985, after which there appears to have been essentially no technological progress and where that slowdown contributed substantially to lower rates of real wage growth.

Sustained economic growth in recent decades has provided Colombia with a substantial cushion against social strife and appears to be the source of rapid demographic change favoring women's entry into the labor force and rising educational attainment (Robbins, 1998). Continued low rates of technological change, and consequently lower rates of real wage growth, can be expected to exacerbate social conflict and slow demographic change and educational attainment, and contribute to further slowdown in average real wage growth and economic welfare.

Average real wages can rise due to an acceleration in technological change, to increases in the returns to schooling or to increases in the average level of education or experience. However, growth in educational attainment alone is not enough. Furthermore, growth in educational attainment is linked to growth in per capita economic output and hence technological change, so that policies directed to affect educational attainment without encouraging technological change and economic growth are unlikely to achieve great success. And as regards policies that might be directed towards increasing the returns to education, the negative impact this would have upon the distribution of earnings would likely be too high a price to pay to marginally increase average real wages. Thus, priority should be given to policies that lead to accelerating technological change and per capita economic growth.

[10] Using this technique for Taiwan I obtain estimates of technological change very similar to those of Alwyn Young (1995, 1999).

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