WAGES, TURNOVER AND JOB SECURITY

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Abstract

Many developing countries have far reaching regulations enforcing security of employment, mostly limited to the modern sector. Tenure protecting legislation can be seen as reflecting union power or the political desire to extract from the firms in the formal sector benefits to labor in exchange for favorable treatments in credit or trade and market policies. An alternative explanation, pursued in the paper, is that employment security is an aspect of efficiency wages. Security would be offered and is offered by firms even without coercive legislation to reduce turnover of laborers with firm specific human capital. The paper analyzes employer-worker equilibrium in a two-sector economy. It is shown that the degree of security, defined as the probability of being retained on the job, rises with the profitablity of the firm and declines with the variability of external economic conditions. Whether wages will rise or decline with security depends on whether wage pay and security are complements or substitutes. It is also shown that the determination of wages by firms introduces inefficiency into the market equilibrium.

WAGES, TURNOVER AND JOB SECURITY

Firms, particularly in capital intensive and technology intensive industries, invest in selection, hiring and training. The faster labor turnover, the higher the investment. To reduce turnover, firms raise the level of the wage rate and introduce rising wage scales, pension funds and fringe benefits--measures that are often associated with length of employment. These forms of compensation reduce quitting and reduce turnover cost.

The literature dealing with labor turnover and its implications is vast and many aspects of these issues have been considered. More recently, the professional discussion has focussed on viewing the employment arrangements as contractual and analyzing the associated problems. This line will not be pursued here, though it will be shown that the firm-worker relation discussed in the paper has the economic properties of a contract.

The contribution I wish to attempt is the addition of the effect of the possibility of dismissal on quitting and turnover. In many aspects the discussion will follow Stiglitz (1974). Parsons (1972) incorporated job security in his specific human capital model, but his was only a firm level analysis and mostly empirical. Another predecessor is Azariadis (1975) who focused mostly on the unemployment implications of his pioneering model. The paper also follows these earlier writers in limiting the formal model to a single period.

The motivation for the analysis stems from the following. Workers value both wage level and job security, thus firms will offer--particularly to highly paid workers--some security in lieu of pecuniary payments. Higher wages and more secure employment will reduce labor mobility--comparatively to instantaneously clearing markets. The questions that the tradeoff between wage level and job security entails, are questions of efficiency and welfare. I shall attempt to deal with some of them in the paper.

Preliminaries and Summary

The paper is written having in mind a typical developing country with a two sector economy: a formal, capital intensive sector, and an informal and rural sector. Training and labor turnover problems are assumed to be limited to the formal sector. It is also assumed, for simplicity, that full employment prevails and that laborers leaving a firm in the formal sector find employment in the informal economy (in some countries read government for the sector with assured employment). These assumptions are made not because they are believed to reflect accurately the real world, but rather to focus on the major subject of the paper and in order not to repeat analysis that was already conducted by others, particularly Stiglitz' analysis of urban unemployment.

Job security is a promise to keep labor employed even if conditions worsen. We take product price as fluctuating and the degree of security is defined as the lowest price under which labor will not be employed. Given the probability distribution of prices, security is the probability of being retained on the job.

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This version of the paper portrays mostly the theoretical aspects of the economics of the firm with specific human capital. The firm offers its employees both wage and job security. It is shown that job security is augmented with profitability of the firm and with training costs, it is reduced with variability in economic conditions. Since firms in the formal sector of developing countries often enjoy monopoly positions, have to train unskilled labor, and are sometimes protected from external economic changes, one may expect to find job security to be more important in developing than in developed countries even in the absence of tenure protecting legislation or unions. The economy at large is discussed only in two short sections and it is shown that with training costs a free market equilibrium is not Pareto efficient.

By its very nature, job security reduces the mobility of labor and other resources. The questions that then arises are: under what circumstances, if any, will the existence of job security reduce economic efficiency and social welfare? And does the possibility of job security call for policy intervention of one kind or another? These questions will be examined in future work.

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The Worker

Let w_u and w_r be, respectively, wage rate in a typical firm in the formal sector and in alternative, informal sector employment; p is the probability of dismissal and, accordingly, 1-p is the job security coefficient; v() is a concave utility function. The expected utility of the worker is

$$(1) \quad Ev = (1-p)v(w_u) + pv(w_r)$$

The slope of the indifference curve between security and wage pay is given by

$$\frac{d(1-p)}{dw_u} = -\frac{(1-p)v'(w_u)}{v(w_u)-v(w_r)}$$

Hence

$$\frac{d(1-p)}{d\,w_u} < 0, \quad \frac{d^2(1-p)}{dw_u^2} > 0 \qquad \text{for } w_u > w_r$$

The indifference curves have the regular shape.

By assumption, security of employment in the traditional sector is complete. Firms in the modern sector have therefore to offer $w_u \geq w_r$. If workers were uncertain about finding employment in the traditional sector, they may have been willing to take employment in the modern sector for lower pay.

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Workers quit for many reasons: personal, family, inconvenient transportation, social relations on the job. The firm views the workers, somewhat mechanically, as each having a certain probability of quitting. This probability, q, is called here the quit function: the proportion quitting out of those accepted for employment. The quit function can be affected by economic factors, particularly by w_u and by 1-p, which are the parameters of the indirect utility function of the worker.[1/]

$$(3) \quad q = q(w_u/w_r, 1-p)$$

$$0<q<1, \; q_i<0, \; q_{ii}>0, \; i = 1,2$$

By the assumptions on the derivatives of q, both wages and job security reduce quitting, though at decreasing rates. In general, we shall also assume $q_{12}<0$; that is, wages and security are complementary factors, as highly paid workers value job security more than others.

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The Firm

The decisions on the amount of labor employed and on the wage and job security policy are made simultaneously. To simplify the discussion, we start by assuming a given work force and a constant marginal (physical) product of labor, y. The unit of the product is defined such that the average price is one, but actual price varies randomly. The value of the marginal product is

$$(4) \quad VMP = y(1 + \Theta)$$

where Θ is a stochastic price component with

$$E\Theta = 0 \quad Var\Theta = \sigma^2$$

The probability distribution $F(\Theta)$, with density $f(\Theta)$, is known; Θ is realized at the beginning of the year.

The period of operation is one year and the firm is seen here as a repeated stochastic process. The firm maximizes expected profits (details below) and announces in advance the value of its two control variables. The first control is w_u, the wage rate. The second is a cut-off value for Θ, a, such that

(5) if $\Theta \geq a$ labor is retained and the firm operated

$\Theta < a$ labor dismissed and the firm is closed down for the year

The probability of labor being dismissed is F(a) and the coefficient of job security is 1-F(a).

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Quitting takes place after training and before reporting to work, and the quitting function can now be written as

$$q = q(w_u/w_r,\ 1-F(a))$$

Given q, the firm has to train $(1-q)^{-1}$ workers for every position. For simplicity of the algebra, we shall use a recruiting function $\beta()$

$$(6) \qquad \beta = \beta(w_u/w_r, 1-F(a)) = \frac{1}{1-q}$$

$$\beta_i<0,\ \beta_{ii}>0 \quad i = 1,2$$

$$\beta_{12} = (2q_1q_2 + (1-q)q_{12})/(1-q)^3$$

The signs of the derivatives of β are derived from the derivatives of q. The cross effect of β_{12} will be negative only if the cross effect in the quit function q_{12} is large in absolute value compared with the own effects q_1, q_2.We further assume that the training cost is T, a constant for each trainee, and that the firm maximizes expected profits per worker2/

$$(7) \qquad E\pi = \int_a^{\infty}[y(1 + \theta) - w_u]f(\theta)d\theta - \beta T$$

$$= [1-F(a)](y-w_u) + y\int_a^{\infty}\theta f(\theta)d\theta - \beta T$$

The maximization is with respect to w_u and a and the first order conditions are

(8a) $-\beta_1 T/w_r = [1-F(a)]$

(8b) $\beta_2 T = y - w_u + ya$

$= y\ (1 + a) - w_u$

Since β_1, $\beta_2 < 0$, the left-hand-sides of (8a) and (8b) are positive and negative, respectively.

The interpretation of (8a) is straightforward. 1-F(a) is the expected value of an addition of 1 unit to the wage level, since workers will be dismissed and wages not paid in probability F(a). The expression on the left is the marginal contribution of such a pay rise in terms of reduced cost of training.

Equation (8b) is more complicated. The negative sign implies that either $w_u > y$ or $a < 0$ or both. If $w_u < y$, $a < (w_u - y)/y$--the cut-off point is a loss point. In principle, the solution may dictate $a < -1$, but this is a negative price and we shall assume that this situation does not occur and that $1 + a > 0$. For interpretation, examine the first line of (8b) and note that f(a) appears as a multiplier in all terms in the derivative $\partial E\pi/\partial a$; it was cancelled out in the equation presented. By the derivative, increasing the cut-off θ by da reduces the probability of operating the firm by f(a)da and reduces the expected profits by $(y-w_u)f(a)da$. Also, increasing the cut-off point by da removes a slice at the lower bound of the expectation integral in the profit function; the slice is yaf(a)da. From the point of view of the firm, such a change is a gain as most often $a < 0$. The left hand term in (8b) is the benefit; again, in reduced training cost.

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The Offer as a Contract

A contract between an employer and an employee--in our case on wage rate and job security--is an agreement they may reach voluntarily. Such an agreement is Pareto efficient in the sense that neither party to the agreement can improve its position without worsening the position of the other side. Analytically, a firm-worker contract is equivalent to the firm maximizing its profit given a constant utility of the worker.

In the discussion in the paper, the firm maximizes its profits taking into account the worker's quit behavior. We have to show that in doing so it creates a contract so that another worker will not be able to approach the firm and suggest an alternative wage-job security combination that will be superior to at least one party compared with the offer the firm had originally made. We show that the firm offer is a contract by showing that it is equivalent to profit maximization given the worker's utility level.

To this end write the quit function in full

$$(9) \quad q = q\ [v(w_u/w_2),\ 1-F(a)]$$

The same could be shown for

$$Ev = (1-F(a))v(w_u) + F(a)v(w_r)$$

still $\beta = (1-q)^{-1}$

Maximizing (7) the first order conditions can be rewritten as

$$(10) \quad \frac{v_1}{v_2} = - \frac{[1-F(a)]w_r}{[y(1+a)-w_u]}$$

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To maximize firm profits subject to given worker's utility, v*, write the Lagrangian

$$(11)\quad H = E\pi - \lambda[v(w_u/w_2),\ 1-F(a)) - v^*]$$

The first order conditions of (11) can also be rewritten as (10). This proves that the firm's offer of a pair (w_u, a) that maximizes eq. (7), is a contract.

Second Order Conditions

The Hessian matrix of the cross derivatives is

$$(12)\quad H = \begin{pmatrix} -\beta_{11}T/w_r^2 & f(a)(1+\beta_{12}T/w_r) \\ f(a)(1+\beta_{12}T/w_r) & -f(a)[y+\beta_{22}Tf(a)] \end{pmatrix}$$

Since $\beta_{ii}>0$, the condition on negative second self derivatives is realized. The other part of the second order condition--in this two variable case it is $|H|>0$--is realized if the following inequality holds

$$(13)\quad \frac{\beta_{11}T}{w_r^2}[y+\beta_{22}Tf(a)] > f(a)\,[1+\beta_{12}T/w_r]^2$$

which can be rewritten as

$$\frac{\beta_{11}y}{w_r^2 f(a)} + \frac{\beta_{11}\beta_{22}T}{w_r^2} > \frac{1}{T} + \frac{2\beta_{12}}{w_r} + \frac{\beta_{12}^2\,T}{w_r^2}$$

It is useful to check the required inequality in its two representations in the two lines of (13); both highlight the critical role played by the cross effect β_{12} (see eq. (6)).

The term $f(a)[1 + \beta_{12}T/w_r]$ is the cross derivative of $E\pi$. If $[1 + \beta_{12}T/w_r] < 0$, the controls w_u and a are complementary in affecting profits. This is "strong" complementarity for which the weaker complementarities in quitting and recruitment, q_{12}, $\beta_{12} < 0$, are necessary but not sufficient conditions.

The inequality in the first line of (13) depends on the complementarity factor not being too large. For large values of the cross derivative of $E\pi$ a maximum in (7) is not assured; job security and wage rate reinforce each other's effect so strongly that it always pays to increase both. Reinforcement is plausible in quitting and recruitment, but not necessarily in the profit function. Therefore we do not attribute *a priori* a sign to the complementarity factor $(1 + \beta_{12}T/w_r)$. Even if complementarity in profits exists, it is implausible that mutual reinforcement of a and w_u be so strong that profits will be unbounded. We therefore assume that the inequality in (13) is maintained and (7) has a finite maximum.

The second line in (13) indicates that the concavity of the β function $\beta_{11}\beta_{22} > \beta_{12}^2$ and, particularly, β_{11} large compared with β_{12}, contribute to the satisfaction of the inequality condition. The same inequality also indicates that the training cost T should not be too small: by (8a) for T=0, w_u cannot be a control variable associated with an internal maximum of $E\pi$.

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Variance

Increased intensity of economic fluctuations is represented in our model by an increased variance of the stochastic element in product price. To analyze the effect of changes in the variance of the distribution assume that the variance of θ is $\sigma^2 = 1$ and that $f(\theta)$ and $F(\theta)$ are the standardized normal functions. These assumptions do not alter any of the results of the paper. Further, mark the stochastic element in product price as $\sigma\theta$. Equation (7) is now

$$(7') \quad E\pi = \int_{\sigma a}^{\infty} [y\ (1+\sigma\theta) - w\ ]\ (\frac{f(\theta)}{\sigma})\ d\sigma\theta$$

Since $pr(\sigma\theta<\sigma a) = Pr(\theta<a) = F(a)$, the definition of β (eq. (6)) is not modified.

The first order conditions are now

$$(8'a) \qquad -\beta_1 T/w_r = [1-F(a)] \qquad \text{(unchanged)}$$

$$(8'b) \qquad \beta_2 T = y\ (1+\sigma a) - w_u$$

Increased variance, keeping σa constant, increases the profits of the firm since it increase the probability of realizing higher prices. Increased variance, again for a constant cut-off value, σa, reduces job security. Whether the firm will maintain the same level of job security (a = constant) or change it, and what the direction of such a change will be, can be examined in the analysis of comparative statics to which we now turn.

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Comparative Statics

The writing of this section is detailed to help the reader follow the argument. The exogenous parameters in the analysis are y, T, σ, and w_r -- the general symbol will be x. The endogenous variables are w_u and a. Rewrite (8a) and (8b) as

$$(8''a) \quad h_1(w_u, a; y, T, \sigma, w_r) = 0$$

$$(8''b) \quad h_2(w_u, a; y, T, \sigma, w_r) = 0$$

For simplicity, we shall continue to assume $\sigma^2 = 1$ when not dealing with the effect of the variance on the firm.

The Hessian can now be expressed as

$$H = \begin{pmatrix} \frac{\partial h_1}{\partial w_u} & \frac{\partial h_1}{\partial a} \\ \frac{\partial h_2}{\partial w_u} & \frac{\partial h_2}{\partial a} \end{pmatrix}$$

and the system of the equations of the comparative statics is

$$(14) \quad H \begin{pmatrix} \frac{dw_u}{dx} \\ \frac{da}{dx} \end{pmatrix} = - \begin{pmatrix} \frac{\partial h_1}{\partial x} \\ \frac{\partial h_2}{\partial x} \end{pmatrix}$$

The signs of the solutions in the column vector on the left-hand-side of (14) are determined by examining the solution of (14) using Cramer's Rule and the assumption $|H|>0$.

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The vectors $\partial h/\partial x$ for $x=y$, T, σ, w_r are

y	T	σ	w_r
0	$-\beta_1/w_r$	0	$\frac{T}{w_r^3}[\beta_1 w_r + \beta_{11} w_u]$
$-f(a)(1+a)$	$\beta_2 f(a)$	$-yaf(a)$	$-\frac{\beta_{12} T f(a) w_u}{w_r^2}$

The signs obtained from the solutions to the analysis of comparative statics are as follows ($\overset{s}{=}$ means equal in sign and f(a), always positive, was eliminated where possible)

(15) $\frac{dw_u}{dy} \overset{s}{=} -(1+a)(1+\beta_{12}T/w_r)$

$$\frac{da}{dy} \overset{s}{=} -\frac{\beta_{11}T(1+a)}{w_r^2}$$

(16) $\frac{dw_u}{dT} \overset{s}{=} -\frac{\beta_1}{w_r}(y + \beta_{22}Tf(a)) + \beta_2 f(a)[1 + \beta_{12}T/w_r]$

$$\frac{da}{dT} \overset{s}{=} \frac{1}{w_r}\left[\frac{\beta_{11}\beta_2 T}{w_r} - \beta_1(1+\beta_{12}T/w_r)\right]$$

(17) $\frac{dw_u}{d\sigma} \overset{s}{=} -ya(1+\beta_{12}T/w_r)$

$$\frac{da}{d\sigma} \overset{s}{=} -ya\beta_{11}T/w_r^2$$

(18) $\frac{dw_u}{dw_r} \overset{s}{=} \frac{T}{w_r^3}\{[\beta_1 w_r + \beta_{11} w_u][y + \beta_{22}Tf(a)] - f(a)[1+\beta_{12}T/w_r]\beta_{12}Tw_u w_r\}$

$$\frac{da}{dw_r} \overset{s}{=} -\frac{\beta_{11}\beta_{12}T^2 w_u}{w_r^4} + \frac{T}{w_r}[1+\beta_{12}T/w_r][\beta_1 w_r + \beta_{11} w_u]$$

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Three magnitudes play a pivotal role in determining the signs of the derivatives in eqs. (15)-(18). The most important of the three is the complementary factor, $(1 + \beta_{12}T/w_r)$, already encountered in the discussion of the second order conditions. The other two magnitudes affect only eqs. (18) and they will be introduced below. Table 1 summarizes the effect of the exogenous variables on the controls, w_u and a.

Increasing y raises the net value of operating the firm. It therefore induces the firm to increase the probability of operation by reducing the cut-off point a; this effect is independent of the sign of $(1 + \beta_{12}T/w_r)$ and whatever that sign, $da/dy < 0$. Recall also that we are assuming $a<0$, and $(1+a)>0$. With a negative complementarity factor, a and w_u reinforce each other and $dw_u/dy>0$. If, however, $(1 + \beta_{12}T/w_r) > 0$, the firm will trade-off wages for job security in reacting to increased y.

The effects of a change in T are identified only if $(1 + \beta_{12}T/w_r)<0$. Then job security and wages will be increased to reduce turnover. When $(1 + \beta_{12}T/w_r)>0$, the comparative statics effect is not identified.

Since $\beta_2 < 0$, the right-hand side of (8'b) is negative. This implies that the term in the square brackets in eqs. (17) is also negative (recall $a<0$). This determines the corresponding signs in Table 1: job security is reduced in reaction to increased variance of product price; the reaction of wages, w_u, depends on whether security and pay are substitutes or not.

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Table 1

Comparative Statics--The Effect of the Complementarity Factor

	Sign of $1 + \beta_{12}T/w_r$	
	negative	positive
$\frac{dw_u}{dy}$	+	-
$\frac{da}{dy}$	-	-
$\frac{dw_u}{dT}$	+	?
$\frac{da}{dT}$	-	?
$\frac{dw_u}{d\sigma}$	-	+
$\frac{da}{d\sigma}$	+	+
$\frac{dw_u}{dw_r}$	+	?
$\frac{da}{dw_r}$	?	+

Notes:

The signs in the Table are derived from eqs. (15)-(18).

The signs of da/dy and $da/d\sigma$ are unaffected by the magnitude of $(1 + \beta_{12}T/w_r)$.

It is assumed that $\beta_{12} < 0$, $(\beta_1 w_r + \beta_{11} w_u) > 0$.

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The change in the non-standardized cut-off point, in terms of product price, is

$$\frac{d(\sigma a)}{d\sigma} = a\ (1+\sigma\frac{da}{d\sigma})$$

and, depending on the sum in the parentheses, it may be positive or negative.

We turn now to the effect of w_r, examined in eqs. (18). The signs of the derivatives are affected here by two other magnitudes, in addition to the complementarity factor. One is β_{12} (see eq. (6)); the signs in Table 1 are reported for $\beta_{12} < 0$. The other magnitude is $\beta_1 w_r + \beta_{11} w_u$ and it has the opposite sign of the cross derivative.

$$- \frac{\partial^2 \beta}{\partial w_u\ \partial w_r} \lesseqgtr \beta_1 w_r + \beta_{11} w_u$$

The rate of recruiting, β, is depicted in Figure 1 as a function of w_u. As w_r increases, from $w_r(1)$ to $w_r(2)$, the ratio w_u/w_r decreases and the value of the β function increases (recall $\beta_1 < 0$). As the graphs are depicted, for a given w_u the magnitude of β_1 is larger in absolute value, the higher w_r. This is reasonable for, again, the higher w_r the lower the ratio w_u/w_r. If the way the diagram is presented is accepted then

$$- \frac{\partial^2 \beta}{\partial w_u\ \partial w_r} \text{ and } (\beta_1 w_r + \beta_{11} w_u) > 0$$

This is the assumption incorporated in the signs reported in Table 1. With these assumptions the signs are identified for two of the four possible effects of w_r in Table 1.

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Variable Wages

Up to now wages, w_u, once offered, were constant. But employers may wish to offer variable wages, depending on the realized economic conditions. One possibility is to make the wage payment in eq. (7) $w(1+\alpha\theta)$ where α is a positive parameter to be announced in advance. It can be shown in comparative statics analysis that with plausible assumptions, at least for small values of α,

$$\frac{dw_u}{d\alpha} < 0 \ , \ \frac{da}{d\alpha} < 0$$

that is, the higher wage variability the more there is tradeoff between (average) wage level and job security.

This result contradicts Azariadis' (1975) finding of the dominance of wage rigidity in employment contracts. Azariadis' proof (Lemma 1) rests on the assumption that job security is not affected by wage variability. This seems to be an unreasonable assumption, employers can be expected to increase security of jobs if wages are allowed to vary with economic circumstances.

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Market Equilibrium

Let the amounts of capital be given, both in the formal and in the informal sector; so also the area of land in agriculture is given. Sectoral production is a function of labor distribution

(19a) $Y_u = Y_u(L_u)$ formal sector

(19b) $Y_r = Y_r(L_r)$ informal sector

(19c) $L_u + L_r = L$ full employment

Concavity of the production functions $Y_i()$ is assumed.

The labor market can be visualized as operating each year in three stages. In the first stage the formal sector recruits βL_u workers for training. In the second stage q percent of the trainees quit and return to the informal sector, then the urban sector is left with L_u workers. In the third stage, another group of workers may be dismissed and they will also return to seek employment in the informal sector. The system (19), particularly the full employment equation (19c), depicts the economy as seen in the second stage. In the analysis below we assume for simplicity that the workers dismissed from the formal sector do not affect the marginal product of labor in the informal sector. The implication of this assumption is that either these workers do not find employment for the year at which they were dismissed or that their numbers are small relative to L_r and their effect on the marginal productivity can be disregarded.

Employment in the informal sector determines the wage rate

(20) $Y_r'(L_r) = w_r$

The firms in the formal sector decide on the parameters a and w_u and on L_u. From the latter's perspective they can be seen as choosing a level of employment to maximize $E\pi$ in (21)

(21) $E\pi = \int_a^\infty [Y_u(L_u)(1 + \theta) - w_u L_u] f(\theta) d\theta - \beta T L_u$

The first order condition is

(22) $Y_u'(L_u) \int_a^\infty (1+\theta) f(\theta) d\theta = [1-F(a)] w_u + \beta T$

In the earlier sections of the paper $Y_u'()$ was the constant y and level of employment--number of openings in each firm--was given.

The market equilibrium is closed with the full employment equation (19c). Given β, or q, the ratio of the wages in the sectors w_u/w_r can be solved from the inverse function β^{-1} for any level of the job security coefficient 1-F(a). We shall not detail this procedure here.

The present model differs from Harris-Todaro's (1970) in that there workers are recruited to the formal sector from the pool of the unemployed, while here they are recruited from the informal sector and those who quit or are laid off return to work in that sector.

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Efficiency

By setting wages w_u which differ from w_r and hence from Y_r', firms in the formal sector create inefficiency. This was already pointed out in a similar context by Stiglitz (1974) and is shown here for completion.Let a central planner maximize National Product, G in the following,

$$(23)\quad G = \int_a^\infty Y_u(L_u)(1+\theta)f(\theta)d\theta - \beta TL_u + Y_r(L_r)$$

subject to (19c). Assume that the planning instrument is the informal wage rate, w_r, which the planner sets. The employers then hire labor freely to equate $Y_r' = w_r$. The formal sector sets its labor policy and employment, as in a free market, according to eqs. (8a), (8b).

The planner does not take w_r as given and for the planning authority the quit function is

$$(24)\quad q = q(w_u/Y_r'(L_r),\ 1-F(a))$$

The recruiting function is, as before, $\beta = (1-q)^{-1}$.

The first order condition for labor distribution that maximizes G in (23) is

$$(25)\quad \int_a^\infty Y_u'(1+\theta)f(\theta)d\theta = \frac{\beta_1 TL_u w_u Y_r''}{(Y_r')^2} + \beta T + Y_r'$$

$$= w_u[1-F(a)][\frac{L_u Y_r''[1-F(a)]}{\beta_1 T}] + \beta T + w_r$$

The second line in (24) is obtained by incorporating (8a)--the policy rule

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followed by the employers--and the equality $w_r = Y_r'$ in the first line.

The cost of labor as envisaged by the firms in the formal sector in a free market is, from (22), $[1-F(a)]w_u + \beta T$. The planning shadow price of labor is the right-hand-side of (24). The two are not equal and the inequality means that a free market solution is, in this case, inefficient. Employment in the free market can be either too high or too low, if, for example

$$L_u Y_r''[1-F(a)]/(\beta_1 T)^{-1} > w_r - w_r[1-F(a)]^{-1}$$

the planning shadow price is higher than the free market calculated cost and the formal sector employs too much labor.

Of special relevance to developing countries is the surplus labor case. If the assumptions underlying this case prevail, $Y_r'' = 0$ and the planning, efficiency solution, shadow price of labor is $Y_r + \beta T = w_r + \beta T$. It will be higher than the free market calculated cost if in the formal sector $w_u(1-F(a)) < w_r$; and then the formal sector will employ too much labor. Otherwise, the share of the labor force in the formal sector is too small.

Future work

Job security ties resources in the economy, to some extent at least, and reduces their mobility. If economic conditions change, job security may be an obstacle to labor reallocation. But we have seen that as economic fluctuations intensify, job security is reduced. Is this reduction sufficient to eliminate the associated potential inefficiencies?

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FOOTNOTES

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1/ If unemployment and the possibility of moving between firms in the formal sector were not disregarded by assumption in the current analysis, the rate of unemployment, or the probability of being unemployed, and the expected earnings in the alternative firm would have also appeared as arguments in q().

2/ The maximization in (7) is per worker who stays on the job after training and after the quitting stage. These workers can still be dismissed if realized θ is lower than the cut-off level.

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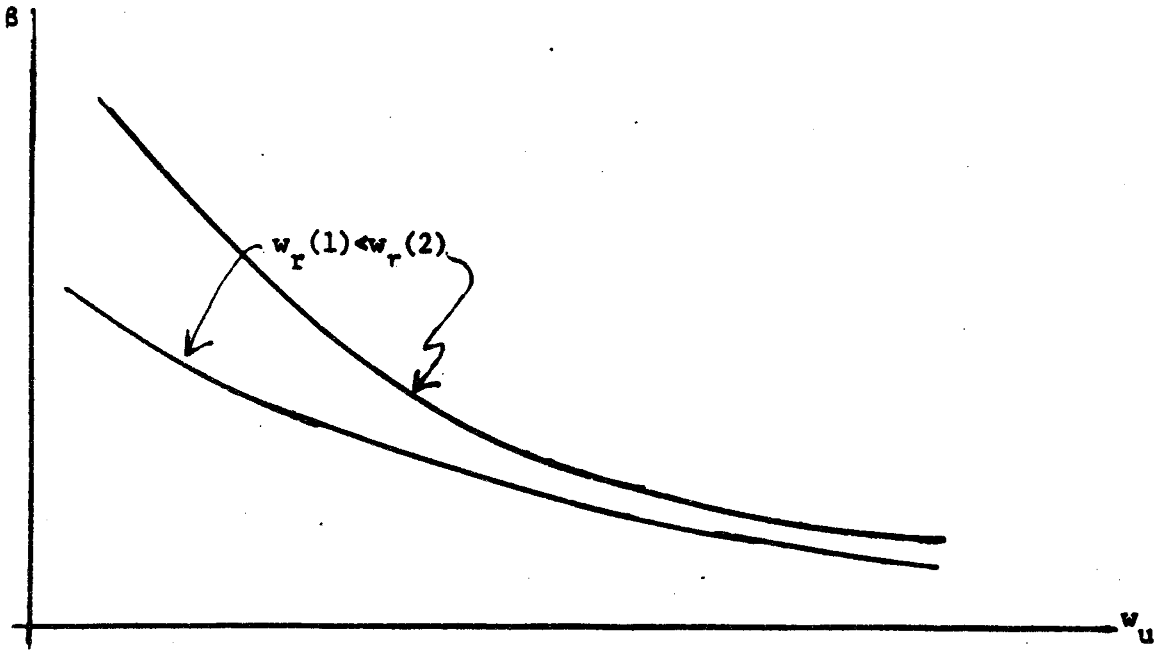

Figure 1 : The function β().

October, 1986

A SIMPLE MODEL OF SENIORITY AND TURNOVER

Yoav Kislev*

Abstract

A two period model in which workers are trained before commencing employment is considered. Wages are set to reduce turnover and cost of training. It is shown that in the absence of discounting, wages will rise with seniority, but this need not be so if rates of interest are positive. It is also shown that the wage paid in the second period may exceed marginal product. The main results hold in a three period model and extensions to n periods are considered. The discussion stresses exposition and intuitive explanation.

Journal of Economic Literature Category:

821 Theory of Labor Markets and Leisure.

October, 1986

A SIMPLE MODEL OF SENIORITY AND TURNOVER

Hiring workers and training them for their tasks is an investment; often in firm specific human capital. The investment creates an incentive for the employer to reduce turnover by increasing the salaries of the employees. Two patterns of investment were suggested: on the job training that reduces the contribution of the worker at the training period and increases it afterwards, and the simpler alternative of hiring cost and entry point training--before the commencement of employment. Similarly, premiums to workers with firm specific capital were suggested both as seniority scales and as higher flat rate salary. The economics of on the job training was elaborated on by Becker (1975); Stiglitz (1974) assumed entry point training and higher pay in his model of urban unemployment in developing countries. Recently Collier and Knight (1986) suggested a model of entry point training to explain seniority premium in the United Kingdom and Japan. A concise review of recent literature is included in Yellen (1984); Mazumdar (1983) presents a useful discussion of urban labor markets in LDCs.

Seniority premiums were explained as payments for accumulated experience, a means for selection of prospective loyal employees, an incentive for effort, a way to share investment in human capital, and a form of an optimal contract. The determination of a wage structure aimed at reducing quitting and saving on hiring cost is perhaps the simplest case to analyze, but the algebra of even a simple problem of turnover optimization is quite complicated. I wish to show that the analysis of such a problem is not only complicated but also illuminating. The discussion in the paper is restricted to a two period problem, but the main findings are extended to three periods. Hiring and training costs are incurred only at the entry point--on the day of recruitment (sometimes called period zero). It is shown that in this model, as long as the discount factor is unity (zero interest)--the wage scale will be rising, with the wage paid in the second year higher than in the first. The wage scale does not necessarily rise, and it may even decline, when the interest rates are positive. It is also shown that the wage paid in the second period may be higher than the marginal product of labor since the benefits to the firm of the worker staying for another period come both in product and in reduced training. We conclude that the model developed may indeed explain seniority premium, but it is not likely that its underlying assumptions are the sole explanation. Given the richness and the complexity of labor relations, this should not come as a surprising conclusion.

The discussion follows Collier and Knight's. The definition of the problem and some of the analytical tools are borrowed from their presentation. The findings, however, are not all the same; but the paper is not written as a systematic criticism of the Collier and Knight analysis.

Preliminaries

To make the notion of a 2-period analysis clear and precise, we make the following assumptions. A firm hires workers on December 31 each year. The workers are identical. Once hired, they are trained at a cost T to the firm and thus acquire firm specific capital. The workers do not invest time or money in training. Hiring is for two years, but some workers quit before the mandatory retirement date: either on January 1 of the first year, with probability q_1, or on January 1 of the second year, with probability q_2. Those who do not quit on the first of the year, stay to its end.

The quit rates, q_i, are functions of the wages[1/]

$$(1) \quad q_1 = q_1(U(w_1) + U(w_2))$$

$$q_2 = q_2U(w_2)$$

$$0<q_i<1, \; q'_i()<0, \; q''_i()>0 \quad i = 1,2$$

where w_1, w_2 are, respectively, wage in year 1 and in year 2 in the firm; $U(w_i)$ is the utility function, with the usual concavity properties.

The assumption in equation (1) is that the workers do not have access to the capital market, their rate of discount is zero and they consume all their earnings, wages, at the period at which they receive them. With these assumptions, the utility of future incomes is simply the sum of future utilities. The quitting rate is a decreasing function of the utility of staying with the firm. Implicitly and in the background, the worker is also affected by the utility of alternative employment. We are not analyzing the details of the quitting decision and take a somewhat mechanical approach--workers act as if their behavior reflects a random process with probability of quitting affected by the wage schedule.

The function q_1 is simplified in yet another way: in considering whether to stay with the firm, a rational individual will generally also take into account that he may quit at the beginning of the second year. Therefore, q_2 should appear as an argument in $q_1()$. This possibility is disregarded in equation (1). Non-zero interest rates and expected future quits are introduced below.

We consider the firm with a given number of workers, E, and at the steady state. The firm recruits each year RE workers (R is the percentage share of new recruits). The workforce cohorts are

$$(2) \quad E_1 = ER\,(1-q_1)$$

$$E_2 = ER\,(1-q_1)\,(1-q_2)$$

The total number of workers

$$(3) \quad E = E_1 + E_2$$

from which the steady state recruitment rate is

$$(4) \quad R = [(1-q_1) + (1-q_1)(1-q_2)]^{-1}$$

Given the size of the labor force, the firm's objective is to minimize cost per worker, including cost of training T,

$$(5) \quad z = R\,[T + w_1(1-q_1) + w_2(1-q_1)(1-q_2)]$$

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The control variables are w_1 and w_2 and the first question is: is seniority premium, $w_2>w_1$, optimal?

Structure

It is shown in the Appendix that optimality of seniority premium can be proved, in this model, in a straightforward manner using Lagrange constrained minimization. Here we take an expository approach to the problem and examine its separate components. Start by minimizing z in equation (5)

$$(6) \quad \frac{dz}{dw_1} = \frac{\partial z}{\partial q_1}\frac{\partial q_1}{\partial w_1} + \frac{\partial z}{\partial w_1} = 0$$

$$\frac{dz}{dw_2} = \frac{\partial z}{\partial q_1}\frac{\partial q_1}{\partial w_2} + \frac{\partial z}{\partial q_2}\frac{\partial q_2}{\partial w_2} + \frac{\partial z}{\partial w_2} = 0$$

Second order conditions are assumed to be satisfied.

The first partials are the effects of changes in the quit rates on labor cost

$$(7) \quad \frac{\partial z}{\partial q_1} = \frac{\partial R}{\partial q_1}[\quad] - R\left[w_1 + w_2(1-q_2)\right]$$

$$\frac{\partial z}{\partial q_2} = \frac{\partial R}{\partial q_2}[\quad] - R(1-q_1)w_2$$

The effects of changes in the quitting rates on the rate of recruitment--the derivatives in the right hand side of eqs. (7)--are expressed in the following:

$$(8) \quad \frac{\partial R}{\partial q_1} = R^2(2-q_2)$$

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$$\frac{\partial R}{\partial q_2} = R^2(1-q_1)$$

Rearranging (7), incorporating (8),

$$(9) \quad \frac{\partial z}{\partial q_1} = R^2(2-q_2)T$$

$$\frac{\partial z}{\partial q_2} = R^2(1-q_1)T + R^2(1-q_1)^2(w_1-w_2)$$

$$= \text{(training cost effect)} + \text{(wage rate effect)}$$

An increase in either q_1 or q_2 raises the recruitment rate and therefore the total training cost of the firm . The training cost effect of a change in q_1 is approximately double that of a change in $q_2\left[(2-q_2)\geq 2(1-q_1) \text{ if } q_2\leq 2q_1\right]$ because a laborer quitting at the beginning of the first year creates a two cohort vacancy to be filled by new trainees. At the same time, a change in q_1--the rate of quitting before ever starting work--does not affect the cohort-seniority distribution and does not affect, therefore, the wage bill of the firm. A change in q_2 changes the cohort distribution and, if $w_1 \neq w_2$, changes total wage payment.

The first order conditions derived from equations (6) can now be written as

$$(10) \quad - R^2T(2-q_2)\frac{\partial q_1}{\partial w_1} = R(1-q_1)$$

$$- R^2T\left[(2-q_2)\frac{\partial q_1}{\partial w_2} + (1-q_1)\frac{\partial q_2}{\partial w_2}\right] - R^2(1-q_1)^2(w_1-w_2)\frac{\partial q_2}{\partial w_2} = R(1-q_1)(1-q_2)$$

In equations (10) the terms with R^2T are training cost effects; the others are wage bill effects of changes in w_1 and in w_2.

Interpretation

There are two aspects to the optimization of the wage rate: the wage level and the seniority scale. In this section we consider the wage level. To this end assume that the firm seeks to optimize wage payments while maintaining $w_1 = w_2$. In this case, the term with $w_1 - w_2$ vanishes--there is no cohort distribution effect--and the marginal benefit of a change in the wage level is the sum of the left-hand-sides in (10). The sum of the right-hand-sides is 1, this is the marginal cost of increasing the wage level by one unit (of adding 1 to the wage of the representative worker who is a weighted average of the two cohorts).

Seniority Premium

It will be useful to start with an intuitive argument--to be made rigorous below. We have seen that the training cost effect of a change in q_1 is approximately twice the size of a similar change in q_2. From this perspective, it is more important for the firm to reduce q_1 than to reduce q_2. The most effective way to reduce q_1 is to increase wage payment while maintaining $w_1 = w_2$, as considered in the earlier section. This is the most effective way because the argument in $q_1()$ is the sum $U(w_1) + U(w_2)$ and any departure from equal wages reduces utility due to the concavity of the utility function U(). Nevertheless, with the present formulation, a seniority premium will be preferred.

To see why wages will rise with seniority, consider a firm which

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minimized z in (5) subject to $w_1 = w_2 = \bar{w}$. Let the seniority pay be x (small) such that $w_2 = w_1 + x$. From the constraint equilibrium the firm moves to a seniority pay regime by setting $w_1 = \bar{w} - x/2$, $w_2 = \bar{w} + x/2$. Such a change will have two desirable effects on the firm: it will reduce total wage bill, because the first cohort is larger than the second, and it will reduce q_2. In general, a move to seniority pay will also have an undesired effect--the aforementioned reduction in first period utility and, consequently, increased quitting. However, at the constrained equilibrium point at which $w_1 = w_2$, this undesired effect is negligible for small values of x.

More rigorously, we wish to show that $\partial z/\partial x > 0$, which in turn implies that (11) holds.

$$(11)\quad \frac{dz}{dw_1} > \frac{dz}{dw_2} \quad \text{for minimum z, subject to } w_1 = w_2$$

It also means

$$(12)\quad \begin{array}{l} \dfrac{dz}{dw_1} > 0 \\ \dfrac{dz}{dw_2} < 0 \end{array}$$

The equality $w_1 = w_2$ implies by eq. (1), $\partial q_1/\partial w_1 = \partial q_1/\partial w_2$, and that (11) can be rewritten, using (10),

$$(11')\qquad R(1-q_1) > R^2T(1-q_1)\frac{\partial q_2}{\partial w_2} + R\,(1-q_1)(1-q_2)$$

$$q_2 > RT\frac{\partial q_2}{\partial w_2}$$

The last inequality always holds because $\partial q_2/\partial w_2 < 0$. This proves that with the current assumptions a seniority premium is preferred to equal pay.

Time Preference

The firm and the workers are affected differently by the introduction of discount factors, even if their subjective rates of interest are identical.

Focusing on seniority premium, we may disregard non-labor capital. For concreteness, assume that workers are paid each December 31 after a year of work. A worker who works to retirement receives two salary payments. The procedure of paying once annually at the end of the year is followed by all employers in the economy. We may, thus, disregard discounting in the first year and write the utility upon entering employment in the firm as

$$U_o = U(w_1) + \alpha\, U(w_2)$$

with α the discount factor $(0<\alpha<1)$. The quit function $q_1()$ is now

$$(13) \quad q_1 = q_1\left[U(w_1) + \alpha U(w_2)\right]$$

As for the firm, its monetary outlays are training costs and wages on December 31 of each year. To maintain the symmetry of the basic conditions of the workers and the firm, assume that the firm faces the same interest rate as the workers and that its time schedule is also similar to that of its laborers: let it sells its product on December 30 of each year. So the firm has to borrow the total labor cost each year for one year (or it uses equity capital, the alternative cost of which is the common rate of interest). The

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firm's objective is to minimize z/α,

$$(14)\quad z/\alpha = R[T + w_1(1-q_1) + w_2(1-q_1)(1-q_2)]/\alpha$$

where $q_1()$ is defined by (13) and $q_2()$ is still defined as in (1). The controls are again, w_1 and w_2.

Equations (13) and (14) demonstrate the difference in the effect of discounting on the firm and on the worker. For the worker, a seniority scale means deferred payments. The firm is only affected by the total cost of labor. Inter-cohort shifts of wages, so long as they do not affect total labor cost, do not affect directly the firm's cost (indirectly they do, by modifying quit rates).

Given α (a constant), minimizing z/α is minimizing z in (14). Start the analysis, again, from a minimization constrained to $w_1 = w_2$. Noting that

$$(15)\quad \frac{\partial q_1}{\partial w_2} = \frac{\partial q_1}{\partial w_1}\alpha \quad \text{for } w_1 = w_2$$

equation (11') can be rewritten as

$$(16)\quad R^2T(2-q_2)\frac{\partial q_1}{\partial w_1}(1-\alpha) + R(1-q_1) > R^2T(1-q_1)\frac{\partial q_2}{\partial w_2} + R(1-q_1)(1-q_2)$$

$$RT\frac{\partial q_1}{\partial w_1}\left(\frac{2-q_2}{1-q_1}\right)(1-\alpha) + 1 > RT\frac{\partial q_2}{\partial w_2} + (1-q_2)$$

$$q_2 > RT\left[\frac{\partial q_2}{\partial w_2} - \frac{\partial q_1}{\partial w_1}\left(\frac{2-q_2}{1-q_1}\right)(1-\alpha)\right]$$

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Since both $\partial q_2/\partial w_2$ and $\partial q_1/\partial w_1$ are negative, the right hand side in the last line of (16) may be positive and then the inequality will hold only for relatively large values of q_2. With positive interest rates, with $0 < \alpha < 1$, seniority premium is not always optimal (but note that for $\alpha = 1$, eq. (16) is reduced to (11')).

The machinery of the analysis can be used to rescue a quasi seniority premium. Let the firm minimize z subject to the constraint

$$(17) \quad \frac{\partial q_1}{\partial w_1} = \frac{\partial q_1}{\partial w_2}$$

Equation (17) implies $w_1 > w_2$, and given (17) the inequality in (11') holds. Hence, at the optimum, w_2 will always be higher (relative to w_1) than the level needed to maintain (17). This is the sense in which a quasi premium will prevail even with a positive discount rate. But only if the inequality in (16) holds, will an actual seniority premium, $w_2 > w_1$, be optimal.

Moreover, if the inequality in (16) is reversed, the optimal pay scale will be $w_1 > w_2$. With positive discount rates, negative seniority premiums are also likely.

Marginal Product

In the original Becker analysis, a worker receives more than the marginal product in the first period with the firm--the training period--and receives less than the marginal product thereafter.[2/] In the present model, there is no training period and the issue of the relation between the wages and the marginal product did not arise because we have hitherto assumed

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constant marginal product and constant workforce. Under these assumptions, the decision of the firm is divided into two stages: (a) minimize z in (5) or in (14); (b) if $z<m$ (m being the value of the marginal product) do not operate the firm, if $z>m$--operate.

It is quite simple analytically to incorporate in the discussion a production function with decreasing marginal productivity of labor and to let the firm expand employment until the marginal cost of labor equals its marginal product. However, since the algebra is cumbersome, and we are only interested in finding whether $w_2>m$ is possible, we adopt a simplified approach.

Assume that at the constrained minimum ($w_1=w_2=\bar{w}$) of equation (5) the solution is such that $z = m$: on its labor account the firm just breaks even. At this point, $z = RT + \bar{w}$. Disregarding for the moment changes in q_i and hence changes in R, if the firm sets the seniority premium $x \geq 2RT$, then $w_2 = \bar{w} + x/2 \geq m$.

We cannot repeat now the steps that led to the inequality (11') since that analysis was appropriate only for small values of x. For large values of x, the worker has to be compensated for departure from $w_1 = w_2$. The compensation, C, similar to risk premium, is approximated by the following expression[3/]

$$(18)\quad C = -\left(\frac{x}{2}\right)^2 \frac{U''(\bar{w})}{U'(\bar{w})}$$

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Let x = 2RT, labor cost per laborer is then

$$(19) \quad z = RT + R\left[(\bar{w}-RT)(1-q_1) + (\bar{w} + RT)(1-q_1)(1-q_2)\right] - (RT)^2 \frac{U''(\bar{w})}{U'(\bar{w})}$$

$$= RT + \bar{w} - R^2T(1-q_1)\,q_2 - (RT)^2 \frac{U''(\bar{w})}{U'(\bar{w})}$$

If $x \geq 2RT$, second period payment exceeds marginal product. We show now that such a value of x may be optimal. Recall that in the absence of a seniority premium $z = RT + \bar{w}$. Hence, the sufficient condition that a seniority premium will be larger than 2RT and $w_2>m$ is that z in (19) is smaller than RT + $\bar{w}$, which in turn implies

$$(20) \quad R^2T(1-q_1)q_2 > \left| (RT)^2 \frac{U''(\bar{w})}{U'(\bar{w})} \right|$$

$$\frac{(1-q_1)\,q_2}{T} > \left| \frac{U''(\bar{w})}{U'(\bar{w})} \right|$$

The inequality in (20) is only a sufficient and not a necessary condition because we have disregarded the beneficial effect of the seniority pay in reducing q_2. Therefore, $w_2>m$ is possible even if (20) does not hold; but if (20) holds--the wage rate in the second period will be higher than the value of the marginal product of labor.

The last conclusion was reached under the restrictive assumptions that E=constant and z=m. Instead, let now the size of the workforce vary, and assume that marginal productivity of labor is decreasing, and that marginal cost of each laborer is z (changes in the length of the work day or the working week are not possible). Then, in equilibrium z=m, and $w_2>m$ if (20) holds.

There is no apparent reason why the inequality in (20) should never hold. We conclude therefore that it is in principle possible that the second period wage will be higher than the marginal product.

Extensions

We have seen that a rising wage scale in a firm with two period employment reduces turnover and shifts wages from the larger to the smaller cohort. The same is true for a three cohort firm. Proof of the optimality of seniority payments in a three period model is outlined in Part B of the Appendix. In principle, there is no reason why the same considerations will not apply in n cohort cases. Wherever they apply, wages will grow with seniority even with multi-period employment. Needless perhaps to add, this conclusion rests on the simplifying assumptions embodied in the quit functions of eq. (1) and their extension to n periods. The effect of positive rates of interest on changing optimal wage scales will be stronger the longer the prospective employment.

Another crucial assumption of eq. (1) was that the possibility of second period quitting does not influence q_1. With expected future quitting, the utility at the beginning of employment is

$$(21)\quad U_o = U(w_1) + U(w_2)(1-q_2)$$

The term $(1-q_2)$ in eq. (21) has a similar effect as the introduction of the discount factor α in eq. (13): seniority premium is not always optimal. The analysis is more complex since, unlike α, $(1-q_2)$ cannot be treated as a constant in the minimization procedure.

It is often argued and found in practice that wages in the training period are lower than alternative earnings and higher subsequently. With entry-point training, as in the present model, this need not be so. Firms with comparatively higher training cost may pay wages higher than others from the first day of employment, as Stiglitz (1974) demonstrated in his two sector analysis.

Conclusion

We have seen that with recruitment and training costs wages will be set to optimize turnover. The possibility of turnover will be reflected not only in the wage rate but also in the wage scale--giving rise to seniority premium. However, with positive interest rates, the optimal theoretic solution may well be a negative seniority premium.

Seniority payments are widespread and exist under varying economic circumstances. While we found that in the model presented here, rising wage scales are not always adopted. It seems, therefore, that cost of recruitment and entry point training can participate in determining wage scales but they are unlikely to be the sole factors in the prevalence of seniority premiums.

Firm specific training and the associated premiums create wage differentials which raise questions of general elquilibrium and welfare analyses. Another set of issues raised by the discussion in the paper is of the probability of layoffs and firing and their effects on quit rates and turnover. These questions are beyond the comparatively narrow scope of the present analysis.

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Appendix: Lagrangian Constrained Minimization

We show in this Appendix that optimality of seniority premium can be established using Lagrange multipliers.

A. Two Periods

The seniority premium is x, and define 2s = x; the wage rates are $w_1 = w - s$; $w_2 = w + s$. Write the Lagrangian

$$\text{(A.1)} \qquad \begin{aligned} H &= R[T+(w-s)(1-q_1) + (w+s)(1-q_1)(1-q_2)] - \lambda s \\ &= z - \lambda s \end{aligned}$$

The control variables are w and s, and if $\lambda<0$ then $s>0$ and seniority pay is optimal at the unconstrained minimum. Differentiating

$$\text{(A.2)} \qquad \frac{\partial H}{\partial w} = \frac{\partial z}{\partial q_1}\frac{\partial q_1}{\partial w} + \frac{\partial z}{\partial q_2}\frac{\partial q_2}{\partial w} + \frac{\partial z}{\partial w} = 0$$

$$\frac{\partial H}{\partial s} = \frac{\partial z}{\partial q_1}\frac{\partial q_1}{\partial s} + \frac{\partial z}{\partial q_2}\frac{\partial q_2}{\partial s} + \frac{\partial z}{\partial s} - \lambda = 0$$

$$\frac{\partial H}{\partial \lambda} = -s = 0$$

At $s = 0$

$$\text{(A.3)} \qquad \frac{\partial q_1}{\partial s} = q_1'()[-U' + U'] = 0$$

$$\frac{\partial q_2}{\partial s} = \frac{\partial q_2}{\partial w}$$

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Also, note

$$\text{(A.4)} \qquad \frac{\partial z}{\partial s} = - (1-q_1)q_2 \quad <0$$

$$\frac{\partial z}{\partial w} = (1-q_1)(2-q_2) \quad >0$$

Rearrange (A.2), using (A.3)

$$\text{(A.5)} \qquad \lambda = \underset{(-)}{\frac{\partial z}{\partial s}} - \underset{(+)}{\frac{\partial z}{\partial w}} - \underset{(+)}{\frac{\partial z}{\partial q_1}} \underset{(-)}{\frac{\partial q_1}{\partial w}}$$

By the first order conditions, since the first 2 expressions on the right-hand-side in the first line of (A.2) are negative,

$$\frac{\partial z}{\partial w} > \left| \frac{\partial z}{\partial q_1} \frac{\partial q_1}{\partial w} \right|$$

And, in (A.5)

$$\left| \frac{\partial z}{\partial s} - \frac{\partial z}{\partial w} \right| > \frac{\partial z}{\partial w}$$

This proves that $\lambda < 0$.

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B. Three Periods--Outline of Analysis

Define the wage rates as

$$w_1 = w - s_1; \; w_2 = w + s_1 - s_2; \; w_3 = w + s_2.$$

For seniority scale $w_1 < w_2 < w_3$, which imply

(a) $s_1, s_2 > 0$

(b) $s_2 > s_1/2$

(c) $s_2 < 2 s_1$

The analysis is conducted in three stages. In the first stage, the constraint is $s_1 = s_2$. In the next stages the constraints corresponding to conditions (b), (c) above are imposed. Note that if $s_1 = s_2$, then $w_1 = w_2 = w_3$, and if $s_2 = s_1/2$ then $w_2 = w_3$, $s_2 = 2s_1$ implies $w_1 = w_2$. These equalities are used in the calculations of $\partial q_i/\partial s_j$ under the alternative constraints.

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FOOTNOTES

* Hebrew University, Rehovot, Israel and The World Bank, Washington DC.

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1. The formulation of equations (1) to (4) is due to Collier and Knight (1986).

2. Except in cases in which the value of the marginal product was reduced unexpectedly and, in the judgment of the firm, temporarily.

3. For details see Collier and Knight (1986).

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AN INTERCOUNTRY ANALYSIS OF EMPLOYMENT AND RETURNS TO LABOR IN AGRICULTURE

(An Interim Report)

by

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ABSTRACT

The inter-country analysis reported in this paper focuses on the following features. In growing economies, labor shifts from agriculture in a gradual process of reallocation. With growth, relative income gaps between agriculture and the rest of the economy narrow but absolute income differences increase. Despite the smaller relative gaps, occupational migration is comparatively more intensive in the higher income countries. Exit from agriculture explains most of the increase in the returns to the farm labor of the developed countries, it explains only a relatively small part of the increase in the developing countries. In a preliminary simulation analysis it was found that in the developing countries the long term effect of an increase in non-farm income on returns to labor in agriculture is only 15 percent of the corresponding magnitude in the developed economies. Intensification of irrigation will have, on the other hand, a comparatively stronger effect on the returns to farm labor in the developing countries.

Introduction and Summary

Many of the lower income countries are agrarian economies and others have large agricultural sectors. The welfare of a great number of people in the developing countries depends, therefore, on the returns to labor in agriculture. This is particularly so in the densely populated countries, where many of the workers in the farm sector are landless.

In this paper we report some preliminary findings in a study of employment and returns to labor in agriculture. Two major topics are covered in the report. Basically, the study is an exploration of the process of labor shift from agriculture and an explanation of several of its characteristics. At the same time, the paper is also an elaboration of a conceptual approach to labor market analysis in the agricultural sector in growing economies: Labor supply is a time consuming process; the conventional supply function and the associated analysis of comparative statics of markets in equilibrium are inappropriate tools of study in a dynamic context. A growing economy is characterized by income disparities between the sectors and by occupational migration out of agriculture. These income gaps gradually narrow as labor is reallocated.

The approach is not new. The theoretical background is based on Mundlak's earlier work on growth paths and on agricultural supply (Mundlak 1979, 1985, Cavallo and Mundlak 1982). Partly we even duplicate Mundlak's work. The study of migration has a long history (Harris and Todaro, 1970, Greenwood 1981, Kuznets 1982); and Kirzner (1973), for example, argues for the analysis of competitive markets in terms of processes, not equilibria.

Our study is an intercountry analysis, covering 43 developing and developed economies (listed in the Appendix), with observations for three points in time, 1960, 70, 80. We are using the Hayami and Ruttan (1985) sample which was taken because of its comprehensive coverage of agricultural data. The sample was expanded to include labor market information and prices. The sample and the data will be explained in a review now in preparation. Separate papers will report in detail on the analysis of demand and on other aspects of the study.

The framework of the analysis is partial equilibrium--prices of products and inputs are considered as exogenous variables even in the long run. A general equilibrium analysis is impossible at this stage. Moreover, partial equilibrium is the appropriate framework for the investigation of the effects of price distortion and market intervention in which we are interested. In the short run, we are taking factor quantities to be constant; the economic rational behind this approach is explained in detail for the case of labor; similar reasoning applies also to other factors, particularly production assets and land. We plan to elaborate on these issues in future reports.

The basic features of the process of labor shift from agriculture are presented in the next section. The noteworthy characteristics are that, with growth and development, migration intensifies, relative income gaps between agriculture and the other sectors narrow, but absolute income differences increase. That section is followed by a discussion of the operation of the labor market, by a presentation of the logistic migration equation, and an estimation of its parameters. These sections lead to an analysis of the effect of labor reallocation on wage equalization. The paradoxical finding of narrowing relative gaps and widening absolute income differences is explained with reference to human capital theory. Between 1960 and 1980 wages in agriculture increased by 32 percent in the developing countries; they doubled in the developed countries. By the calculations presented, labor shift explains almost all of the wage increases in the developed countries; while in the developing countries--in which labor force in agriculture actually grew despite migration--wages increased mostly due to production intensification. The paper closes with an example of a simulation analysis of the operation of the labor market in agriculture and a discussion of the distribution of income gaps in the sample countries, pointing to the need for further research.

Basic features

The world labor force grew between 1950 and 1980 from 1.2 to 2.0 billion workers and it is expected to reach 2.7 billion by the end of the century (Table 1 and see similar information in Figure 1). The share of agriculture is declining both in the developed and the developing groups of countries. But in absolute numbers, the size of farm labor is decreasing only in the developed countries; it is increasing in the developing ones (again, taken as a group). As a result, while the farm labor force of the developing countries was in 1950 four times larger than that of the developed ones, it will, by our estimate, be more that thirty times larger in the year 2000.

In the sample, the share of farm labor decreased between 1960 and 1980 from 63 to 48 percent in the developing countries and from 23 to 10 percent in the developed ones (Table 2). In fact, all countries in the sample

Table 1

World Labor Force Distribution
(millions)

	1950	1980	2000
Total	1200	2000	2700
Agriculture	800	1000	1190
Share in Agr. (ratio)	0.67	0.50	0.44
Agriculture in Developing Countries	650	925	1153
Share in Agr. (ratio)	0.81	0.65	0.55
Agriculture in Developed Countries	150	68	37
Share in Agr. (ratio)	0.38	0.13	0.06

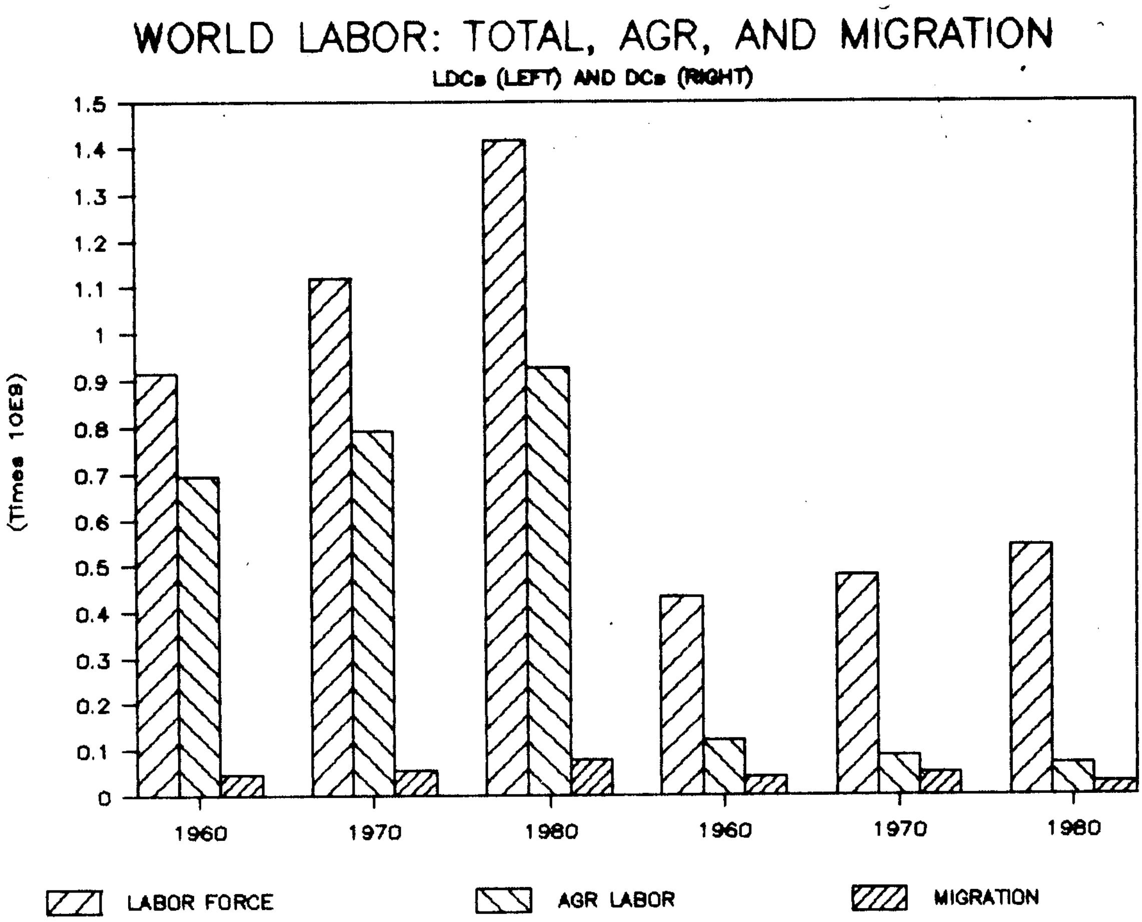
Notes:

Developed countries are in Europe, North America, Australia, New Zealand and Japan. Numbers are rounded.

Source: World Bank World Development Report, 1986.

Agricultural labor force for 2000 is our estimate arrived by extropolating past trends.

Figure 1:


WORLD LABOR: TOTAL, AGR, AND MIGRATION
LDCs (LEFT) AND DCs (RIGHT)
(Times 10E9)
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1960
1970
1980
1960
1970
1980
LABOR FORCE
AGR LABOR
MIGRATION

experienced positive migration from agriculture for the three decades of the 1950s, 60s, and 70s.[1/]

The choice of a measure of the income gap between agriculture and the other sectors raises both conceptual and empirical questions. Two alternative measures are used in the study: the differences in wages and the differences in the average products. Wages measure the returns to labor and are, in general, the appropriate variable to use in the study of labor allocation; but the change from agricultural to non-agricultural occupation is often also a geographic migration, and the migrants may be self employed, in the rural as well as in the urban sector, not only wage earners.[2/] The average product may therefore be a more appropriate measure of the alternative to agricultural income. Also, wherever the marginal product is proportional to the average, the latter is an appropriate measure of the return to labor in an exponential specification, such as in the commonly used double log regression.

In addition, wage data are often incomplete. In agriculture the wages are only for a relatively small share of the farm labor force, are often paid partly in kind, are hard to observe, and measurement methods vary between countries. In the non-agricultural sector, comparable comprehensive wage statistics are not available. We are using, therefore, two measures of the income gap: the difference between wages in agriculture and in manufacturing and the difference between the average product, per laborer, in agriculture

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1/ An exception is Paraguay that registered a negligible occupational shift to agriculture in the 1950s. This decade is not included in the empirical analysis and, as explained below, migration may be underestimated due to the assumption of identical natural growth rates in the rural and in the urban sectors; the real shift might have been out of agriculture in this case too.

2/ At this stage of the study labor is treated as uniform. A distinction between self employed and hired laborers will be attempted in the future.

Table 2

Labor Allocation and the Income Gap

	Developing Countries			Developed Countries		
	1960	1970	1980	1960	1970	1980
1. Share of labor force in Agriculture, s_a	.63	.57	.48	.23	.15	.10
2. Wage Gap						
farm wage, w_a	1.43	1.90	1.69	5.19	8.09	11.17
relative, w_a/w_u	.32	.37	.31	.44	.47	.49
absolute, w_u-w_a ($ per day)	3.07	3.22	3.83	6.69	9.26	11.79
3. Product Gap						
product in agr., p_a	487	507	605	2,203	3,505	5,978
relative, p_a/p_u	.27	.25	.26	.43	.44	.66
absolute, p_u-p_a ($ per year)	1,311	1,540	1,764	2,862	4,412	3,102
4. Rate of growth of total labor force, n	.020	.024	.028	.011	.012	.012
5. Rate of migration, m	.011	.014	.022	.042	.056	.062
6. Kuznets' measure of change						
$s_a(t-1) - s_a(t)$	.059	.067	.075	.083	.071	.042
ms_a	.072	.082	.107	.095	.087	.064

Notes:

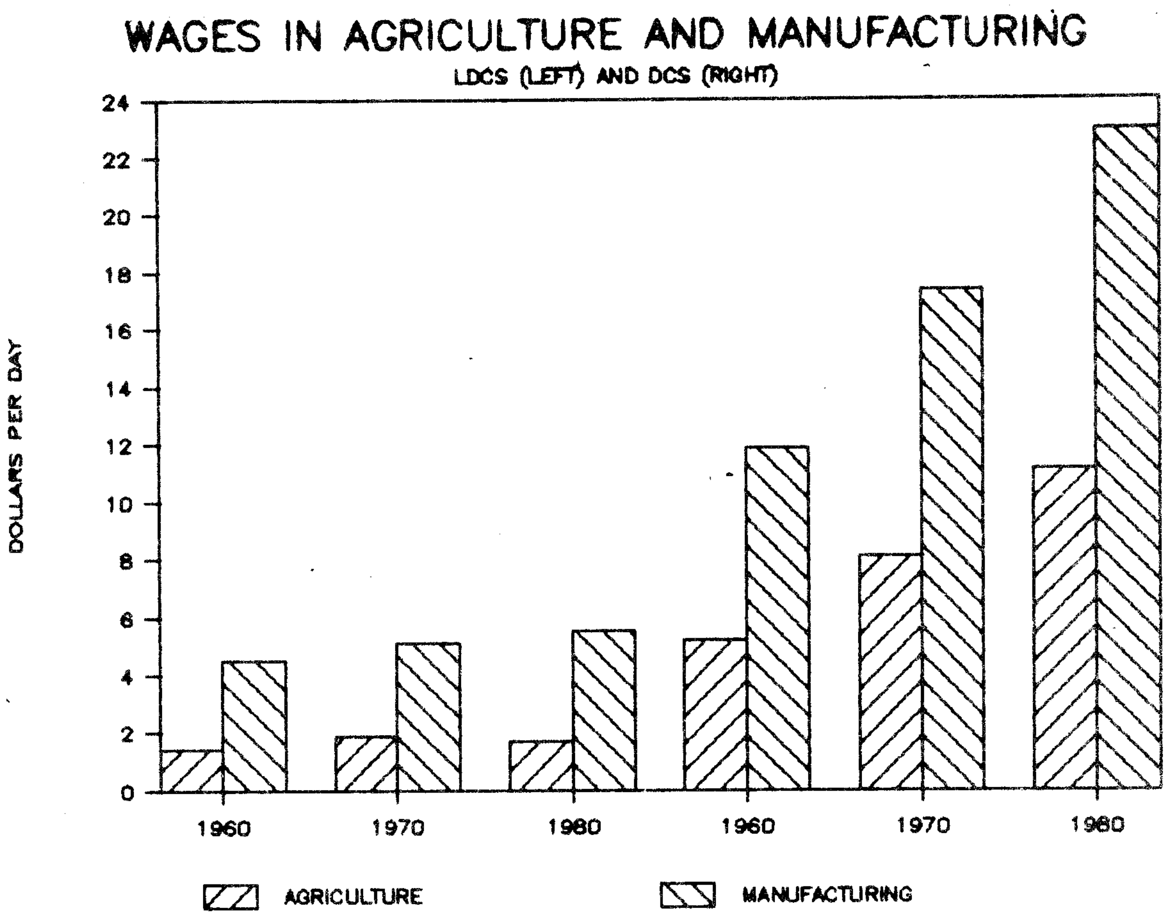
s_a share of labor force in agriculture;
w_a, w_u wage rate in agriculture and in manufacturing, 1970 dollars per day;
p_a, p_u product per laborer, agriculture and non-agricultural, 1970 dollars per year.

Wages and values of products were deflated by local Consumer Price Index and converted to dollars using Kravis et al., 1978, Purchasing Power Parity exchange rates.

Lines 4, 5--average rate of change per year over the decade prior to the year in the column.
Line 5--the rate of migration is the number migrated divided by the labor force in agriculture at the end of the decade, calculated according to eq.(7).
Line 6, see text.

Averages are arithemetic and non-weighted.

Figure 2:


WAGES IN AGRICULTURE AND MANUFACTURING
LDCS (LEFT) AND DCS (RIGHT)
DOLLARS PER DAY
24
22
20
18
16
14
12
10
8
6
4
2
0
1960
1970
1980
1960
1970
1980
AGRICULTURE
MANUFACTURING

and in the rest of the economy. Whether measured in wages or in average product, the returns to labor in agriculture in developed countries were in 1960 more than 3 times larger than in the developing ones (Table 2 and Figure 2). These differences were even larger in 1980.

The two intersectoral income gaps are measured, in Table 2, as absolute differences and as ratios, and these two measures move in opposite directions. The absolute differences, both in wages and in products, are larger in the developed countries than in the developing ones, and they are growing in time within each group (an exception is the decline in the product gap in the developed countries in the 70s when the industrial economies stagnated but their agriculture continued to expand). In terms of ratios, the gaps are smaller in the developed countries than in the developing ones (the ratio w_a/w_u is higher) and they were narrowed with time; again, with one exception: the wage gap in the developing countries widened in the 1970s.

We turn now to migration. Labor reallocation need not take the form of shift of workers from one occupation to another. Gradual redistribution can be achieved when all the new entrants into the labor force are employed by the growing sector and the labor force in the declining sector is reduced at the natural attrition rate. Indeed, as the economy develops and the share of agriculture in product and employment decreases, a significant part of the reallocation process is achieved by the young, new entrants taking non-agricultural employment. Geographic migration is also not a necessary component of labor reallocation even if involving agriculture--many farmers take part-time non-farm employment in the rural areas. But since a great share of the farm to non-farm labor redistribution involves exit from agriculture and involves geographic movement and these kinds of exit and movement determine the marginal cost of adjustment, we follow other students of the subject and term the general reallocation process "migration."

Two factors combine to make the process of labor supply time consuming: occupational migration is costly, and the rate of shift is constrained by the supply of younger people with long planning horizons. Labor reallocation is therefore a gradual process.

The rate of migration, the ratio of the number of those who migrated over the decades of the 1950s, '60s, and '70s to the labor force in agriculture, is calculated in the study as the difference between the natural rate of growth of labor and the actual change in its size. Migration may in this way be underestimated if the natural rate is higher in rural than in urban areas. The natural growth rate is, in Table 2, twice as fast in the developing countries as in the developed ones. The rate of migration is higher in the developed countries--despite narrower relative income gaps--and it has been increasing in both groups of countries through time.

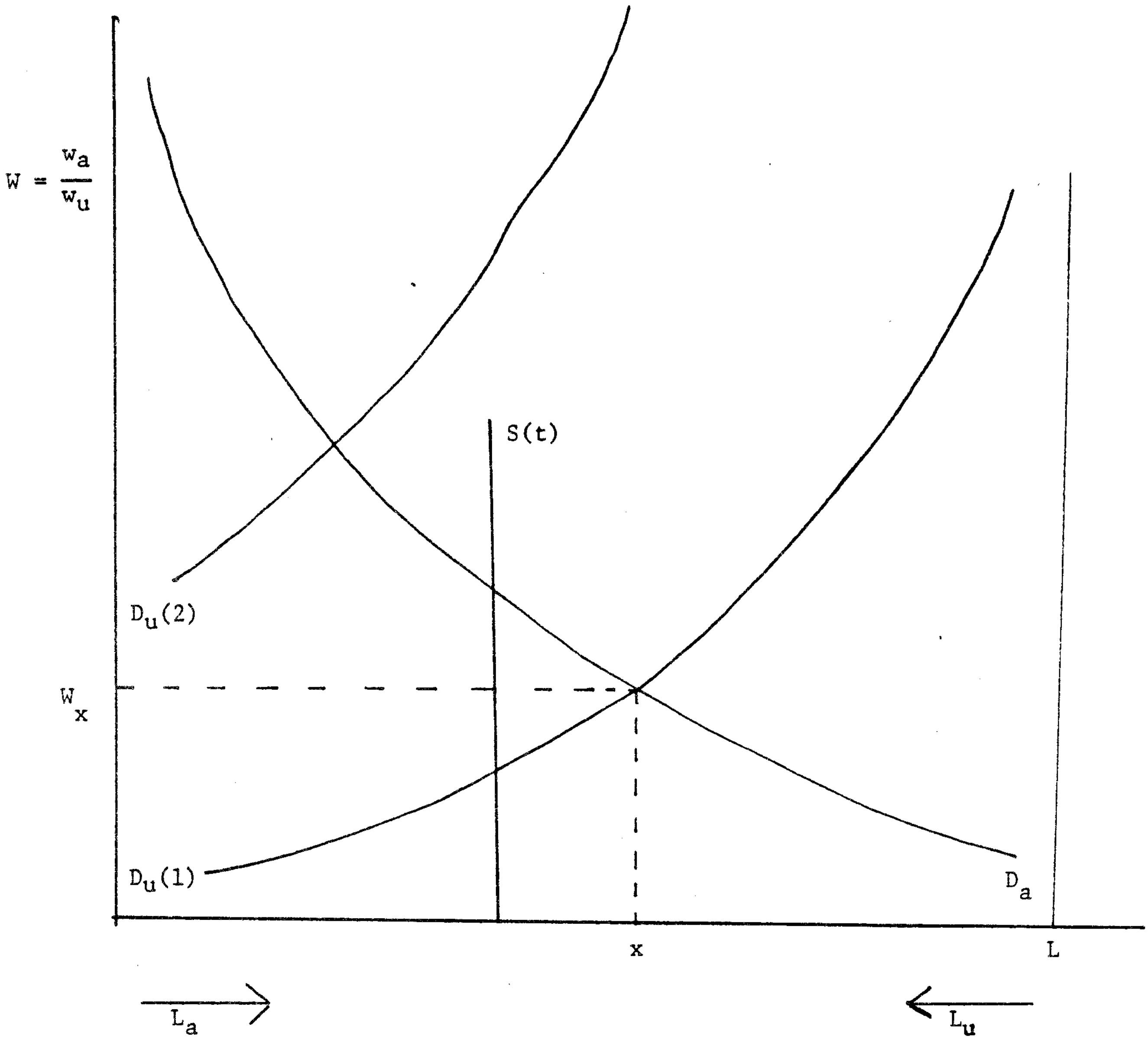
The labor market

It was already indicated that all countries in the sample registered positive migration from agriculture in the period of the analysis. This means that all the observations in the study are for labor markets in the process of adjustment, not in long run equilibrium. In this section we describe the operation of a labor market in adjustment and draw econometric implications from this description. We start by considering the market in a single country and then broaden the analysis.

The labor market of a country allocates workers between agriculture and the rest of the economy. In Figure 3, D_a is the long run demand for labor in agriculture and the curves D_u are the long run demand in the u sector; in both sectors, the demand is a function of the wage ratio. The diagram is drawn for a given labor force, L. The function D_u is the long run supply of labor to agriculture. In the stagnant initial equilibrium, the allocation was x and the wage ratio was W_x. Assume that the demand for labor in the u sector increased from $D_u(1)$ to $D_u(2)$. If this was the only change in the economy, then eventually a new allocation will be reached with wage ratio at the intersection of $D_u(2)$ with D_a. Introduce now the assumption that the process of reallocation is time consuming; say it takes 10 years. Over this period labor migrates from agriculture. Then at each point in time during the migration period, the short run labor supply is an inelastic function such as S(t) in Figure 3. The process of labor shift gradually traces the demand function.

In the real world it is not a once and for all shift in the demand for labor that affects the labor market, but rather continuous shifts in demand in the sectors and a continuous growth of the national labor force. Permanently, therefore, the market is in an intermediate, non-static-equilibrium position as in Figure 3.

Figure 3: The Labor Market



The operation of the market can be described by the following system of equations[3/]

demand:

(1) $$w_{at} = c_o + c_1 L_{at} + c_2 K_{at} + c_3 S_t + v_{1t}$$

short run supply:

(2) $$L_{at} = (1 + n)\, L_{a,t-1} - M_{t-1}$$

migration

(3) $$M_t = M\, (w_{ut}/w_{at},\, n,\, L_a,\, L_u) + v_{2t}$$

In the equations w, K and S, are wages, capital, and other factors in agriculture, L_a, L_u labor force in agriculture and in the other sectors, M the number of migrants, and the error terms in the regressions are v_1 and v_2. The migration equation will be formulated explicitly in the next section. During the period of adjustment, the flow of labor from agriculture is determined at each point of time, t, by the migration equation (3) in which it is affected by the wage ratio and by the relative size of the labor forces in the sectors a and u. The short run labor supply, eq. (2), is determined by $L_{a,t-1}$, by the rate of growth, n, and by migration. Given the inelastic short run

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3/ At this stage we present short run estimates of the demand equation (1) in which wages in agriculture are a function of the quantities of labor and other inputs. A long run formulation with prices of fertilizers, energy, and capital assets will be attempted in the future.

supply, market clearing wages are determined by (1), and they, in turn, affect next period's migration and short run supply.

The market operates in a recursive fashion--note that migration in the short run supply equation (2) is for t-1--allocation and wages are not determined simultaneously. This view of the market leads to two empirical implications.

The first implication is that in a single country, the migration equation and the demand function can be estimated separately by Ordinary Least Squares. In an intercountry analysis, on the other hand, we are observing not one single market, but a set of markets. And while each may operate recursively, simultaneity may exist in an intercountry sample. This possibility is tested in the estimates (details in the next version of the report).

The second implication stemming from the view of the labor market presented above is that the long run supply function is not traced by the market experiment in a process of adjustment and cannot be estimated from observations accumulated during such processes. To see why, recall that in a regular market setting the supply function can be identified if there were exogenous changes in the demand. In the market depicted by Figure 1 and during the adjustment period, changes in demand do not trace the supply function. Assume that the demand in agriculture shifted and, consistently with the observation of continuous migration, the shift was relatively small so that it did not stop migration or reverse its direction. Such a shift, if it occurred, affected the rate of the flow of labor from agriculture, but it did not trace the supply curve, because the market never reached points on the long run supply function.

Distributed lags models were proposed to estimate long run behavioral functions; they can be applied in this setting. Workers considering migration, compare expected future incomes in the alternative sectors, a simple assumption can be that expectations are weighted averages of past experience. This leads to a distributed lags formulation of the migration equation. This is a legitimate formulation which was not adopted here due to the paucity of data. But such a formulation will also not trace the long run supply function; again, because none of the observations in the sample is a point on that function.

We turn now to an explicit formulation of the migration equation.

Migration as A Modified Logistic

Consider a country with a constant labor force of size L divided into s_a (= L_a/L) percent in agriculture and $s_u = 1-s_a$. Opportunities are better in the u-sector and labor moves gradually. The occupational migration is affected by the relative size of the source, by s_a, and by that of the absorbing sector, by s_u. A simple formulation is that the share of labor force in agriculture changes according to the differential equation

$$\frac{ds_a}{dt} = -\rho s_a(1-s_a) \tag{4}$$

where ρ is a positive constant. This is a conventional formulation of the mathematic representation of constrained population growth (Davis, 1962, p. 96). Note that

$$\frac{ds_u}{dt} = -\frac{ds_a}{dt}$$

and the process of growth of s_u is the same as that of the decline of s_a.

The solution of (4) is the logistic function

(5) $$s_a = \frac{1}{1+ae^{\rho t}}$$

See Figure 4.

In application, the elementary logistic function of eq. (5) is modified in several ways. The rate of migration is affected by income differentials, by population pressure and by other factors. The parameter ρ is therefore not treated as constant, rather

(6) $$\rho = \rho(w_u/w_a, n)$$

where w_u and w_a are income or wages in the u and the a sectors, respectively, and n is the natural rate of growth of the labor force.

Equation (4) is also slightly modified and takes a more flexible formulation:

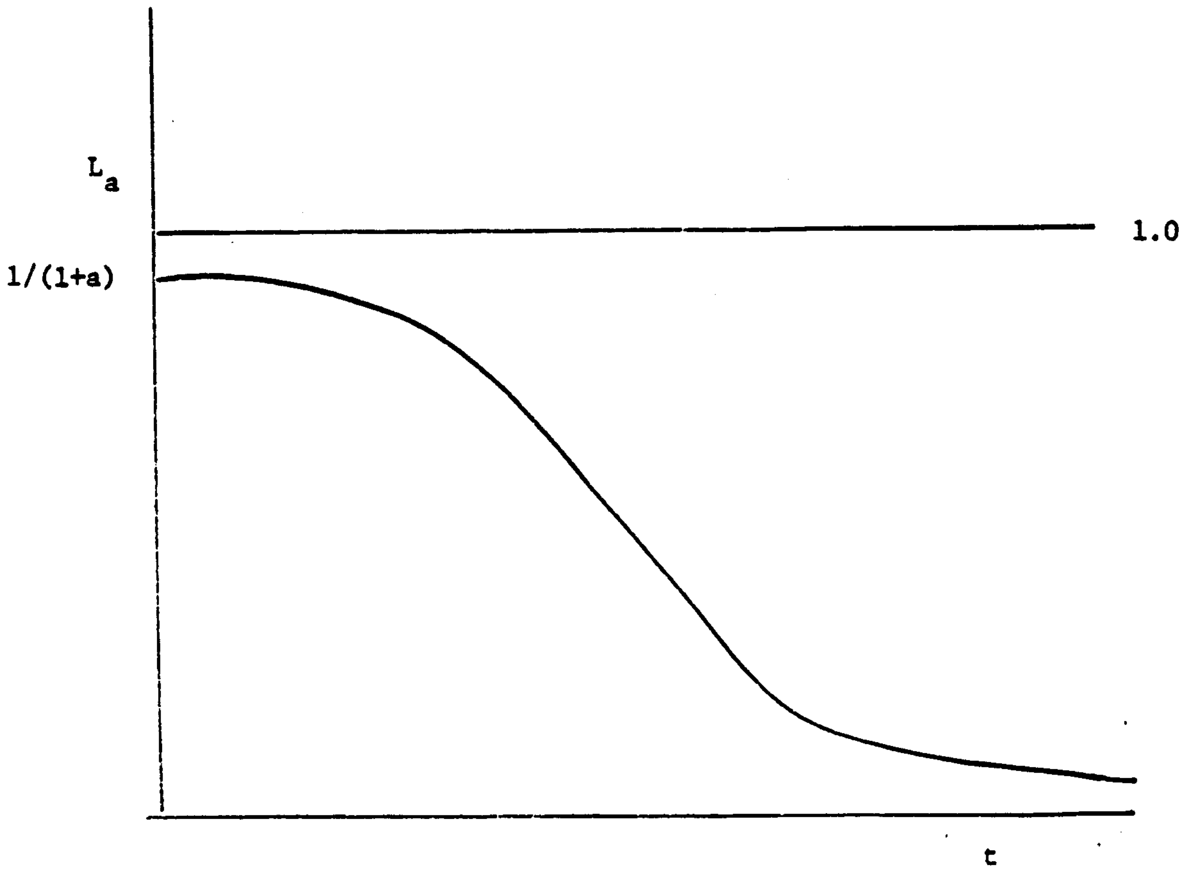
(4') $$\frac{ds_a}{dt} = -\rho s_a^{1-\beta}(1-s_a)^{\beta}$$

with β to be estimated empirically.

Migration, m, is defined as an annual rate, relative to the size of the labor force in agriculture. For a non-constant labor force, the change in L_a is

$$\frac{dL_a}{dt} = (n - m)L_a$$

Figure 4: The Logistic Curve



Not having separate information on the natural rate of growth the agricultural sector, n is measured for the total labor force: $n = (dL/dt)/L$. The rate of migration is measured in the study as the discrete equivalence of eq. (7).

$$(7) \qquad m = n - \frac{dL_a}{dt}\frac{1}{L_a}$$

Note that

$$(8) \qquad m = -\left(\frac{ds_a}{dt}\frac{1}{s_a}\right)$$

Dividing (4') through by s_a, combining with (8) and with an explicit formulation of (6), we get

$$(9) \qquad m = B(w_u/w_a)^{\beta_1}(1+n)^{\beta_2}[(1-s_a)/s_a]^{\beta_3}$$

Estimates of the parameters of eq. (9) are reported in the next section.

The logistic process converges to $s_a = 0$, while long run equilibrium will be established at a positive s_a. We will have to eat even in the long run. This possibility of a convergence to a constant s_a is outside the sample space of this study and is therefore disregarded here. 4/

4/ For an attempt to incorporte long run cessation or reversal of migration in empirical estimates, see Mundlak (1979).

Empirical Evidence

The data in Table 2 confirm the general logistic nature of the migration process. As we have seen, combining eqs. (4) and (8) in this process in its elementary formulation

$$m = \rho(1-s_a)$$

and for a constant ρ, m grows as the share of labor in agriculture (the denominator in m) decreases and the relative size of the absorbing sector increases. Indeed, in Table 2, m grows as s_a decreases both within the groups of countries and between the groups.

It will be useful to consider here the pattern of labor shift found by Kuznets (1982). He worked with 131 countries, ordered them by the share of labor in agriculture, and calculated the percentage point reduction in this share over the decades of the 1950s and 1960s. Moving from the most agrarian to the most industrialized country, the magnitude of the change Kuznets calculated first increased and then decreased. Expressed in the symbols of this paper, Kuznets calculated the difference

$$s_a(t-1) - s_a(t)$$

where t is 1960 and 1970 and t-1 is 1950 and 1960, respectively. This measure of the change is approximately ms_a (see eq. (8)). The measure is calculated for the data of the this study in line 6, Table 2 and it shows the same general pattern that Kuznets reported (he worked with 9 groups of countries and in single periods; the pattern of growth and decline was therefore more pronounced in his data than in Table 2). The growth and reduction that

Kuznets observed are due to the opposite effects of the components of the product ms_a.

With time, and as development proceeds, returns to labor move toward equalization; again, both within and between the groups of the countries in Table 2. We shall take up the equalization process in more detail below.

Income equalization can be expected to modify the logistic nature of the migration process. When wages are completely equalized (allowing for skill differences and other specific factors) migration will stop. In terms of the parameters, ρ will be zero. This has not happened yet in the groups of countries for which data are summarized in Table 2, and, as noted earlier, the possibility of the cessation of migration was, therefore, not incorporated in the empirical specification.

The estimated migration equation is, in logarithms

$$(9') \qquad \log m = \beta_o + \beta_1 \log(w_u/w_a) + \beta_2 \log(1+n) + \beta_3 \log[(1-s_a)/s_a] + \varepsilon$$

The first three terms on the right of (9'), as in eq. (9), are the components of the parameter ρ. The equation will also be estimated with a time variable and a dummy distinguishing developed and developing countries.

Eq. (9') is estimated in a sample of countries with data for two decades. Since countries differ in their position on the migration logistic, we get variability in the observations. This variability facilitates the empirical estimates, even if the variability over time within each country for the relatively short history of the analysis is small.

Table 3: Regression Estimates

Regression	Migration (1)
R^2(adj)	.572
Intercept	-5.326 (12.698)
Ratio of average product, non agr to agr (p_u/p_a)	.789 (2.922)
Labor allocation $(s_u)/s_a$	.555 (3.645)
Natural Growth (1+n)	-4.034 (.423)
Developed countries	.990 (2.928)
Decade, 1960s	-.123 (.611)

	Labor Demand	
	Wages (2)	Average Product (3)
R^2 (adj)	.544	.943
Intercept	2.9135 (.753)	.887 (4.549)
Labor (male)	-1.373 (2.530)	-.552 (12.20)
Land	-.201 (.202)	-.109 (3.55)
Livestock	.680 (2.944)	.486 (9.57)
Fertilizers	-.122 (1.209)	-.031 (.87)
Machinery	.143 (2.044)	.114 (3.84)
Schooling	1.195 (3.283)	.312 (2.75)
Irrigation	.031 (.728)	.087 (4.44)
Year, 1960	.182 (.720)	-.082 (1.23)
Year, 1980	-.149 (-.817	.139 (2.39)
DCs	-.213 (1.633)	.451 (4.35)

Notes to Table 3:

Dependent variables

Regression 1: annual rate of migration, m, in the decades 1960-70, 1970-80;

Regression 2: wage rate in agriculture;

Regression 3: average product per worker in agriculture;

s_a, s_u = share of labor in agriculture and in the rest of the economy.

n = rate of growth of total labor force;

Product ratio and labor allocation in the migration equation are for the beginning of the decade, natural growth is over the decade;

Country, decade and year variables are dummies;

In parentheses, t statistics;

Number of observations: 65, 78, 105 in Regressions 1, 2, 3, respectively.

The estimates are reported in Regression 1 under the heading "migration" in Table 3 (the other regressions in the table will be discussed below). The significant factors in the migration regression in the table are the coefficients of the ratio of returns to labor, of labor force in the sector, and the DCs variable. The effect of "population pressure"--growth of labor force--is negative and not significant in this regression.

The migration equation for the two groups of countries and for the decades of the 1960s and the 1970s is reconstructed in Table 4. This is done in stages. In line group 1 the components of log ρ [the first three terms in (9')] are reconstructed. Then the geometric average s_u/s_a ratio, reported in line 4, is raised to the power of β_3 and multiplied by the calculated ρ to yield the "predicted" m value in line 5. These calculated migration rates are compared to the actual rates (reported in line 6, in accordance with the procedure in the regression, as geometric means).

Despite the fact that in Table 3 the coefficient of the average product ratio (p_u/p_a) is substantial in size and significant, the quantitative effect of this variable on the migration coefficient is relatively small [the magnitude of .789 times $\log(p_u/p_a)$ is between 15 and 25 percent of log ρ]. Quantitatively, the most important component of ρ is the intercept in the regression equation. This may imply that, contrary to the theoretical hypothesis that migration is mainly driven by income differentials, the data show that other factors--not specified in the estimated model--affect migration to a much larger extent than income differentials do. But there may also be another explanation for this statistical finding: It will be seen below that countries with similar labor allocation differ substantially in product and wage ratios. This may indicate that the equilibrium income ratio

Table 4

The Migration Equation: $m = \rho (s_a/s_u)^{\beta_3}$

(Annual Rates)

	Developing Countries		Developed Countries	
	1960s	1970s	1960s	1970s
1. The components of ρ (in logs)				
Intercept	-5.326	-5.326	-5.326	-5.326
DC Dummy			.990	.990
1960 Dummy	-.123		-.123	
$.789 \log (p_u/p_a)$	1.055	1.037	.607	.586
$- 4.034 \log (1+n)$	-.080	-.096	-.044	-.044
2. Log ρ	-4.474	-4.385	-3.896	-3.794
3. The value of ρ	.011	.013	.020	.023
4. Labor ratio, s_u/s_a	.802	1.055	4.651	8.065
5. Calculated migration rate, m	.010	.012	.047	.072
6. Actual migration, m (geometric average)	.009	.015	.056	.061

Notes:

Calculated with the parameters of the migration regression in Table 3.

Line 5: $m = \rho (s_u/s_a)^{\beta_3}$, $\beta_3 = 0.555$

(the post migration ratio--if the process is ever to cease) differs between the countries; for different countries a different ratio will cause migration to stop (will bring the value of ρ to zero). Estimating the migration equation in cross-sectional data, the income ratio is a "variable with an error," the coefficient of which is under-estimated and the "explanation" is taken over by the intercept of the regression.

Absolute and Relative Measures of the Income Gap

Two countervailing forces operate on the income and the wage gap in a growing economy. On the one hand, migration eliminates wage differentials, it closes the income gap. On the other hand, the process of development, capital intensification and the rise in the general level of wages and income--increase the absolute wage and income differences. The explanation of the second phenomenon is based on the observation that the demand for skills is lower in agricultural employment than in the non-farm sector and on the theory of human capital. The presentation is based on Mincer (1974).

Start with schooling. The major cost of schooling is time spent--income foregone; assume this to be the only investment of the student. Let the income of a person with s years of schooling be y_s, and let the rate of returns to schooling be r. We are interested in the effect of additional schooling on income differentials.[5/] When a person with income y_o per year stays in school for another year, the investment is y_o and income next year, if this person quits schooling then, is y_1

$$y_1 = y_o + ry_o$$

[5/] To simplify the presentation, we assume infinite life and accordingly compare income levels and not human capital stocks.

$$= y_o(1+r)$$

Similarly

$$y_2 = y_o(1+r)^2$$

and

$$y_s = y_o(1+r)^s$$

The schooling of the labor force in agriculture is generally lower than that of the non-farm labor force. This is true not only for hired workers, but also for the average of hired and self employed. Assume, as an example, that the schooling level of the farm labor force is 6 years, that of the non-farm is 10 years and the rate of return is 10 percent, then

$$y_{10} = y_6 1.1^4$$

$$= 1.46 y_6$$

Hence the ratio between income in the sectors in constant; if y_6 increases, the absolute difference will grow.

Just as most of the investment in schooling is in the form of income foregone, so also a great part of the investment in training is in this form. Therefore, if in the non-farm sector the demand for trained personnel is relatively higher than in the farm sector, wages in the non-farm sector will be higher than those in the farm sector. Formally, let a worker in the urban sector with s years of schooling be trained on the job for n years and at this period the income of the trainee is k percent lower than what it would otherwise have been. Then, income in the training period is $y_s(1-k)$ and income after training is $y_s(1+k(1+r)^n)$.

With development, growth and capital accumulation--all wages in the economy grow, including y_o of the previous equations. Then y_s grows, on account of schooling, by $(1+r)^s>1$; training adds another muliplying factor (mitigated somewhat by the relative reduction of the earnings of the trainees). Hence, growth and development increase the absolute wage differentials due to schooling and experience. However, so long as the structure of demand for skills does not change, economic growth will not affect the relative income gap.

The foregoing was an analysis of earning differentials in equilibrium. Two questions are raised when this analysis is incorporated into a dynamic context with occupational migration: is migration driven by absolute or by relative income differences? and, will migration close the absolute income differences or only the relative gaps?

Migration is costly, it takes time and income is foregone, it is therefore a form of investment in human capital subject to the same eonomic considerations as schooling. If this is so, then it should be expected that similar relative income gaps will induce similar migration rates, even if the absolute income differences are not the same. With this explanation, when the relative gap increases, migration intensifies because workers with higher comparative advantages in agriculture will also migrate. On the other hand, if the cost of migration is constant, then workers will migrate when the absolute income differences (their capitalized value) will be higher than that cost. It is harder to explain however the positive correlation between the rate of migration and the income gap in such a constant cost formulation.

Turn now to the second question. By the human capital theory, if the demand for skills is comparatively lower in agricuture, there will be earning differences between agriculture and the other sectors even in the long run, and these differences will be higher in absolute value but unchanged in relative terms the higher the average level of the income of the country (actually, the relevant magnitude is not the average income but the base income of the unskilled: y_0 of the preceding analysis). Hence, in a county without capital accumulation in which the returns to skill levels do not change, migration will reduce both the relative and the absolute income gap. In an economy in which capital is accumulating, technology improves, and earnings increase, absolute income gaps will widen, and the effect of migration will be realized in the reduction of the relative gap.

Reallocation and Equalization

The effect of labor reallocation on the wages and the income gap depends on the demand for labor in agriculture. We present in Table 3 two estimates of the demand equation: in Regression 2 the dependent variable is the wage rate, in Regression 3 it is average product in agriculture. The equation was also estimated in a covariance analysis of a "within" country regression with similar results, but those are not reported here. The estimated demand functions are used in the following in two kinds of simulation analysis. First Regression 2 is used in this section to explain changes in wages. In the next section we use the estimates of Regression 3 to simulate time paths of employment and returns to labor in agriculture and to assess the reaction elasticities to exogenous changes.

The observed changes in wages in agriculture between 1960 and 1980, reported in Table 5, were an increase of 32.2 percent in the developing countries and of 91.4 percent in the developed countries. In part A of the table this change is divided into its components: In the developing economies labor increased over the period by 5.9 percent and the net effect of this change was to reduce wages by 8 percent; in the developed countries, labor supply in agriculture was decreased by 75.9 percent causing an increase of 104 percent in wages. By the same calculation, the accumulation of the non-labor factors had a much larger positive effect on the farm wages in the developing than in the developed countries--39.9 and 4.9 percent, respectively (the effect of prices, of terms of trade, will be studied in future work). Accordingly, the "prediction" of the regression of Table 3 is that wages in agriculture increased by 31.9 and 108.9 percent for the two groups of countries, respectively; close to the observed changes.

Two alternative hypothetical developments are simulated in Part B of Table 5. If labor force in agriculture had not changed at all, farm wages in the developing countries would have been higher by 8 percentage points than what they actually were (an increase of 39.9 instead of 32.2 percent); in the developed countries, under the same assumption, wages would have increased only by 4.9 percent (instead of a calculated increase of 108.9 percent). Similarly, without migration, the farm labor force would have increased--by 51.4 percent in the developing countries and by 22.2 percent in the developed ones--wages would have decreased by 30.7 percent in the developing countries, and by 25.6 percent in the developed economies.

Changes in the relative income gap--in wages or product ratio--affect the rate of migration. The elasticity of migration with respect to the ratio p_u/p_a is .789 (Table 3). Between 1960 and 1970 the product ratio changes only slightly both in the developing and the developed countries (Table 2). The

Table 5: The Effect of Labor and of Other Variables on the Changes in Wages, 1960- 1980 (Percent)

A. Explanation	Developing Countries	Developed Countries
Observed change of wages in agriculture	32.2	91.4
Calculated		
Labor (-1.373 times .059 for LDCs, times -.759 for DCs)	-8.0	104.0
Other factors	39.9	4.9
Change in wages	31.9	108.9
B. Simulated change in wages		
No change in agricultural labor force	39.9	4.9
No migration (Growth of labor force over the period LDCs .514, DCs .222)	-30.7	-25.6

Note:

Part A was calculated using the estimated coefficients of the demand equation in Table 3 and the geometric averages of the changes, over the period, of the explanatory variables in the regression.

effect of these changes on the rate of migration was evidently small. The product ratio changed markedly between 1970 and 1980, and when the data on the decade of the 1980s are available it will be interesting to see whether this narrowing of the gap actually reduced migration.[6/]

Short and Long Run Effects

The implication of the gradual nature of labor reallocation is that the effect of exogenous and policy changes on employment and returns to labor in agriculture is also only gradually realized. The impact and the short run effects of such changes are in general different from their long run effects.

In Table 6 we report simulation exercises designed to assess the effects of two exogenous changes: an increase in non-farm income and an increase in the intensity of irrigation. (In some cases irrigation is an endogenous variable in the economy of agriculture, in many others it is part of the infrastructure provided exogenously.)

The first column in the table is the actual geometric mean per country of labor, product and migration, for the sample years. The second column reports the replay of history with the model: we start in 1960 with the historically given labor force, calculate wages in agriculture according to demand regression 2 in Table 3 and calculate labor shift according to the migration equation. Subsequently, labor force for 1970 is determined by eq. (2) and the process continues.

6/ A single year may be an outlier, particularly after 1970 when farm prices were volatile. The average ratio for a period is a more appropriate measure of the gap.

Table 6: Preliminary Simulation Exercises (Geometric Averages)

	Developing Countries				Developed Countries			
	Actual	History Repl'd	Double Non-ag Income	Double Irrigation	Actual	History Repl'd	Double Non-ag Income	Double Irrigation
1960								
Labor ('000)	5548	5548	5548	5548	1168	1168	1168	1168
Avg. product ($)	760	698	698	741	2244	2430	2430	2580
Rate Of Mig (%)	0.009	0.011	0.019	0.0105	0.056	0.045	0.077	0.043
1970								
Labor ('000) ($)	5920	6044	5581	6073	802	825	585	843
Avg. Product ($)	974	928	970	983	3822	3796	4590	3983
Rate Of Mig (%)	0.0146	0.0128	0.022	0.012	0.061	0.072	0.124	0.069
1980								
Labor ('000)	6073	6628	5631	6689	564	470	199	492
Avg. Product ($)	1306	1212	1326	1.281	6464	6753	10853	6992
Elasticities								
Migration								
Impact (1960s)			0.73	-0.045			0.71	-0.044
Intermediate (1970s)			0.72	-0.063			0.72	-0.042
Employment								
Impact (1960)			0	0			0	0
Intermediate (1970)			-0.077	0.005			-0.29	0.022
Long Run (1980)			-0.15	0.009			-0.58	0.047
Average Product								
Impact (1960)			0	0.062			0	0.062
Intermediate (1970)			0.045	0.059			0.21	0.049
Long Run (1980)			0.094	0.057			0.61	0.035

Note: based on regressions 1 and 3 in Table 3. See text for explanations.

The simulation is done for each country separately and the figures reported in the first part of Table 6 are geometric averages per group of countries. The correlation between the country level actual observations and the "history replayed" simulation were higher than .90 for labor allocation and for average product, and .75, .65 for the migration flows in the two decades.

The third and fourth columns are simulations with non-agricultural income (average product) doubled in each of the years 1960, 70, 80 or with irrigation intensity doubled similarly. These changes have no impact effect on employment in 1960. Doubling irrigation increases the demand for farm labor and the average product rises in the first year and subsequently; doubling non-farm income affects returns to labor in agriculture only to the extent that it affects labor supply. This change is realized for the first time in the simulation exercise in 1970.

The second part of Table 6 reports elasticities calculated from the simulation exercises. It is striking how slow exogenous changes are realized in the farm sector. In the very long run, a rise in non-farm income will cause a proportional increase in returns to labor--the very long run elasticity of this effect is one--but by our simulation doubling non-farm income will result, after 20 years, in an increase of only 61 percent in agriculture in the developed countries. In the developing countries the reaction is much slower: after 20 years income in the farm sector will rise by less that 10 percent. The effect of irrigation, on the other hand, is comparatively stronger in the developing countries.

The differences between the developed and the developing countries reaction time is due to differential effects of migration on the labor force in the two groups. A proportional change in migration has a much larger effect on labor supply in the developed countries. As a result, improved non-farm opportunities has a comparatively large effect on labor supply in the agriculture of the rich countries; its effect on labor supply in the poorer countries is smaller. It is not the elastic long run supply of labor (surplus labor in the sense of Lewis, 1954, and Ranis and Fei, 1961) but the slow reaction of a large mass of workers that keeps returns to labor constant in agrarian economies. Similarly with irrigation, increased demand for labor is met by increased supply that dampens the beneficial effect of irrigation of the returns to labor in agriculture. This dampening effect is comparatively stronger in the developed countries.

General Pattern and Dispersion

The general patterns of wage and product gaps and labor allocation follow the logistic outline, but countries deviate markedly from this pattern. It will be useful to examine the relations between the income gaps and labor allocation diagramatically.

Figures 5 and 6 are scatter diagrams of the wage ratio and of the product ratio in the sample. Several features are noteworthy in these diagrams: We have less information, and therefore fewer points in the diagram, on wage ratio than on the product ratio. Wage data are not only scarce, they are also less reliable--there are several outliers in Figure 5, all of them for developing countries: Argentina, Yugoslavia and Turkey. The outliers probably reflect differences in the definition of agricultural workers or their wages between the countries. There is evidently more uniformity in measurement of the product--in agriculture and elsewhere in the economy.

Both Figures 5 and 6 reveal the general negative correlation between the share of labor in agriculture and the product ratio. But, both diagrams also reveal the fact that behind this negative correlation there exists a marked dispersion of the country data. This is manifested more clearly in Figure 6: Most of the developing countries are grouped at the lower range of the product ratio, but they differ substantially in the share of labor in agriculture. The developed countries are characterized mostly by comparatively lower shares of labor in agriculture but exhibit a large dispersion in the product ratio. These dispersions--both for the developing and for the developed countries--will have to be studied separately.

Figure 5: Wage Ratio and Labor Allocation

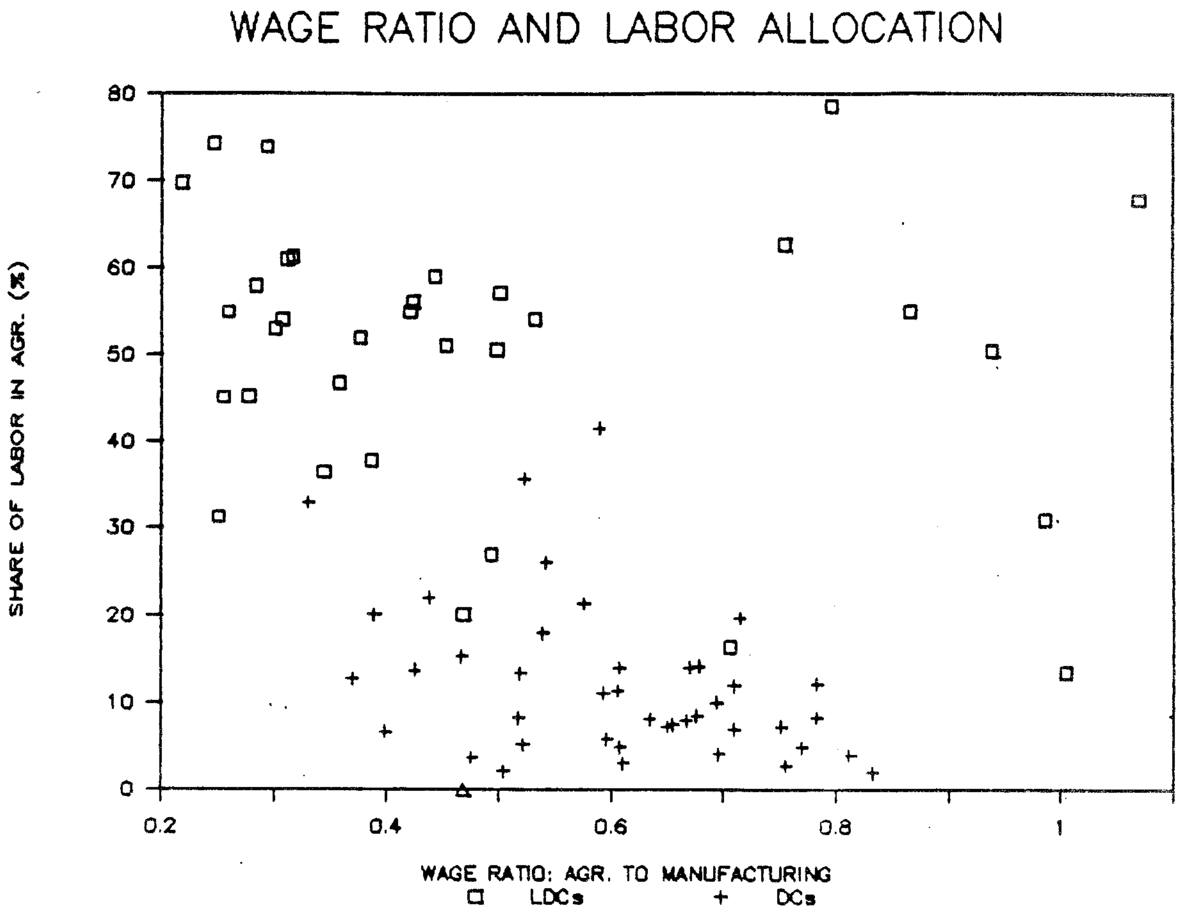
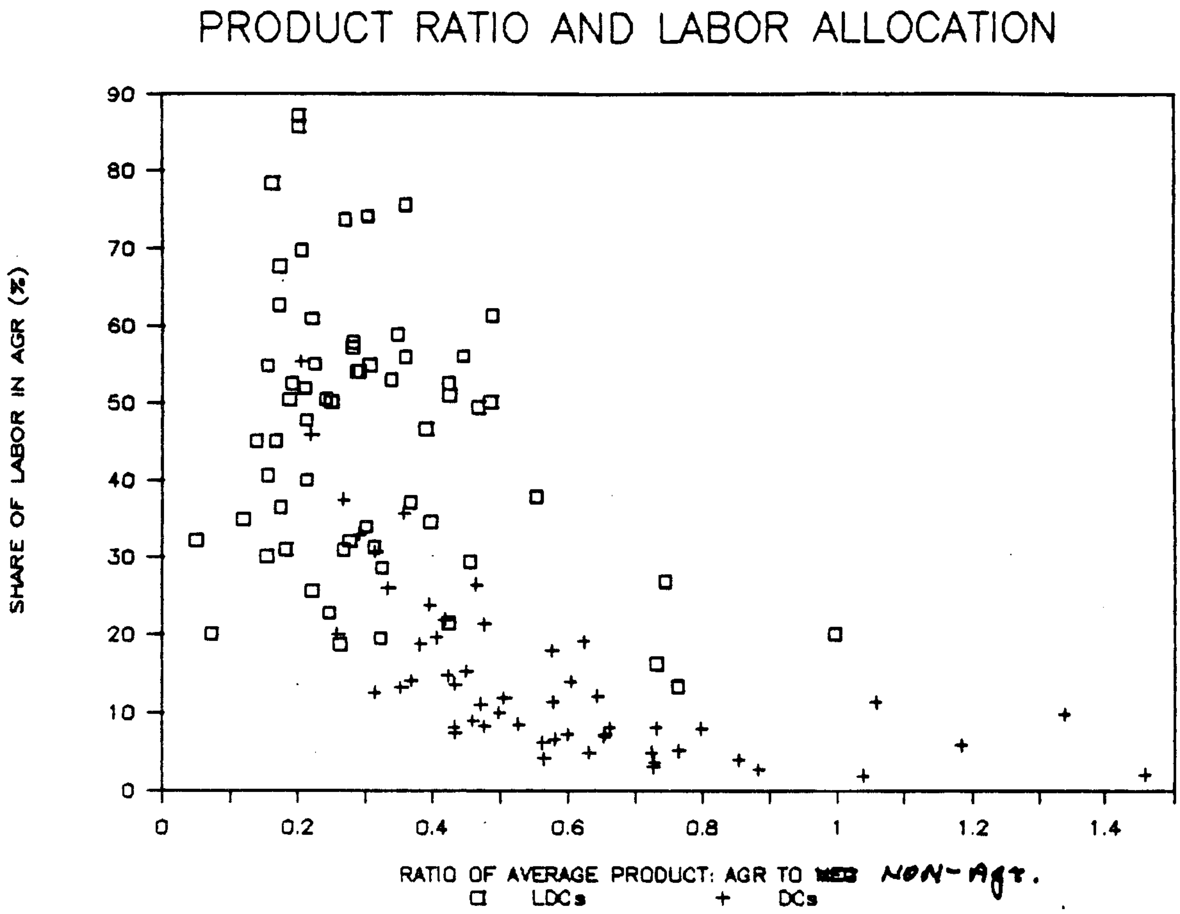


Figure 6: Product Ratio and Labor Allocation



Appendix

Sample Countries

Argentina	Australia
Bangladesh	Austria
Brazil	Belgium
Chile	Canada
Colombia	Denmark
Egypt	Finland
India	France
Libya	Germany, Fed Rep
Mauritius	Greece
Mexico	Ireland
Pakistan	Israel
Paraguay	Italy
Peru	Japan
Philippines	Netherlands
Portugal	New Zealand
South Africa	Norway
Sri Lanka	Spain
Syria	Sweden
Taiwan	Switzerland
Turkey	United Kingdom
Venezuela	United States
Yugoslavia	

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