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This paper concerns itself with uncertainty about individual skills. Skills vary across individuals and skill requirements vary across technologies. In general the matching of workers to technologies is a matter of importance both at the individual and social levels.

It is assumed that there are possibilities for generating imperfect but useful data on individual skills. Schooling, at least in part, may be looked upon as such an activity. These data, although imperfect, are useful to firms and affect one's income, the extent of the effect being dictated by the quality of the information. It is also assumed that after a period of time at work, output is observed and the individual's true skills revealed. Schooling and observation are the two sources of objective information in the model.

The individual's career decision is assumed to be permanent. There are two basic choices, self-employment versus work for a firm. Individuals have prior beliefs about their skills. If these beliefs are strongly held, it may be optimal for the individual to seek no further information and choose self-employment. More moderate (but still strong) priors lead to some schooling being taken, the information so generated leading to self-employment or working for a firm, depending on the information. Whenever self-employment (essentially just a one-man firm) is chosen, the individual reaps the full returns from correct matching but also bears the full cost of a mismatch whichever is the outcome.

If working for a firm is chosen, there are again two options. One is to let the output observation process take its course. At some later date the truth is revealed. This may necessitate job mobility as the individual may be worth more when working under a different technology. The other alternative is to form a contract with the firm wherein one agrees to work for the firm permanently at the partial information wage if output is not monitored. This situation occurs when the individual feels that partial information has led him to an advantageous situation which is likely to be reversed by new data.

The paper is structured as follows. The behavior of firms is spelled out. Second, information acquisition through schooling is considered. Individual behavior is then analyzed, the self-employment and contract decisions being presented in detail. The effect of the self-employment option on schooling is also dealt with. Finally, brief consideration is given to some empirical implications.[1]

I. BEHAVIOR OF FIRMS

Technologies vary across firms and individuals are more productive in some firms than in others. The income a firm is willing to offer an individual therefore depends on the output of any particular job-worker match and the probability that that match has occurred. In this section I derive these "offer functions". They summarize all the economically relevant information about firms.

There are two kinds of firms, α and β. Individuals are of two types, A and B. Type A (B) individuals are more productive under the type α (β) technology. Indexing individuals by I = A or B, individual lifetime outputs are as specified in Table 1.[2]

Firms are assumed to be risk neutral expected profit maximizers in competitive equilibrium. Accordingly, they offer individuals their expected

TABLE 1

Individual Outputs

Firm Type \ Individual Type	A	B
α	$\alpha_0 + \alpha_1$ $\alpha_1 > 0$	$\alpha_0 > 0$
β	$\beta_0 > 0$	$\beta_0 + \beta_1$ $\beta_1 > 0$

marginal product. Let Ξ denote an arbitrary person-specific information set.[3] Type α firms offer

(1) $$R^{\alpha}(\Xi;\alpha_0,\alpha_1) = \alpha_0 P(I=B|\Xi) + (\alpha_0+\alpha_1) P(I=A|\Xi) = \alpha_0 + \alpha_1 P(I=A|\Xi) .$$

α_0 is the minimum output a type α firm could obtain from any worker, the value of a "working body". $\alpha_1 P(I=A|\Xi)$ is the expected increment to output as a result of correct allocation.

In a similar fashion

(2) $$R^{\beta}(\Xi;\beta_0,\beta_1) = \beta_0 + \beta_1 P(I=B|\Xi).$$

Typically, full-information ($P(I=A|\Xi) = 0$ or 1) incomes differ by firm type. Arbitrarily then,

(3) $$\alpha_0 + \alpha_1 > \beta_0 + \beta_1.$$

Further, it is algebraically convenient to assume that

(4) $$\alpha_0 + \frac{1}{2}\alpha_1 = \beta_0 + \frac{1}{2}\beta_1 \equiv R^o$$

That is, an individual's expected marginal product is equal in both firms if $P(I=A|\Xi) = P(I=B|\Xi) = \frac{1}{2}$. Equations (3) and (4) imply

$$\alpha_1 > \beta_1$$

and $$\alpha_0 < \beta_0.$$

Correct allocation is worth more at the margin, and bodies worth less, in firms of type α.

Equations (1)-(4) summarize the behavior of firms. (1) and (2) delineate the manner in which individual information sets affect income. Note that raising $P(I=A|\Xi)$ lowers $P(I=B|\Xi)$ and vice versa, so that any objective information the individual provides increases his offer from one firm and lowers that from the other. Further, (4) specifies that the lowest offer an individual can receive occurs if there is no information on what group he is in.

II. THE ACQUISITION OF OBJECTIVE INFORMATION

There are two methods for generating information on individual skills.[4] One is simply to put the individual to work and wait to observe his output. This process generates information that may be stylized as specific and accurate.

A second method is for the individual to participate in activities that are correlated with ability to do the tasks that make up various jobs. Performance in these activities generates information which is imperfect but applicable to a variety of jobs. I will refer to these activities as schooling.

These two processes are modelled as follows.

Observation of output requires a period of employment, q. q is constant across firms. Observation correctly identifies which group the individual is a member of. The random variable Y summarizes the observation process and is freely available to all agents. Y = A or B and is such that

$$P[Y=A|I=A] = P[Y=B|I=B] = 1.$$

Schooling yields data X=a or b at the end of the schooling period, s. X=x is freely available to all agents. The probability that X=x correctly identifies which group a given person is a member of is assumed to be the same across groups.

$$P[X=a|I=A] = P[X=b|I=B] \equiv P \geq \frac{1}{2} .$$

P, which may be referred to as the quality of the information X=x, depends on the length of the schooling period.

$$P = f(s),\ f' > 0,\ f'' < 0,\ f(0) = \frac{1}{2}.$$

It is more convenient to work with $s(P) = f^{-1}(P)$ where

$$s' \geq 0, \ s'' > 0, \ s(\tfrac{1}{2}) = 0.$$

s(P) is the time required to generate data X=x with quality P. Below I shall use the assumption that the marginal time cost of information quality is low for low values of P. That is

$$s'(\tfrac{1}{2}) = 0.$$

III. PRIOR INFORMATION

Prior to observing X=x or Y=y, individuals may believe what they wish about which group they are a member of. Denote this by

$$P(I=A) = \pi, \qquad \pi \in [0,1].$$

Firms, before observing X=x and Y=y, have two pieces of information.[5] One is that the population is comprised of a certain fraction of A's. Let this fraction be $\frac{1}{2}$. Second, the firm may be told π, or may be able to infer it from schooling choice.

I assume that the firm ignores π. This is a sufficient condition for the results that follow below. What is required is that there is some disagreement between the firm and individual, and that the firm be more uncertain than the individual. That is, denoting the firm's prior by $\pi^f = P(I=A)$,

$$|\pi^f - \tfrac{1}{2}| < |\pi - \tfrac{1}{2}|.$$

If there are costs to inferring π or verifying information supplied by the individual, the required disagreement follows. For simplicity, I assume $\pi^f = \frac{1}{2}$.[6]

Therefore, prior to observing X=x and Y=y, firms behave as if $P(I=A|\Xi) = P(I=B|\Xi) = \frac{1}{2}$. Accordingly both firm types offer (from (4))

(6) $$R^{o} \equiv \alpha_0 + \frac{1}{2}\alpha_1 = \beta_0 + \frac{1}{2}\beta_1.$$

Once X=x is observed, $\Xi = \{P, X=x\}$ and

$$P(I=A|\Xi) = \begin{cases} P & \text{if } X=a \\ 1-P & \text{if } X=b. \end{cases}$$

(2) and (3) then become

(7) $$R^{\alpha}(P,X=a;\ \alpha_0,\alpha_1) = \alpha_0 + \alpha_1 P \equiv R^{\alpha}$$

(8) $$R^{\alpha}(P,X=b;\ \alpha_0,\alpha_1) = \alpha_0 + \alpha_1(1-P)$$

(9) $$R^{\beta}(P,X=a;\ \beta_0,\beta_1) = \beta_0 + \beta_1(1-P)$$

(10) $$R^{\beta}(P,X=b;\ \beta_0,\beta_1) = \beta_0 + \beta_1 P \equiv R^{\beta}.$$

Using (6), (7)-(10) imply that if X=a (b), the individual's highest offer is from a type α (β) firm.

Finally, if Y=y is observed $\Xi = \{I\}$ and firms offer

(11) $$R^{\alpha}(1) = \alpha_0 + \alpha_1 \equiv R^{A} \text{ if } Y=A$$

and

(12) $$R^{\beta}(1) = \beta_0 + \beta_1 \equiv R^{B} \text{ if } Y=B.$$

From (3), $R^A > R^B$. (7)-(12) are illustrated in Figure 1.

IV. SELF-EMPLOYMENT AND LONG-TERM CONTRACTS

If an individual is self-employed, he may operate the α or β technology. His expected output when self-employed is easily shown to be

(13) $$R^{\alpha}(\pi,P,X=a;\ \alpha_0,\alpha_1) = \alpha_0 + \alpha_1\ P[I=A|X=a] \equiv \tilde{R}^{\alpha}_{a}$$

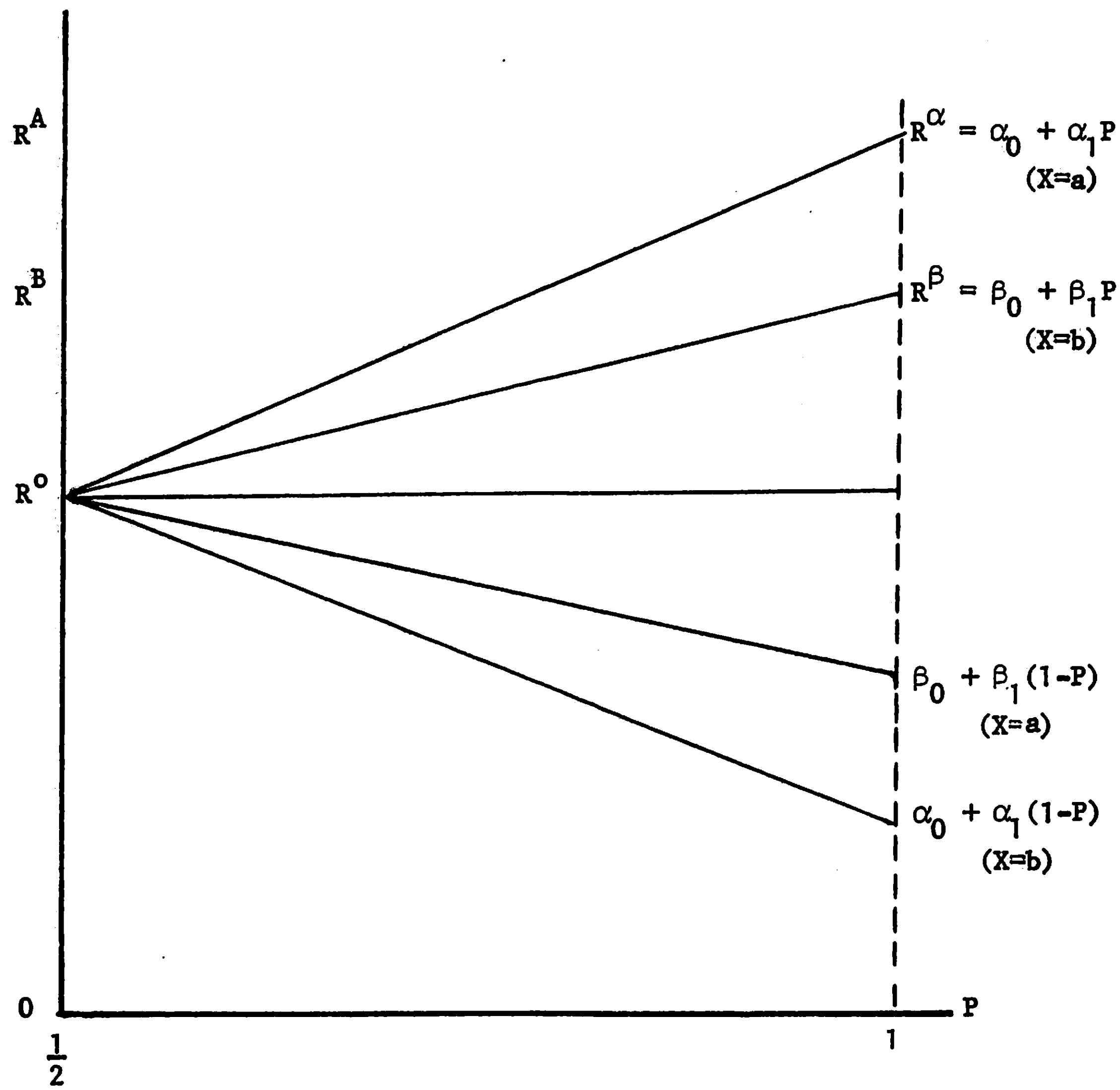
(14) $$R^{\alpha}(\pi,P,X=b;\ \alpha_0,\alpha_1) = \alpha_0 + \alpha_1\ P[I=A|X=b] \equiv \tilde{R}^{\alpha}_{b}$$

(15) $$R^{\beta}(\pi,P,X=a;\ \beta_0,\beta_1) = \beta_0 + \beta_1\ P[I=B|X=a] \equiv \tilde{R}^{\beta}_{a}$$

(16) $$R^{\alpha}(\pi,P,X=b;\ \beta_0,\beta_1) = \beta_0 + \beta_1\ P[I=B|X=B] \equiv \tilde{R}^{\beta}_{b}$$

Figure 1

Offer Functions



where $\hat{R}_x^i$ denotes expected output under technology i ($i=\alpha,\beta$) when X=x. (13)-(16) differ from (7)-(10) in that the probabilities are as assessed by the individual in (13)-(16), while they are as assessed by the firm in (7)-(10). Note that for $\pi \geq \frac{1}{2}$, $\hat{R}_a^\alpha > R^\alpha$ and that for $\pi \leq \frac{1}{2}$, $\hat{R}_b^\beta \geq R^\beta$.

Self-employment is taken to be a permanent decision. If self-employment is optimal the individual chooses a technology and operates it for his entire (post-schooling) working life.

The other alternative is to work for a firm. If this option is chosen, a second decision must be made. The firm may observe output after q. If the individual and firm agree that output will not be observed, the individual receives an income of R^α or R^β for the rest of his working life. This agreement is referred to as a long-term contract (LTC). If a LTC is not chosen, output is observed after q and the individual works where he is worth most. This is referred to as a short-term contract (STC).

V. INDIVIDUAL BEHAVIOR

Individuals are assumed to be risk neutral maximizers of expected life wealth. This assumption allows the analysis to focus on the impact of differential expectations as opposed to differences in tastes. The problem individuals face is as follows. At the outset of their working life they must decide how much (if any) schooling (s) to take. This determines information quality, P. At the end of the schooling period, X=x is observed. At that time, the individual makes his career choice, choosing between work for a firm and self-employment (SE). If the former is chosen, the decision on LTC or STC is made.

Analytically, the most intuitive way to solve the problem is to begin with the decisions that must be made at the end of the schooling period and proceed to the beginning. For given P and X=x, the problem of whether to be self-employed or work for a firm under LTC or STC is considered. Given the optimal behavior that follows X=x and given P, the choice of P is made.

At this point it is useful to provide some notation.

SE_j^x : self-employment using technology j when X=x
($j = \alpha,\beta$; x=a,b)

LTC^x: long-term contract if X=x (x=a,b)[7]

STC^x: short-term contract if X=x (x=a,b).

Let $V(\omega_x)$ denote expected remaining life wealth after X=x is observed under contract ω_x ($\omega_x = SE_j^x$, LTC^x, STC^x). Let $\Omega(\omega_x,\omega_y)$ denote expected life wealth under optimal choices of ω_x and ω_y. $\Omega(\cdot)$ and $V(\cdot)$ satisfy

$$\Omega(\omega_x,\omega_y) = P(X=a)\ V(\omega_a) + P(X=b)V(\omega_b).$$

Using this notation, the individual's full problem may be written

$$\max_{s,P} \Omega(\omega_x,\omega_y) = \max_{s,P}\{P(X=a)\ \max_{\omega_a} V(\omega_a) + P(X=b)\ \max_{\omega_b} V(\omega_b)\}$$

subject to

$s = s(P)$,

(7)-(12),

and (13)-(16).

A. <u>The Choice of Self-Employment and Contract Type for X=a</u>

For a given P and X=a, the individual problem is

$$\max_{\omega_a} V(\omega_a)$$

subject to (7), (9), (13) and (15).

There are four possible choices and corresponding values of $V(\omega_a)$[8]

i) $V(SE^a_\alpha) = (1-s)\hat{R}^\alpha_a$;

ii) $V(SE^a_\beta) = (1-s)\hat{R}^\beta_a$;

iii) $V(LTC^a) = (1-s)R^\alpha$;

and iv) $V(STC^a) = q\, R^\alpha + (1-s-q)\, E^a(R)$,

where $E^x(R) = P(I=A|X=x)R^A + P(I=B|X=x)R^B$ is the conditional expectation of full-information income given X=x.

The four possibilities generate six paired comparisons. Before getting involved in the details, it may be useful to summarize the results. For fixed P, π determines the individual's choice. The choices do however, depend on the value of P that is chosen. There are two regimes corresponding to two sets of values of P. If P is such that $R^\alpha < R^B$, there is a $\pi_1^* \in (0, \frac{1}{2})$ such that the individual will ignore the data X=a and choose SE^a_β over STC^a if $\pi < \pi_1^*$. Further, there is a $\pi_2^* \in (\frac{1}{2}, 1)$ such that the individual will choose SE^a_α over STC^a if $\pi > \pi_2^*$. For $\pi \in [\pi_1^*, \pi_2^*]$, STC^a is chosen.[9]

If P is such that $R^\alpha \geq R^B$, there is a $\pi_3^* \in [0, \frac{1}{2}]$ such that LTC^a is chosen if $\pi < \pi_3^*$. As above, SE^a_α is chosen if $\pi > \pi_2^*$, and STC^a for $\pi \in [\pi_3^*, \pi_2^*]$. These propositions are illustrated in Figure 2.

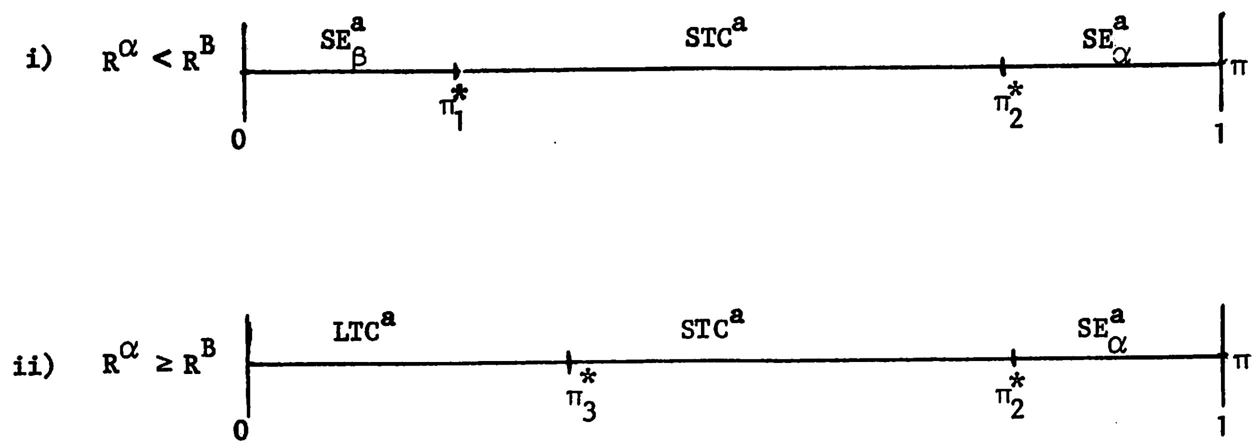
To see how these results follow refer to Figure 3.

First consider the choice between LTC^a and STC^a. LTC^a is optimal if

$$(17) \quad V(LTC^a) - V(STC^a) = (1-s)R^\alpha - q\, R^\alpha - (1-s-q)E^a(R)$$
$$= (1-s-q)\, [R^\alpha - E^a(R)]$$

Figure 2

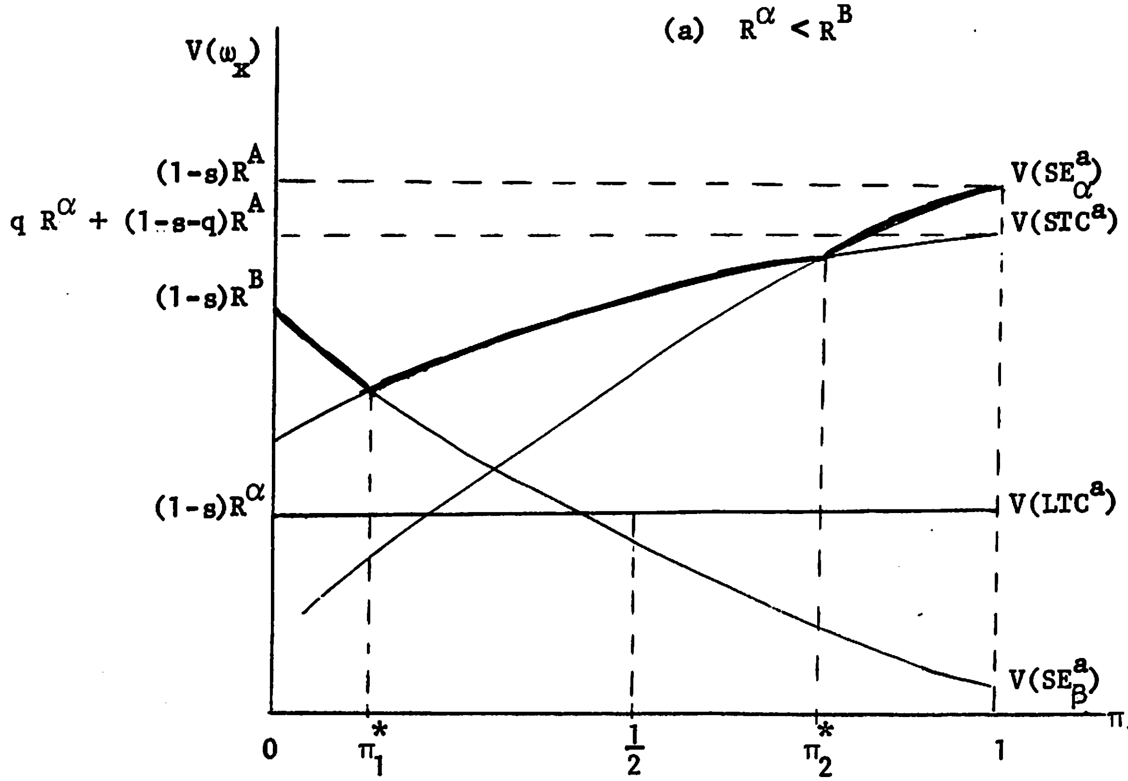
Self-Employment and Contract Type for Various π Values: $X=a$[†]



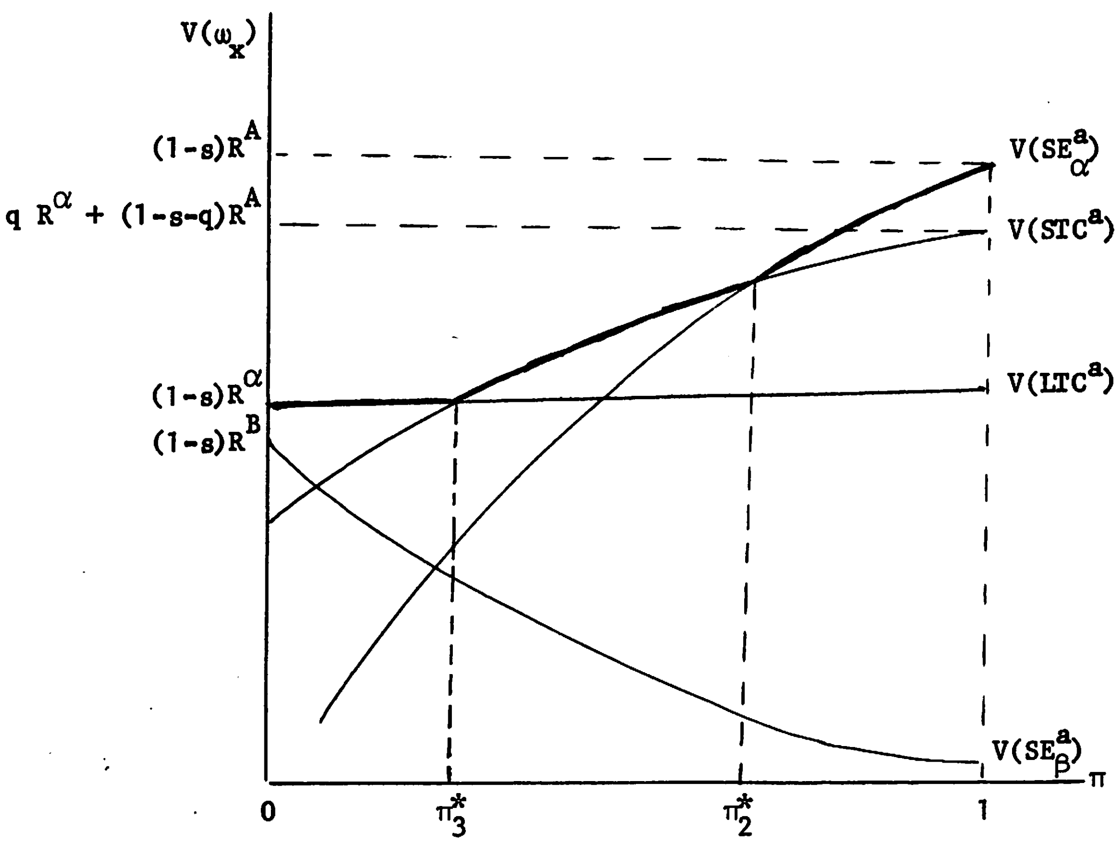
[†]The π^{*}_{i} in parts (i) and (ii) of the Figure cannot be compared as P is not held constant at the same level.

Figure 3

(a) $R^{\alpha} < R^{B}$



(b) $R^{\alpha} \geq R^{B}$



is positive. Since $E^a(R) \geq R^B$, $R^\alpha \geq R^B$ is necessary for (17) to be positive. Both LTC^a and STC^a offer the same income over the potential observation period q. The difference is in terms of income after q. Under LTC^a, income remains at $(1-s-q)R^\alpha$, while changing to $(1-s-q)R^A$ or $(1-s-q)R^B$ under STC^a. Receiving $(1-s-q)R^B$ necessitates changing jobs. In this model, non-mobility occurs either because it is precluded (LTC^a) or unnecessary (STC^a and Y=A), the current allocation being optimal. Mobility is explicitly productive as it improves the job-worker match.[10]

It is interesting to examine this case for $\pi = \frac{1}{2}$. For $\pi = \frac{1}{2}$, individuals and firms have the same expectations. It is easy to show that (17) is negative for $\pi = \frac{1}{2}$. That is, for identical information sets, individuals display a clear preference for STC^a while firms are indifferent, all offers yielding zero expected profit. The reasoning behind this seemingly unusual result is simply that firms and individuals do not face the same alternatives. Consider the period starting at 1-s-q. If I=A, the firm obtains output valued at $(1-s-q)R^A$, obtaining $(1-s-q)\alpha_0$ if I=B. Consequently their LTC^a offer for that period is

$$(1-s-q)\{P[I=A|X=a]R^A + P[I=B|X=a]\alpha_0\} = (1-s-q)R^\alpha.$$

Individuals, if they choose STC^a, receive $(1-s-q)R^A$ if I=A and $(1-s-q)R^B$ if I=B (through job mobility). For $\pi = \frac{1}{2}$,

$$(1-s-q)\{P(I=A|X=a)R^A + P(I=B|X=a)R^B\} > (1-s-q)R^\alpha$$

since $R^B > \alpha_0$. Individual preference for STC^a if $\pi = \frac{1}{2}$ arises from the ability to move across firms to where their skills are worth most. $\pi < \frac{1}{2}$ is therefore a necessary condition for LTC^a to dominate STC^a.

Thus the choice of LTC^a is limited to relatively low values of π and high values of $P(R^{\alpha} > R^{B})$.

It may be verified that $V(LTC^a) - V(STC^a)$ is monotone declining in π, and that for $R^{\alpha} > R^{B}$, LTC^a is optimal for $\pi = 0$. Therefore, there exists $\pi_3^* \in (0, \frac{1}{2})$, depending on P, for which

$$V(LTC^a) \gtreqless V(STC^a) \Leftrightarrow \pi \lesseqgtr \pi_3^* .$$

Now consider the choice between STC^a and SE_a^{α}. STC^a is chosen if

$$(18) \quad V(STC^a) - V(SE_{\alpha}^a) = q\,R^{\alpha} + (1-s-q)\;E^a(R) - (1-s)\hat{R}_a^{\alpha}$$

is positive. (18) is monotone declining in π, positive at $\pi = \frac{1}{2}$ and negative at $\pi = 1$. Therefore, there exists a $\pi_2^* \in (\frac{1}{2},1)$ such that

$$V(STC^a) \gtreqless V(SE_{\alpha}^a) \Leftrightarrow \pi \lesseqgtr \pi_2^*.$$

If the individual is sufficiently optimistic, he will choose to forego the opportunity to move across firms, and take his chances with self-employment wherein he bears the full cost of any mismatch.

Another alternative is to disregard the data X=a and choose SE_{β}^a. Suppose $R^{\alpha} < R^{B}$ so that the relevant alternative is necessarily STC^a. SE_{β}^a will be chosen if

$$(19) \quad V(STC^a) - V(SE_{\beta}^a) = q\,R^{\alpha} + (1-s-q)\;E^a(R) - (1-s)\hat{R}_a^{\beta}$$

is positive. (19) is monotinically increasing in π, negative at $\pi = 0$ and positive at $\pi = \frac{1}{2}$. There is therefore $\pi_1^* \in (0, \frac{1}{2})$ such that

$$V(STC^a) \gtreqless V(SE_{\beta}^a) \Leftrightarrow \pi \gtreqless \pi_1^*.$$

Finally, consider the comparison of LTC^a and SE_{β}^a. Suppose that $R^{\alpha} > R^{B}$ so that LTC^a is potentially optimal.

$$(20) \quad V(LTC^a) - V(SE_{\beta}^a) = (1-s)R^{\alpha} - (1-s)\hat{R}_a^{\beta}.$$

But $\tilde{R}_a^{\beta} < R^B < R^{\alpha}$. (20) is therefore positive whenever LTC^a is feasible.

The remaining two comparisons, LTC^a versus SE_{α}^a and SE_{α}^a versus SE_{β}^a, are irrelevant. Referring to Figure 3(a), whenever LTC^a is optimal STC^a dominates SE_{α}^a. In Figure 3(b), whenever SE_{β}^a is optimal, STC^a dominates SE_{α}^a. If SE_{α}^a is optimal, STC^a dominates SE_{β}^a.

Summarizing, for X=a, those individuals who are fairly sure they are in group A will become self-employed using the α technology. Those less sure will choose a short-term agreement, keeping their mobility options open. Those who are fairly sure they are in group B will choose self-employment using the β technology or a long-term arrangement with a type α firm. The latter will be chosen if the LTC^a offer is high relative to the income expected under self-employment.

B. <u>The Choice of Self-Employment and Contract Type for X=b</u>

For X=b and a given value of P, the $V(\omega_x)$ are as follows:

i) $V(SE_{\beta}^b) = (1-s)\tilde{R}_b^{\beta}$;

ii) $V(SE_{\alpha}^b) = (1-s)\tilde{R}_b^{\alpha}$;

iii) $V(STC^b) = q\, R^{\beta} + (1-s-q)\; E^b(R)$;

and iv) $V(LTC^b) = (1-s)R^{\beta}$.

The discussion is considerably simpler for X=b then for X=a. The reason is that for any P, $R^{\beta} < R^B$, implying that the lowest full information income always exceeds the LTC income. Formally,

$$(21) \quad V(LTC^b) - V(STC^b) = (1-s)R^{\beta} - q\, R^{\beta} - (1-s-q)E^b(R)$$
$$= (1-s-q)\,[R^{\beta} - E^b(R)]$$
$$< 0$$

since $E^b(R) > R^B > R^{\beta}$.

The results are intuitive. For X=b and given P, π determines behavior. There is a $\pi_4^* \in (0, \frac{1}{2})$ such that SE_β^b is optimal for all $\pi < \pi_4^*$. Further, there is a $\pi_5^* \in (\frac{1}{2}, 1)$ such that SE_α^b is optimal for all $\pi > \pi_5^*$. STC^b is optimal for all $\pi \in [\pi_4^*, \pi_5^*]$. These results are summarized in Figure 4.

The results follow directly from examination of V(•).

Compare $V(SE_\beta^b)$ and $V(STC^b)$ (see Figure 5).

(22) $V(SE_\beta^b) - V(STC^b) = (1-s)\hat{R}_b^\beta - q\, R^\beta - (1-s-q)E^b(R)$.

(22) is negative at $\pi = \frac{1}{2}$ and positive at $\pi = 0$. Further, (22) is monotone decreasing in π. There is therefore $\pi_4^* \in (0, \frac{1}{2})$ such that $V(SE_\beta^b) \gtreqless V(STC^b)$ as $\pi \lesseqgtr \pi_5^*$.

Similarly, SE_α^b is chosen if

(23) $V(SE_\alpha^b) - V(STC^b) = (1-s)\hat{R}_b^\alpha - q\, R^\beta - (1-s-q)E^b(R)$

is positive. As (23) is negative for $\pi = \frac{1}{2}$ and positive for $\pi = 1$, there is a $\pi_5^* \in (\frac{1}{2}, 1)$ such that $V(SE_\alpha^b) \gtreqless V(STC^b)$ as $\pi \gtreqless \pi_5^*$.

C. The Relationship Between the π_i^*

From sections A and B, it is evident that a large number of (ω_x, ω_y) pairs are possible. Some are obviously not optimal. For example, $(SE_\alpha^a, SE_\beta^b)$ requires both $\pi > \frac{1}{2}$ and $\pi < \frac{1}{2}$. That is, choosing self-employment requires strong prior beliefs. If the individual is willing to let the data determine which technology to use, his priors could not be strong enough to choose self-employment for all X=x.

One other restriction is possible. It may be shown that $\pi_4^* > \pi_1^*$. That is, when considering self-employment using the β technology, the prior information that the individual is in group B must be stronger when the decision to be self-employed involves ignoring the data X=a. To see that this is the case, note that the returns to choosing self-employment using the β technology are greater when X=b than when X=a. That is $V(SE_\beta^a) < (SE_\beta^b)$.

Figure 4

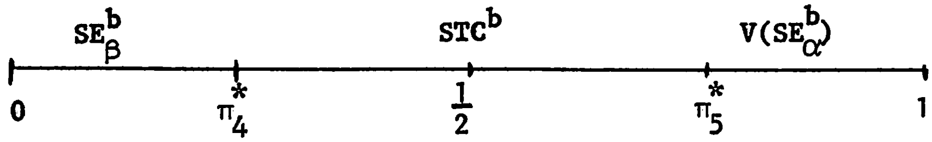
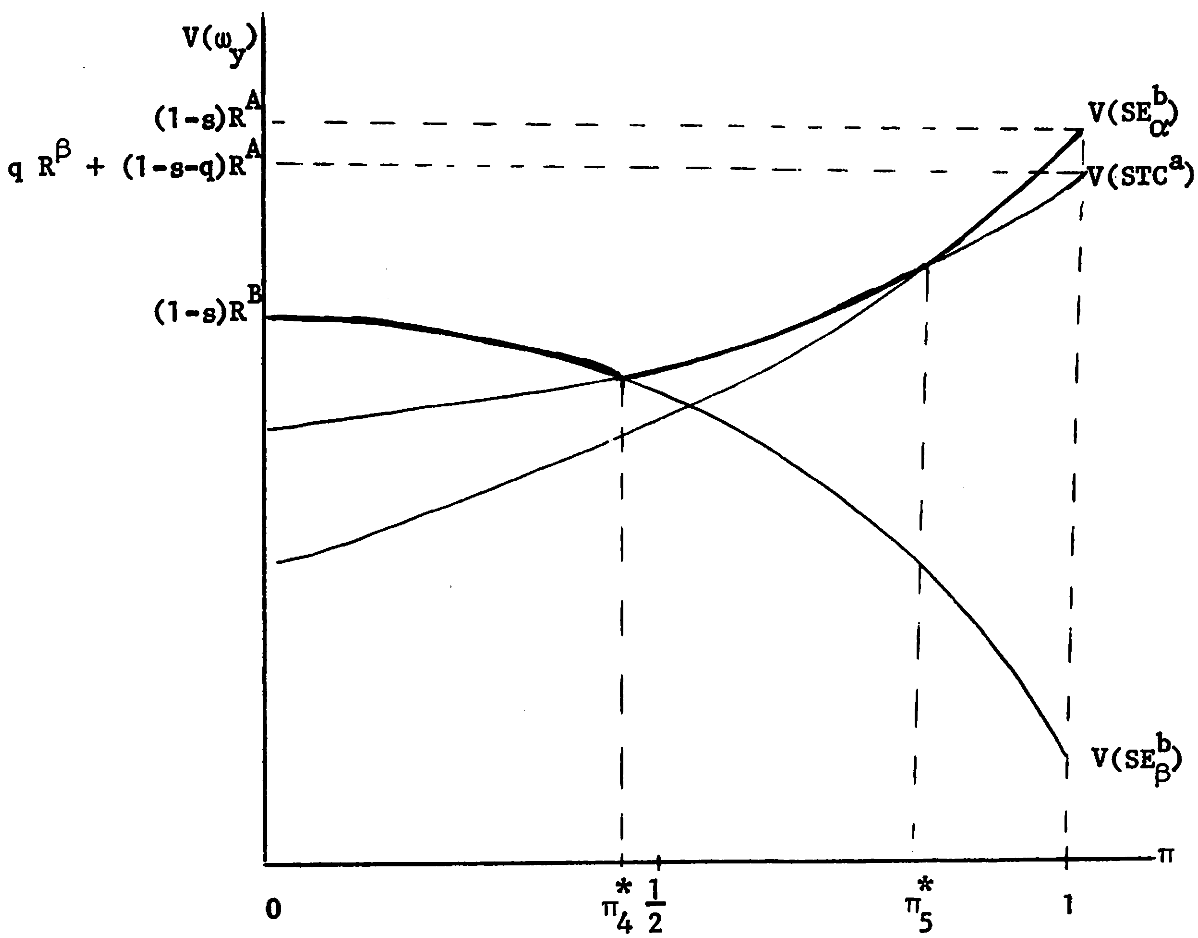


Figure 5



Because $V(STC^b) < V(STC^a)$ always holds, the costs of choosing self-employment are smaller when X=b. Therefore, suppose $\pi = \pi_1^*$. Then $V(SE_\beta^b) > V(SE_\beta^a) = V(STC^a) > V(STC^b)$. Equivalently, $\pi < \pi_4^*$ must hold.

Intuitively, one might expect that $\pi_5^* > \pi_2^*$. That is, when the decision to become self-employed using technology α involves ignoring X=b, the prior information that the individual is in group A ought to be stronger. This is not the case. When X=a, the returns to choosing self-employment are larger than when X=b. That is $V(SE_\alpha^a) > V(SE_\alpha^b)$. If the costs of choosing self-employment were independent of X=x, $\pi_5^* > \pi_2^*$ would follow. But $V(STC^b) < V(STC^a)$ also holds, so that both the returns and costs of choosing self-employment using technology α are lower if X=b. Consequently nothing conclusive can be said about π_5^* relative to π_2^*.

One final point should be noticed. If $P = \frac{1}{2}$, the data X=x contain no information. Also, LTC^a is dominated by STC^a ($R^\alpha < R^B$ at $P = \frac{1}{2}$). Accordingly, at $P = \frac{1}{2}$, $\pi_1^* = \pi_4^*$ and $\pi_2^* = \pi_5^*$. That is, the decision to choose self-employment using either technology depends only on π. Further the only optimal (ω_x, ω_y) pairs are (SE_β^a, SE_β^b), (STC^a, STC^b) and $(SE_\alpha^a, SE_\alpha^b)$.

The results in sections A, B and C are summarized in Table 2.

D. <u>Optimal Choice of Information Quality</u>[11]

There are nine optimal (ω_x, ω_y) choices. These fall into three categories: Those for which the data are disregarded (1 and 6); those for which self-employment is not optimal for any X=x (3 and 2(a)); and those for which self-employment is only chosen for X=a or X=b but not both.

For brevity, optimal choice of information quality will be analyzed for one (ω_x, ω_y) pair from each category.

TABLE 2

(ω_x, ω_y) for Various π Values

$R^{\alpha} < R^{B}$	$R^{\alpha} \geq R^{B}$ †
1. SE^a_β, SE^b_β if $\pi \leq \pi^*_1$	1(a) LTC^a, SE^b_β if $\pi < \min\{\pi^*_3, \pi^*_4\}$
2. STC^a, SE^b_β if $\pi^*_1 < \pi \leq \pi^*_4$	2(a) LTC^a, STC^b if $\pi^*_4 < \pi^*_3$; $\pi^*_4 < \pi < \pi^*_3$
3. STC^a, STC^b if $\pi^*_4 < \pi < \min\{\pi^*_2, \pi^*_5\}$	2(b) STC^a, SE^b_β if $\pi^*_3 < \pi^*_4$; $\pi^*_3 < \pi < \pi^*_4$
4. STC^a, SE^b_α if $\pi^*_5 < \pi^*_2$; $\pi^*_5 < \pi \leq \pi^*_2$	
5. SE^a_α, STC^b if $\pi^*_2 < \pi^*_5$; $\pi^*_2 < \pi < \pi^*_5$	
6. SE^a_α, SE^b_α if $\pi > \max\{\pi^*_2, \pi^*_5\}$	

†For $\pi > \pi^*_3$, the results are the same as those given under $R^{\alpha} < R^{B}$.

Consider case 1: $(\omega_x,\omega_y) = (SE^a_\beta, SE^b_\beta)$. Self-employment using the β technology is chosen regardless of X=x. Expected life wealth is

$$(24)\quad \Omega(SE^a_\beta,SE^b_\beta) = P(X=a)\ V(SE^a_\beta) + P(X=b)\ V(SE^b_\beta) = (1-s)[P(X=a)\tilde{R}^\beta_a + P(X=b)\tilde{R}^\beta_b].$$

Using (15) and (16), and

$$(25)\quad P[Y=B|X=a] = (1-P)(1-\pi)/P(X=a)$$

and

$$(26)\quad P[Y=B|X=b] = P(1-\pi)/P(X=b),$$

(24) simplifies to

$$\Omega(SE^a_\beta,SE^b_\beta) = (1-s)[\beta_0 + \beta_1(1-\pi)]$$

which depends on P only through s, and then negatively so. $P = \frac{1}{2}$ is therefore optional. If one plans to ignore the data, there is no net payoff to increasing its quality.[12] This result applies to case 6 also.

In the second group, consider case 3: $(\omega_x,\omega_y) = (STC^a,STC^b)$.[13]

$$\Omega(STC^a,STC^b) = P(X=a)[q\ R^\alpha + (1-s-q)E^a(R)]$$
$$+ P(X=b)\ [q\ R^\beta + (1-s-q)E^b(R)]$$

The necessary condition determining P is

$$(27)\quad \frac{\partial\Omega}{\partial P} = (2\pi-1)[V(STC^a) - V(STC^b)]$$
$$+ P(X=a)[q\,\alpha_1 + (1-s-q)\frac{\pi(1-\pi)}{P(X=a)^2}(R^A - R^B) - s'\,E^a(R)]$$
$$+ P(X=b)[q\,\beta_1 + (1-s-q)\frac{\pi(\pi-1)}{P(X=b)^2}(R^A - R^B) - s'\,E^b(R)].$$

Understanding the analysis in the sections to follow is facilitated by careful examination of (27). Since $V(STC^a) > V(STC^b)$, expected life wealth is increased if P(X=a) rises. P(X=a) rises (falls) with P if $\pi > \frac{1}{2}$ $(< \frac{1}{2})$. The first line of (27) therefore represents the expected value of the effect of changing P on P(X=a) (hence also P(X=b) = 1-P(X=a)); positive (negative) for $\pi > \frac{1}{2}$ $(< \frac{1}{2})$.

The second line of (27) represents the effects of P on expected life wealth given X=a. Under STC^a, raising P increases R^{α} by α_1 over the period q. Hence the term q α_1 is the effect of P on the partial information income q R^{α}. Given X=a, increasing P raises $P(Y=A|X=a)$ and lowers $P(Y=B|X=a)$. $(1-s-q)R^A$ is received if Y=A and $(1-s-q)R^B$ if Y=B. Since $R^A > R^B$ (equation (3)) increasing P has a positive effect on $E^a(R)$ through making it more likely, given X=a, that the most advantageous result, Y=A, will occur. Finally $s' E^a(R)$ measures the marginal time cost of increasing P.

The last line of (27) provides the effects of P on expected life wealth given X=b. The interpretation is like that of the second line. Note however that increasing P reduces $E^b(R)$ by making it less likely that the most advantageous result, Y=A, will occur given X=b.

Finally, consider the "mixed" case 2: $(\omega_x, \omega_y) = (STC^a, SE^b_\beta)$.

$$\Omega(STC^a, SE^b_\beta) = P(X=a)[q\ R^\alpha + (1-s-q)E^a(R)] + P(X=b)[(1-s)\tilde{R}^\beta_b].$$

The necessary condition is

$$(28) \quad \frac{\partial\Omega}{\partial P} = (2\pi-1)[V(STC^a) - V(SE^b_\beta)]$$
$$+ P(X=a)[q\alpha_1 + (1-s-q)\frac{\pi(1-\pi)}{P(X=a)^2}(R^A - R^B) - s' E^a(R)]$$
$$+ P(X=b)[(1-s)\beta_1 \frac{\pi(1-\pi)}{P(X=b)^2} - s' \tilde{R}^\beta_b].$$

(28) may be interpreted in the same way as (27). Note however, that given X=b, increasing P raises expected life wealth. In the previous case, Y=A was the advantageous outcome because the individual could move across firms, and Y=A generated the largest of all incomes. Here however, Y=B is the advantageous outcome. The individual chooses SE^b_β if X=b and life wealth is greatest if he is in fact correctly matched with that technology.

Before proceeding, recall that for $P = \frac{1}{2}$, the optimal (ω_x, ω_y) pairs are (SE^a_β, SE^b_β), (STC^a, STC^b) and $(SE^a_\alpha, SE^b_\alpha)$, depending on π. The first and last of these options yield $P = \frac{1}{2}$ as optional. $P > \frac{1}{2}$ is optional for the second case.[14] All the other cases are only optional for $P > \frac{1}{2}$. Therefore, unless self-employment is chosen for all x, $P > \frac{1}{2}$ is optimal.

VI. THE EFFECT OF THE SELF-EMPLOYMENT OPTION ON OPTIMAL CHOICE OF INFORMATION QUALITY

Suppose that self-employment were not possible. Then, it follows that all individuals choose $P > \frac{1}{2}$ and hence a positive amount of schooling. Consider those individuals who would choose (SE^a_β, SE^b_β) or $(SE^a_\alpha, SE^b_\alpha)$ were self-employment possible. If self-employment is allowed, those individuals choose $P = \frac{1}{2}$ and hence $s = 0$. There is therefore an intuitive presumption that the self-employment option reduces the level of schooling for those who find it optimal to be self-employed for some (or all) X=x. The intuitive reasoning is that if self-employment may be chosen, improved information is in some sense unnecessary.

This train of thought is in fact fallacious.[15] Allowing for self-employment unambiguously reduces the optimal P only when the data X=x do not affect the self-employment decision. In a number of "mixed" cases (e.g., (STC^a, SE^b_β)), introducing self-employment most likely raises the optimal P.

To see why this is the case, it is useful to first consider why $P = \frac{1}{2}$ is optimal if $(\omega_x, \omega_y) = (SE^a_\beta, SE^b_\beta)$. Recall equation (24):

$$\Omega(SE^a_\beta, SE^b_\beta) = P(X=a)\ V(SE^a_\beta) + P(X=b)\ V(SE^b_\beta). \tag{24}$$

Without further simplification, differentiate (24) with respect to P:

$$\frac{\partial\Omega}{\partial P} = (2\pi-1)[V(SE^a_\beta) - V(SE^b_\beta)]$$
$$+ P(X=a)[(1-s)\ \beta_1 \frac{\pi(\pi-1)}{P(X=a)^2} - s'\tilde{R}^\beta_a]$$
$$+ P(X=b)[(1-s)\ \beta_1 \frac{\pi(1-\pi)}{P(X=a)^2} - s'\tilde{R}^\beta_b].$$

From the earlier analysis, all the terms not involving s' sum to zero.[16] The point however is that, unless $\pi = 0$, the data do affect expectations. Given X=a, expected life wealth is lower than if X=b and increases in P augment this difference. It turns out that the effects of P sum to zero. This does not however imply that the separate effects are themselves equal to zero as the intuitive argument suggests. Thus $P = \frac{1}{2}$ is optimal not because information is not useful but rather because at the time of investment, its effects cancel out.

Given the preceding, it is not hard to see why allowing for self-employment may increase the optimal P. Consider for example those individuals who would choose (STC^a, SE^b_β) and suppose that SE^b_β is ruled out, leaving them with (STC^a, STC^b) as their best choice. The main difference between these two situations is that P affects expected life wealth positively for all X=x under (STC^a, SE^b_β) while the effect may be negative for X=b under (STC^a, STC^b) (see (27) and (28) above). Indeed if one evaluates the necessary condition determining P for (STC^a, SE^b_β), (28), at the level of investment that would be chosen under (STC^a, STC^b), the result is

$$(29)\quad \frac{\partial}{\partial P}\Omega(STC^a, SE^b_\beta)\Bigg|_{\frac{\partial}{\partial P}(STC^a, STC^b) = 0} = (2\pi-1)\{V(STC^b) - V(SE^b_\beta)\}$$
$$+ P(X=b)\{(1-s)\ \frac{\pi(1-\pi)}{P(X=b)^2}\ \beta_1 - q\beta_1 - (1-s-q)\ \frac{\pi(\pi-1)}{P(X=b)^2}\ (R^A - R^B)$$
$$- s'\tilde{R}^\beta_b + s'E^b(R)\}$$

Since $\pi < \frac{1}{2}$ is necessary for SE_β^b to be optimal when X=b, and $\tilde{R}_b^\beta \le R^B \le E^b(R)$, the only negative term is $-q\beta_1$, reflecting the fact that under STC^b, increased P affects income positively for the period q if X=b. Generally (29) may be expected to be positive.

The other mixed cases follow similarly. Therefore, with the exception of those individuals who would choose self-employment under any X=x, there is no presumption that self-employed individuals should take more or less schooling than those who work for firms.

VII. EFFECTS OF PARAMETER CHANGES ON THE CHOICE OF SELF-EMPLOYMENT AND CONTRACT TYPE

As there are nine potentially optimal cases and several parameters, a complete discussion of the effect of parameter changes is not feasible. However, the calculations and explanations are simple and do not vary widely across cases. Consequently, it suffices to consider one representative case.

Recall that for X=a, STC^a is chosen over SE_α^a if

$$V(STC^a) - V(SE_\alpha^a) = qR^\alpha + (1-s-q)E^a(R) - (1-s)\tilde{R}_a^\alpha$$

is positive.

Consider variation in q. Increasing q has no effect on $V(SE_\alpha^a)$, while lowering $V(STC^a)$ by shortening the period over which the highest income is expected:

$$\frac{\partial}{\partial q}\{V(STC^a) - V(SE_\alpha^a)\} = q[R^\alpha - E^a(R)] < 0$$

if $V(STC^a) > V(LTC^a)$ (as is necessary; see (17)). Accordingly, increased q makes SE_α^a more attractive relative to STC^b.

On the other hand, what happens if the marginal value of correct allocation rises, holding R^o fixed. That is, $d\alpha_1 = d\beta_1 \equiv d\xi > 0$ and

$dR^o = d\alpha_0 + \frac{1}{2}\, d\alpha_1 = 0$; a counter-clockwise rotation of R^α and R^β in Figure 1. This represents an increase in the value of correct allocation and a decline in the value of a working body.

$$\frac{\partial}{\partial \xi}\{V(STC^a) - V(SE^a_\alpha)\} = qP + (1-s-q) - (1-s)[P(Y=A|X=a) - \tfrac{1}{2}]$$
$$> qP + (1-s-q) - (1-s)\cdot\tfrac{1}{2}$$
$$> 0.$$

$d\xi > 0$ raises both $V(STC^a)$ and $V(SE^a_\alpha)$. The latter rises by a smaller amount because the self-employed individual may suffer the consequences of a decline in the value of a working body. If STC^a is chosen, this decline is never encountered.

Finally, consider an increase in π.

$$\frac{\partial}{\partial \pi}\{V(STC^a) - V(SE^a_\alpha)\} = (1-s-q)\,\frac{P(1-P)}{P(X=a)^2}\,(R^A - R^B) - (1-s)\alpha_1\,\frac{P(1-P)}{P(X=a)^2} < 0.$$

An increase in π raises $V(SE^a_\alpha)$ more than $V(STC^a)$. The duration of the increase in expected income is longer for SE^a_α. Further, the income difference across Y=y states is larger, α_1 versus $R^A - R^B$ (see Figure 1).

VIII. EMPIRICAL CONSIDERATIONS

The theoretical work has a number of interesting empirical implications. I will focus on those that relate to the emergence of information over time.[17]

For those individuals choosing positive schooling, partial information is available early in the working life. For those who choose a STC, full information becomes available after a period of time at work. If a LTC is chosen, partial information from schooling is all that ever exists.

One simple and direct implication is that a longer duration of schooling raises the frequency of correct job-worker matches. Consequently, the number of separations (quits, layoffs and firings) should be negatively related to length of time spent in school. The data appear to support this, at least at the industry levels. Stoikov and Raimon, using data on 52 industries, make use of a "quality of work force" variable which is primarily a skill index presumably highly correlated with average educational attainment. They report negative simple correlations between the quality variable and both layoff and quit rates. Further, their quit rate regressions suggest that quality has a negative impact.

In a well-known study Parsons reports significant negative effects of education on layoffs, finding an insignificant effect on quits.

A second hypothesis is that as information emerges over time, a larger fraction of the labor force should become correctly matched to their jobs. Consequently, separations should also be negatively related to experience. The literature also provides some support for this hypothesis. Flanagan, estimating both linear probability functions and logits on individual data, finds that the probability of both quits and layoffs are negatively related to experience.[18]

Third, less reallocation across firms implies less changes in individual income and accordingly, less mobility within the distribution of income. Consequently, mobility within the distribution of income should decline as the cohort ages. This empirical phenomena is well known.[19]

Finally, with regard to self-employment, I have characterized it as primarily a job in which one permanently accepts all the risks of an inappropriate matching of the individual to the job. As a consequence, in a cross section, one ought to find that self-employed workers have a higher variance in income and a more significant permanent component. No results appear to be available on the latter hypothesis. However, Wolpin reports that self-employed individuals have a standard deviation of earnings (in the cross section) 71% larger than that of salaried workers, and a coefficient of variation 23% larger (.85 versus .68).

IX. SUMMARY

This paper has presented a model wherein information on individual attributes emerges over time. Depending on the initial stock of information, the individual may choose to participate in activities (schooling) that improve the stock of information. If the prior information is strong enough to render participation in these activities suboptimal, the prior information must also be strong enough to make it optimal for the individual to choose self-employment regardless of the new information that would be produced via these activities.

For less extreme priors, participation in information producing activities is optimal. Depending on the information produced, self-employment or work for a firm will be chosen. The various optimal choices depend, in an intuitively appealing way, on prior beliefs.

If work for a firm is chosen, it is possible for the individual's true attributes to be observed after a period of time at work. It was shown that it may be optimal for the individual to form an agreement with the firm wherein the possibilities for observation go unexploited. If observation occurs, job mobility is optimal if the individual is more productive under a different technology.

Returning to self-employment, it was shown that the optimal level of schooling is not necessarily reduced by the possibility of self-employment if the output of the schooling process affects the self-employment choice.

Finally, the effects of parameter changes on contract choice were sketched and some simple empirical applications suggested.

APPENDIX

Density Functions and Their Derivatives

Density	Derivative with respect to P	Derivative with respect to π
$P(X=a) = P(2\pi-1) + (1-\pi)$	$2\pi - 1$	$2P - 1$
$P(X=b) = P(1-2\pi) + \pi$	$1 - 2\pi$	$1 - 2P$
$P[Y=A \mid X=a] = \frac{P\pi}{P(X=a)}$	$\frac{\pi(1-\pi)}{P(X=a)^2}$	$\frac{P(1-P)}{P(X=a)^2}$
$P[Y=B \mid X=a] = \frac{(1-P)(1-\pi)}{P(X=a)}$	$\frac{\pi(\pi-1)}{P(X=a)^2}$	$\frac{P(P-1)}{P(X=a)^2}$
$P[Y=A \mid X=b] = \frac{(1-P)\pi}{P(X=b)}$	$\frac{\pi(\pi-1)}{P(X=b)^2}$	$\frac{P(1-P)}{P(X=b)^2}$
$P[Y=B \mid X=b] = \frac{P(1-\pi)}{P(X=b)}$	$\frac{\pi(1-\pi)}{P(X=b)^2}$	$\frac{P(P-1)}{P(X=b)^2}$

FOOTNOTES

*Lecturer, Department of Economics, The University of Western Ontario. This paper is a revised version of Chapter III of my Doctoral Dissertation. The comments of Sherwin Rosen, Donald O'Hara, Walter Oi, Barbara Mann and the members of the U.W.O. Labor Workshop are gratefully acknowledged.

[1]The analysis presented herein makes few claims to generality, simple exposition being the goal. A more general and rigorous discussion is contained in MacDonald (1979b).

[2]Table 1 provides the output that the individuals would produce if his entire working life were spent at the job. One can think of output as occurring at the rate $\alpha_0 + \alpha_1$ for example. Normalizing the individual's lifetime to length 1, output produced by spending a fraction, t, of ing life would then be given by (continuing the same example)

$$\int_0^t (\alpha_0 + \alpha_1)dx = (\alpha_0 + \alpha_1)t.$$

[3]Ξ may represent full information. That is $P(I=A|\Xi) = 0$ or 1 is not precluded.

[4]For simplicity, skills are treated as endowed. Uncertainty about the capacity to learn a skill may be modelled in a similar fashion.

[5]If $s > 0$, s must obviously precede q. Y=y makes X=x obsolete.

[6]For the present appraoch to be fully rigorous, it is necessary to assume that π has no content. Setting $\pi^f = \frac{1}{2}$ is then optimal behavior on the part of firms. This generates a self-confirming equilibrium wherein firms' expectations are realized.

If π has objective content, and if workers are not risk neutral, it may be shown that although the firm cannot infer π from schooling behavior, it can infer something about π from the distribution of tastes in the population. This inference alters the wage offers in approximately the manner suggested in the text. While more rigorous, this approach is vastly more complex and evidently yields results very similar to those presented herein. Thus to focus on the issues under consideration, the simpler approach is taken.

[7]Notation such as STC_j^x turns out to be unnecessary. As long as self-employment is not chosen, X=a(b) implies that the individual works for, and forms contracts with, firms of type α (β).

[8]Recall that the individual's life has length 1.

[9]Each of the π_i^* depend on the level of P as well as $R^\alpha \gtrless R^B$.

[10]Job mobility in a simple dynamic model has recently been analyzed by Johnson. In Johnson's model, individuals draw incomes from an exogenous distribution. Mobility corresponds to the choice of a second drawing without recall. A job change will occur if the first income drawn is low. In the informational model, the distribution of wages is endogenous and is generated by the firm's technology and individual's information sets. Individuals change jobs when their value to another firm exceeds their value to the firm to which they are currently attached.

[11]The discussion of optimal investment is brief. A detailed analysis is given in MacDonald (1979a).

[12]This does not imply that if $P > \frac{1}{2}$, X=x would have no effect on expectations. See section VI.

[13]The predictive and conditional densities, as well as their derivatives with respect to P and π, are listed in the Appendix.

[14]Evaluating (27) at $P = \frac{1}{2}$ yields

$$\frac{\partial\Omega}{\partial P} = \frac{q}{2}(\alpha_1 + \beta_1) > 0.$$

$P > \frac{1}{2}$ is therefore optimal.

[15]Of course, $\pi = 0$ or 1 renders new information useless. $\pi \in (0,1)$ is therefore assumed here.

[16]With a little rearranging, the terms not involving s' may be expressed as

$$\beta_1(1-s)\{[P(Y=B|X=a) - P(Y=B|X=b](2\pi-1) - \pi(1-\pi)\ [\frac{1}{P(X=a)} - \frac{1}{P(X=b)}]\}$$

which is easily shown to equal zero.

[17]For a discussion of a number of other issues, see MacDonald (1979a, 1979b).

[18]See Burdett for a search theoretic approach to the same problem.

[19]See, for example, Schiller.

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