HEALTH MAINTENANCE BY WORKERS IN RURAL AND URBAN PRODUCTION STRUCTURES[1]

by

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ABSTRACT: The paper explores some interactions between production environment and health maintenance by workers in developing countries. We argue that rural occupations, being less highly specialized than occupations in urban areas, offer members of rural households a range of productive activities requiring different combinations of health capital and other inputs. Urban occupations, in contrast, typically admit a much smaller range of activities. We use a highly stylized model of a worker's allocation of labor time to demonstrate that the non-specialized production environment of the rural worker raises the opportunity cost of health care at low levels of health, and thus weakens incentives for curative health maintenance. Health policy implications of this result in the context of developing countries are drawn.

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1. Introduction

The purpose of this paper is to explore some interactions between production environment and health maintenance by workers in developing countries. We start with two observations. First, health status in developing countries is generally lower in rural areas than in urban areas (Ribero (1999), Anker and Knowles (1980), Koinange (1982), Bigsten (1977), Republic of Kenya (1986)). Second, a key characteristic differentiating the urban from the rural work environment, particularly in developing countries, is the lower degree of specialization of labor in the rural sector. We argue that rural occupations, being less highly specialized, offer members of rural households a range of productive activities requiring different combinations of health capital and other inputs. Urban occupations, in contrast, typically admit a much smaller range of activities, and these activities themselves offer limited possibilities of substitution between health capital and other inputs. The limited range of productive opportunities for an individual in a specialized work environment such as an urban area, reduces the opportunity cost of labor time. A mechanic or an electrician for example, has fewer productive activities outside his specialized trade relative to a rural trader, who for instance may engage in a variety of commercial and agricultural activities. We show that in the particular cases of *sickness* (low levels of health) when both workers are not in their usual employment, the reservation wage for the urban worker is *lower* than that for the general worker in a rural setting, and explore formally the health maintenance consequence of this wage differential.

Since health care typically requires an allocation of time (e.g., a hospital visit), the maintenance of health should be affected by the worker's perception of the opportunity cost of time away from production. The role of time as a device for rationing health maintenance services in developing countries has been well documented in the literature (see, e.g., Acton (1973, 1975), Akin *et al*. (1986), Dor *et al*. (1987), Mwabu (1989), Alderman and Gertler (1989) Ribero (1999)). In Nigeria, for example, 50 percent of a sample of working women cited the time constraint as the major reason for not getting their children immunized (Akin, *et al*. (1985)). Since human capital theory would suggest that the poor have a lower opportunity cost of time than the non-poor, a major policy implication of these findings has been that rationing of health services through queues, or other mechanisms involving substantial time expenditures, benefits the poor more than the non-poor. We will argue, instead, that the production environment of rural households raises the opportunity cost of a sick worker's time above the level that the same worker would confront in an urban production structure. The rural worker thus has a weaker incentive for curative health maintenance than his or her urban counterpart.

The relatively high opportunity cost of health care in rural areas comes from the fact that the rural worker whose health has deteriorated can generally find some productive use for his impaired health capital. For example, a rural worker suffering from a mild attack of malaria can shift from harvesting to lighter work such as scaring crop predators. In contrast, the opportunity cost of health maintenance for urban workers declines more rapidly as health deteriorates, since other inputs cannot be substituted for health capital, especially in the short run, without a substantial loss in income.[4] While this is less true for the urban informal sector than the formal sector,

[4] This effect is strengthened by the availability of sick leave for urban workers and the greater prevalence of health insurance in urban areas. The effect of these additional institutions on health maintenance has been studied in the literature; see, e.g., Feldstein (1973), Arrow (1963). "Persons

we believe that our distinction still holds when one compares the urban informal sector with the rural sector.

The ability of the rural worker to choose among a range of activities has three basic sources. First, the rural worker has some latitude over the sequencing of production activities, even within the constraints imposed by seasonal requirements (Chambers, *et al*. 1979). For example, a farmer with failing health can undertake relatively heavy farm activities in the morning such as plowing, and less demanding activities in the afternoon, such as repair of farm tools. Second, and more importantly, production and health maintenance decisions are made at the level of the household, where the low level of specialization of labor permits the exchanging of tasks among family members (Mwabu and Wang'ombe (1987), Ribero (1999)). This is true even though economic forces or social custom may impose constraints on the intra-family allocation of tasks. Constraints of this type, such as male/female distinctions in non-market activities and the reserving of market activities for adults, typically rule out only a subset of the possible exchanges of tasks among family members.[5] The third source of the ability of a rural worker to choose from among a variety of occupational activities is the informal nature of his work environment, which unlike that of his urban counterpart, is flexible, in the sense that it is not rigidly regulated by employment contracts or norms (see Ribero, 1999).

In the next section, we use a simple analytical model to bring out the key relationships between production structure, health maintenance, and health status. Section 3 discusses empirical implications of the model and Section 4 concludes the paper.

2. The model

In standard neoclassical labor economics, workers choose between two activities, wage-earning labor and leisure. The optimum allocation of time is to work until the marginal utility of consuming the wage good equals the marginal utility of leisure. To study the interactions between production environment and health maintenance, we begin by making four observations.

First, certain occupations, such as that of the rural peasant worker/producer, offer the individual a range of distinct productive activities with different input-output relationships. Second, the activities workers choose among (including leisure) produce not only pecuniary rewards but also outcomes in terms of health status. Third, workers can choose to allocate time not only to productive activities or leisure, but also to health maintenance, an activity we will view as distinct from leisure.[6]

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with a job that provides social security may be more likely to take days disabled than individuals who are self-employed and uncovered by social security, for whom it may be more costly not to attend their jobs." (Ribero (1999, page 4).

[5] For example, adults and children can exchange certain non-market activities, and male and female adults can exchange certain market activities.

[6] In reality, the boundary between leisure and health maintenance is not very clear. The neoclassical utility theory does not require a description of the leisure activity beyond whatever is implicit in the condition that the utility function be a strictly quasi-concave function of consumption and leisure. Operationally, the theory identifies leisure as anything that is not work. This concept of leisure clearly includes our narrowly defined health maintenance activity (see below), along with a number of other activities – like sleeping and eating – that we will continue to classify implicitly as "leisure", even though they may be more properly thought of as health maintenance.

Finally, effort can be endogenous variable: there are many activities in which the worker is free to alter the productivity of his time by changing the intensity of work. Each of these observations points to a specific modification of the standard consumer theory. Our basic ideas, however, can be made precise in a simple model in which we abstract from the leisure and effort choices and focus on the allocation of labor time between productive activities and health maintenance. We therefore analyze such a model here, recognizing that empirical work will require a richer model.

Activities, occupations, and health tolerance

We define an occupation such as that of a construction worker or peasant farmer, as a subset of the set of all possible productive *activities*. An activity is a way of combining labor and other available inputs to produce (1) a pecuniary value and (2) a change in the worker's health status. The pecuniary value produced by an activity is the direct payoff received by the worker, which might be a fixed hourly wage for a construction worker or the value of a mended plough or plowed land for a peasant farmer. For simplicity, we assume that each activity requires exactly one unit of labor time. The worker's health status is summarized by a single measure, s, that is a sufficient statistic for the health capital that the worker can bring to bear in any activity. This is clearly a simplification. Without further loss of generality, we take s to lie in the interval $S = [0,1]$. Throughout the ensuing analysis, the parameter s, whose values are restricted to lie within a unit interval, represents the health status of workers.

Activity i in period t, then, is defined by a payoff function $A_{ti}: S \rightarrow S\text{x}R$ that is a mapping from the worker's health status to the joint product of a pecuniary reward $r(s_t;i) \in \mathrm{R}$ and a new health status $s_{t+1}(s_t;i) \in S$. The mappings A_{ti} are non-stochastic, i.e., there is no uncertainty about the pecuniary and health effects of each activity.[7] We assume that both r and s_{t+1} are non-decreasing functions of s_t.

An important characteristic of productive activities is what we will call their *health tolerance*, i.e., the extent to which the worker's productivity in the activity is resilient to the reduction in work intensity that accompanies a decline in health status. Formally, we define health tolerance associated with a given activity as follows:

> **Definition** Activity i has higher *health tolerance* than activity k if the following properties hold:
>
> (i) $r(s;i) \geq r(s;k)$ for some $s \in S$ and $r(s';i) \leq r(s';k)$ for some $s' \in S$
>
> (ii) If $r(s;i) \geq r(s;k)$ for any $s \in S$, then $r(s';i) \geq r(s';k)$ for all $s' \in [0,s]$.
>
> (iii) $s_{t+1}(s_t;i) \geq s_{t+1}(s_t;k)$ for all $s_t \in S$.

Property (i) is the requirement that neither activity strictly dominate the other in terms of pecuniary payoff at all levels of health. In other words, while activity k is at least as

[7] If workers were risk-neutral, A_{ti} could simply refer to expected values. In this case our analysis could be trivially extended to incorporate uncertainty. To incorporate risk averse behavior, which plays an important role in a variety of theories of labor supply, from implicit contract theory (Azariadis (1975)) to theories of subsistence production modes (Berry (1977)), we would need a more substantial modification of the analysis.

productive as activity *i* at some health level(s), there must be some level of health at which the individual can do just as well in direct pecuniary terms by allocating his labor to activity *i*. Property (ii) states that if activity *i* is more productive than activity *k* at any level of health, it remains at least as productive as health *deteriorates* further. Together, properties (i) and (ii) imply that the pecuniary reward functions $r(s;i)$ and $r(s;k)$ can cross at most once for $s \in S$, with $r(s;i)$ cutting $r(s;k)$ from above.[8] Figures 1(a) – 1(c) give examples of activities satisfying the single crossing property. Figure 1(d) gives a case where this property is not satisfied.

Property (iii) gives the second requirement for activity *i* to have higher health tolerance than activity *k*: the productivity advantage at low levels of health must not be achieved at a cost in terms of future health status. For the remainder of the discussion, we will make the simplifying assumption that $s_{t+1}(s_t;i) = s_t$ for all productive activities. Under this assumption we can conclude that activity 1 has higher tolerance than activity 2 in Figures 1(a) – 1(c); in 1(d), the two activities cannot be ranked.

Notice that health tolerance is transitive in the sense that if activity *i* has higher tolerance than activity *j*, and *j* has higher tolerance than activity *k*, then *i* has higher health tolerance than *k*. The health tolerance relation does not, however, provide a complete ordering to the set of activities, since not all pairs of activities can be ranked. We therefore cannot represent health tolerance by an ordinal quantity in the same way as the preference relation can be represented by a utility function in consumer theory.

Along with his occupational set of production activities, which we denote $Z_j = \{i: A_i \text{ is an activity in occupation } j\}$, each worker has access to a health maintenance activity. While health maintenance is in reality a complex process involving a range of alternative activities (especially in developing countries; see Mwabu (1986)), we will simplify matters considerably by characterizing health maintenance as a single activity, identical for all occupations. This activity requires an input of labor time (e.g., a hospital visit) and produces a pecuniary reward that is typically non-positive (the uninsured portion of the hospital fee) and an improvement in health status.

2.2 The health maintenance decision

The worker's problem, then, is to choose the activity to which he will allocate his current unit of labor time, given his current health status. The problem is inherently intertemporal, given the presence of health capital. In fact, the labor supply decision can be viewed as the solution to an investment problem, since any activity involves a trading off of current and future payoffs through modifications in the stock of health capital. We emphasize the analogy with investment by assuming that the worker receives no direct utility from his stock of health capital. The payoff to health maintenance is therefore the increase in future pecuniary rewards due to a higher stock of health capital.

The intertemporal aspect of the labor/health maintenance decision can be captured by assuming that the worker is endowed with an initial health status s_1, and two periods of labor time. The problem is to choose activity in each period so as to

[8] The reward functions must touch at least once because of property (i). Since the inequalities in (ii) are weak, they do not have to cross; they can coincide for all *s* above some level.

maximize lifetime utility. For simplicity, we assume that lifetime utility is a linear function of lifetime pecuniary payoff.[9]

Letting $V_{tj}(s_t)$ be the maximized value of remaining lifetime payoff for occupation *j* under an optimal choice of activity in time *t*, the lifetime payoff in period 1 satisfies

$$V_{1j}(s_1) = \max_{\{i \in Z_{1j}\}} r(s_1;i) + V_{2j}(s_2(s_1;i)), \tag{1}$$

where $r(s_1;i)\in R$ and $s_2(s_1;I)\in S$ are the pecuniary and health outputs, respectively, of activity *i* if initial health is s_1. The second period value function, V_{2j}, is given by

$$V_{2j}(s_2) = \max_{\{i \in Z_{2j}\}} r(s_2;i). \tag{2}$$

The solution to the worker's optimization problem depends on the structure of the sequence $\{Z_{1j}, Z_{2j}\}$ of available productive activities. Our task is therefore to characterize the activity sets associated with urban and rural occupations in developing countries. In urban occupations, workers choose from the same small set of activities each period, so that $Z_{1U} = Z_{2U}$. The rural occupation differs in three key respects. First, it contains a larger menu of activities. This is what we mean by the rural work environment being less highly specialized. Second, the rural worker can substitute across activities with different health tolerance. We incorporate this possibility by assuming that the rural occupation contains at least one activity with higher health tolerance than any of the urban activities. Third, the sequence of activity sets for the rural occupation may contain seasonal restrictions that a range of different activities be completed over the planning horizon. As we will see below, this last feature complicates but does not change the conclusion.

A final technical assumption we require is that the maximum pecuniary reward attainable in a single period in the rural occupation, Max $\{r(1;i): i\in Z_{tR}\}$, is not greater than the maximum reward attainable in the urban occupation. Given that the average return to labor is typically higher in urban than rural areas in developing countries (conditional on employment for the urban worker; see, for example, Harris and Todaro (1970) and the subsequent literature), this assumption is consistent with our second claim, which implies that rural workers with low levels of health capital are more productive than urban workers with the same low health status.[10]

2.3 Rural/urban health differentials

Given these assumptions, we can now state our basic result and then illustrate and interpret it in the context of a simple example. The question we address is the following: if initial health levels s_1 of urban and rural workers are independently and identically distributed on *S*, and the health maintenance activity is identical for the

[9] Incorporating a direct payoff to health capital (beyond its marginal product in production activities) would not change the analysis qualitatively. See Grossman (1972) for a discussion of the investment and consumption components of the health maintenance activity. One could also easily add positive time preference, non-zero real interest rates, and/or curvature of the utility function without qualitatively changing the results.

[10] The assumption does not follow trivially, however, since the average health level is also higher in urban areas.

two occupations, which occupation will have the higher average health level in period 2? In other words, what is the effect of production structure on health maintenance?

> **Proposition** If initial health levels are independently drawn for all workers from an underlying distribution $f(s_1)$ and the health maintenance activity is identical for all occupations, there is some number $\underline{C}$ (not necessarily positive) such that if the health maintenance fee exceeds $\underline{C}$, the average health level of rural workers will be lower than that of urban workers in period 2.

For illustrative purposes, we study here an example in which Z_{tU} contains a single activity and Z_{tR} two activities. For simplicity, we assume that both occupations share a common activity A_2, and that the rural occupation has a second activity A_1 with higher health tolerance than A_2.[11]

Using the set of activities Z_{tj}, we can define the single period pecuniary production function for occupation j, $g_j(s)$, as the maximum pecuniary reward in the current period for a worker with health status s. This function, plotted in Figures 2(a) and (b), is simply the upper envelope of the $r(s;i)$ for each occupation. The function $g_j(s)$ has a natural interpretation: since $g_j(s)$ is the direct pecuniary reward given up by spending a unit of labor time in health maintenance, $g_j(s) + C$ is the opportunity cost of health maintenance in the current period, where C is the fixed health maintenance fee.

The optimal choice of activity in period 1 for a worker with health status s is now easy to establish. In period 2, there is no health investment component to the labor supply decision, so the worker simply chooses from the set Z_{2j} the production activity yielding the pecuniary reward $g_j(s_2)$. We therefore have $V_{2j}(s_2) = g_j(s_2)$, and the problem in period 1 (see equation (1)) is to maximize

$$r(s_1;i) + g_j(s_2(s_1;i)) \qquad (3)$$

by choosing i from the set $\{1,2,3\}$ where $i = 3$ is the health maintenance activity.

The problem comes down to one of comparing lifetime utility under the optimum production choice in period 1, $V_{1j}^P(s_1)$, with lifetime utility from choosing health maintenance in period 1, $V_{1j}^H(s_1)$. Since the optimum productive activity in period 1 yields $g_j(s_1)$, these functions are given by

$$V_{1j}^P(s_1) = g_j(s_1) + g_j(s_1) = 2 \cdot g_j(s_1) \qquad (4)$$

$$V_{1j}^H(s_1) = -C + g_j(1), \qquad (5)$$

for j = U, R. Equations (4) and (5) incorporate our assumptions that productive activity leaves health unchanged ($s_2 = s_1$ if production is chosen) and that health maintenance involves paying a fee of C to raise health status to $s_2 = 1$.

There may be levels of health capital at which $V_{1j}^P(s_1) = V_{1j}^H(s_1)$, so that the worker is just indifferent between production and health maintenance in the current period. If health capital has strictly positive pecuniary marginal product (i.e., $g_j(s)$ is monotonically increasing), there can be at most one such point of indifference for

[11] Recall that this means that productivity is higher in A_1 than in A_2 at low health levels.

$s \in (0,1)$. We denote this level of health capital as s_{1j}^I. From (4) and (5), it is apparent that s_{1j}^I is the solution to

(6) $$g_j(s_{1j}^I) = \frac{1}{2} \cdot (g_j(1) - C), \qquad j = U, R.$$

Figure 3 illustrates the determination of s_{1j}^I. The right-hand side of equation (6) is reflected onto the vertical axis starting with the value of $g_j(1)$ and using the lines in the second quadrant. The cutoff values s_{1R}^I and s_{1U}^I can then be read directly from the functions $g_j(s_1)$.

Given that $s_{1R}^I < s_{1U}^I$, it is straightforward to show that rural workers will have a lower average health level in period 2 than urban workers. Since the empirical distributions of urban and rural workers by initial health status converge to the underlying distribution $f(s_1)$, the average health status of occupation j in period 2 converges in probability to the true expectation $E(s_{2j})$, which is given by

(7) $$\begin{aligned} E(s_{2j}) &= E(s_{2j} \mid 0 < s_{1j} < s_{1R}^I) \cdot \text{Prob}(0 < \text{s}_{1\text{j}} \le s_{1R}^I) \\ &+ E(s_{2j} \mid s_{1R}^I < s_{1j} < s_{1U}^I) \cdot \text{Prob}(s_{1R}^I < \text{s}_{1\text{j}} \le s_{1U}^I) \\ &+ E(s_{2j} \mid s_{1U}^I < s_{1j} < 1) \cdot \text{Prob}(s_{1U}^I < \text{s}_{1\text{j}} \le s_{1U}^I). \end{aligned}$$

Since urban and rural workers with health status on the intervals $(0, s_{1R}^I)$ and $(s_{1U}^I, 1)$ make the same health maintenance decision, the only difference between $E(s_{2U})$ and $E(s_{2R})$ comes from the fact that urban workers on (s_{1R}^I, s_{1U}^I) choose health maintenance, while their rural counterparts, whose opportunity costs are higher, choose production. It follows that

(8) $$E(s_{2R} \mid s_{1R}^I < s_{1R} < s_{1U}^I) < E(s_{2U} \mid s_{1R}^I < s_{1U} < s_{1U}^I),$$

and therefore that $E(s_{2R}) < E(s_{2U})$.

In Figure 3a, the upper envelope of rural activities (g_R) meets the envelope of urban activities (g_U) from above and never goes below it. Using our definition of health tolerance, it follows that the rural occupation *as a whole* exhibits higher health tolerance, in this example, than the urban occupation. The existence of such a ranking turns out to be a sufficient but not a necessary condition for lower health maintenance by rural workers. To see this, rewrite equation (6):

(9) $$2 \cdot \frac{g_i(s_1)}{g_i(1)} = 1 - \frac{C}{g_i(1)}.$$

The sick worker therefore compares normalized lifetime income when sick—the left-hand side—with normalized lifetime income net of health maintenance costs (the right-hand side). Health maintenance is worthwhile only if the right-hand side exceeds the left-hand side. Now suppose that the rural occupation has higher health tolerance than the urban one. With greater health tolerance, the fact that average rural incomes are below average urban incomes implies that $g_R(1) \leq g_U(1)$; otherwise rural productivity would dominate urban productivity at all health levels. It follows from this that (a) for sufficiently low health levels, foregone productivity $g_i(s)/g_i(1)$ is smaller for the rural worker than the urban worker; and (b) that for any fee C, the burden of the fee, $C/g(1)$, is at least as great for the rural worker as for the urban worker. These observations reinforce each other to produce $s_R^I < s_U^I$ in equation (9), providing the critical step in our proposition.

A health tolerance ranking is not, however, necessary for our result. A pair of sufficient conditions for the equality in equation (9) take place at a lower level of s in rural areas than in urban areas is (1) that average income be higher in urban than in rural areas and (2) that "normalized" productivity $g_i(s)/g_i(1)$ (rather than absolute productivity) satisfy the single-crossing property. The latter requirement simply states that there must be some level of low health below which the rural worker retains a greater share of his "productivity when healthy" than does his urban counterpart. This does not require that the rural worker be absolutely more productive than the urban worker, even at low health levels.

2.4 Generalizing the production structure

In the case where $Z_{1R} \neq Z_{2R}$, the analysis proceeds along the same lines. Figure 4 indicates why we get similar conclusions as to relative health maintenance. The figure shows a variety of alternative sequences of pecuniary reward functions $\{g_{1j}(s), g_{2j}(s)\}$. The top panel shows the urban occupation, with $g_{1U} = g_{2U}$. Panel (b) shows the case we have just analyzed, where the rural occupation has more activities but $g_{1R} = g_{2R}$. Panels (c) and (d) give the two possible orderings of activities in the rural occupation. There are two alternatives to the assumption that $Z_{1R} = Z_{2R}$: the rural occupation could be strongly seasonal, as in (c) or (d), or it could allow flexibility as to ordering of tasks but require that both tasks be completed over the planning horizon. The second of these alternatives would allow the worker to choose between the orderings (c) and (d) but would rule out performing the same task twice.

Consider first the seasonal alternative, and compare the rural worker's incentive for health maintenance with that of the urban worker. If the low health tolerance activity must be completed in the current period (panel c), then clearly the rural worker will choose the same or lower level of health maintenance than his equally healthy urban counterpart. This is because the two have the same current opportunity cost, while the urban worker has a higher future payoff to health improvement. The same result of lower health maintenance emerges in the off-season (panel d), although in this case the key factor is not future payoffs to health maintenance – which are identical for the two occupations – but current opportunity costs. The rural worker has more productive uses for low levels of health capital and is thus less likely to seek medical care if health is poor.[12]

Since the rural worker's incentive for health maintenance is lower under either seasonal pattern, it follows that health maintenance will be lower if the production structure is such as to allow the worker to choose the ordering of activities. In this case, a rural worker with health status s, compares either panel (c) or (d) (the two

[12] For $s_1 > s^C$, where s^C is the health status at which $r_1(s)$ and $r_2(s)$ cross, this tendency is reversed: the urban occupation has a higher current opportunity cost. The result we can establish for panel (d) is therefore similar to proposition 1, i.e., rural workers will have lower health maintenance levels if C is sufficiently high.

orderings yield identical lifetime payoff, conditional on producing in period 1) with the alternative of seeking health maintenance and then performing the low health tolerance, high payoff activity in period 2. For $s_1 < s^C$, lifetime payoff producing in period 1 is higher than the urban worker, and therefore the incentive for health maintenance is lower.

2.6 Extending the model

We give a brief discussion here of two possible extensions of our analysis. The first is to model the migration decisions of workers, taking urban and rural production structures as given. The second is to allow the production structures themselves to be jointly endogenous.

What should we expect to occur if urban and rural workers have the option of migrating between sectors? This is a complicated issue, and we need to make some simplifications. One way to proceed would be to have the migration decision occur before the first period of work. Abstracting from migration costs, lifetime utility for a worker with initial health s_1 would then be

$$V_1(s_1) = \text{Max}\,[V_{1R}(s_1), V_{1U}(s_1)], \tag{10}$$

where $V_{1j}(s_1)$, the maximized utility of a worker choosing to locate in sector j, is given by

$$V_{1j}(s_1) = \text{Max}\,[V_{1j}^P(s_1), V_{1j}^H(s_1)]. \tag{11}$$

The heterogeneity of workers here makes it difficult to formulate a useful model of locational equilibrium. This is a problem that occurs in the literature on education and human capital as well; by analogy to Mincer's (1974) analysis of schooling, we might assume that there are a large number of workers of each health status, and that migration is the process by which workers arbitrage the returns to health capital in each sector into equality. Equilibrium would then be characterized by

$$V_{1R}(s_1) = V_{1U}(s_1), \tag{12}$$

for all levels of health capital observed in both sectors.

In order to solve equation (12) for the equilibrium distribution of workers of type s_1, we would have to relate the payoff functions $r(s;i)$ to the distribution of workers by health status in each location. The Harris-Todaro (1970) model suggests a possible approach; there, the effect of migration on sectoral real wages comes from diminishing marginal product of labor. We might think of the $r(s;i)$ in the urban sector (for example) as parameterized by the total amount of effective labor in that sector; if $f^U(s)$ is the number of urban workers of health status s, total effective urban labor is approximately

$$L_E^U = \int_0^1 s \cdot f^U(s)ds. \tag{13}$$

Diminishing marginal product of labor would be represented by making *r(s;i)* an increasing, concave function of L_E^U. The problem would then be to solve for the equilibrium distribution $f^U(s)$.

A second possible extension of the analysis would be to allow the distribution of health capital and urban and rural production structures to be jointly endogenous. Historically, the process of economic development has often involved a simultaneous accumulation of capital and sectoral shift out of rural and non-market activities towards urban, market activities. We make two observations. First, accumulation of health capital and human capital is an important component of the overall capital accumulation process that takes place during development. Second, the sectoral shift that occurs in the development process is not simply a migration of resources from one existing production structure to another; rather, it involves the introduction of new activities in the expanding sector. Industrialization involves not just shifting workers out of agriculture but also development of an urban production structure with higher degrees of labor specialization, more elaborate work rules, and a greater preponderance of market activities than in the rural structure. Development of these activities may itself be facilitated by accumulation of human capital in the form of health and education. This suggests a model of the development process as the movement from a one-sector economy, with the introduction and growth of an urban productive sector jointly determined with the overall capital accumulation process.

3. Empirical issues

There are several approaches to testing the above model. One method requires an empirical demonstration of the idea that activities in rural areas are more tolerant to poor health than urban-based activities. If this proposition is true, for a given activity (that is common to rural and urban areas), the health status of the workers engaged in that activity would rise as one moves from rural to urban areas. We have shown that this result may not merely be a reflection of locational decisions of workers: at *low* levels of health, urban workers invest more in better health because they face lower time costs of health maintenance. Testing the effect of production structure on health maintenance is complicated by the need to control for effects of migration and seasonality.

The second, and more direct approach to testing the basic proposition of our model is to estimate the effect of the number of activities performed by workers in a given period on health status. The number of activities performed is a measure of a worker's degree of specialization. More specialized workers will have a smaller bundle of activities than non-specialized workers. In our model, a worker's health status improves as the number of activities performed decreases, i.e., with occupational specialization. Panel data on workers occupations and rural-urban migration are required to test this proposition.

A final testing method involves measuring the effect of a deterioration in health status on earnings of workers in specialized (urban) and non-specialized (rural) activities. The basic proposition of the model would be rejected, if a fall in health status (as measured by disability days for example) were to reduce earnings in rural areas by a smaller magnitude than in urban areas.

4. Conclusion

The focus of this paper has been on interactions between health status, health maintenance and production structures. The main result of the paper is that production structures affect health maintenance costs, and thus could be an important determinant of demand for health services. In developing countries, differences in rural-urban production structures could account for a substantial variation in health status in the population.

The idea that at *low levels of health*, the opportunity cost of time is higher in rural than in urban areas, conflicts with the stylized fact that labor income (particularly in developing countries) is higher in urban areas (see Harris and Todaro, 1970). We have shown that observed labor income is the *average* of income from activities performed by a worker at *low* and *high* levels of health. In doing so, we assumed that labor income is greater the higher the level of health. Thus, irrespective of residence status, a worker's *mean* income from activities performed at low and high levels of health, is lower than income earned at high levels of health.

However, because of gains from specialization, the *mean* labor income is higher in urban than in rural areas. In general, therefore, the opportunity cost of time is higher in urban than in rural areas. At low levels of health, the situation *could* be reversed. We explain this reversal by assuming that rural production structures are more *tolerant* of declining health than rural production structures. As health deteriorates, a rural worker is more likely to find an activity that is compatible with his health status than is an urban worker. Hence, a rural worker faces higher time costs of treating an illness compared to his urban counterpart.

The policy implication of this finding is that in developing countries, where the majority of the population is rural, subsidies for rural health services may be needed to facilitate the achievement of the international goal of good "health for all" (WHO, 1978). Specifically, policies that reduce the time cost of accessing and using rural health services should be implemented. Our study suggests that the poor in rural areas face much higher time costs of health maintenance than previously thought.

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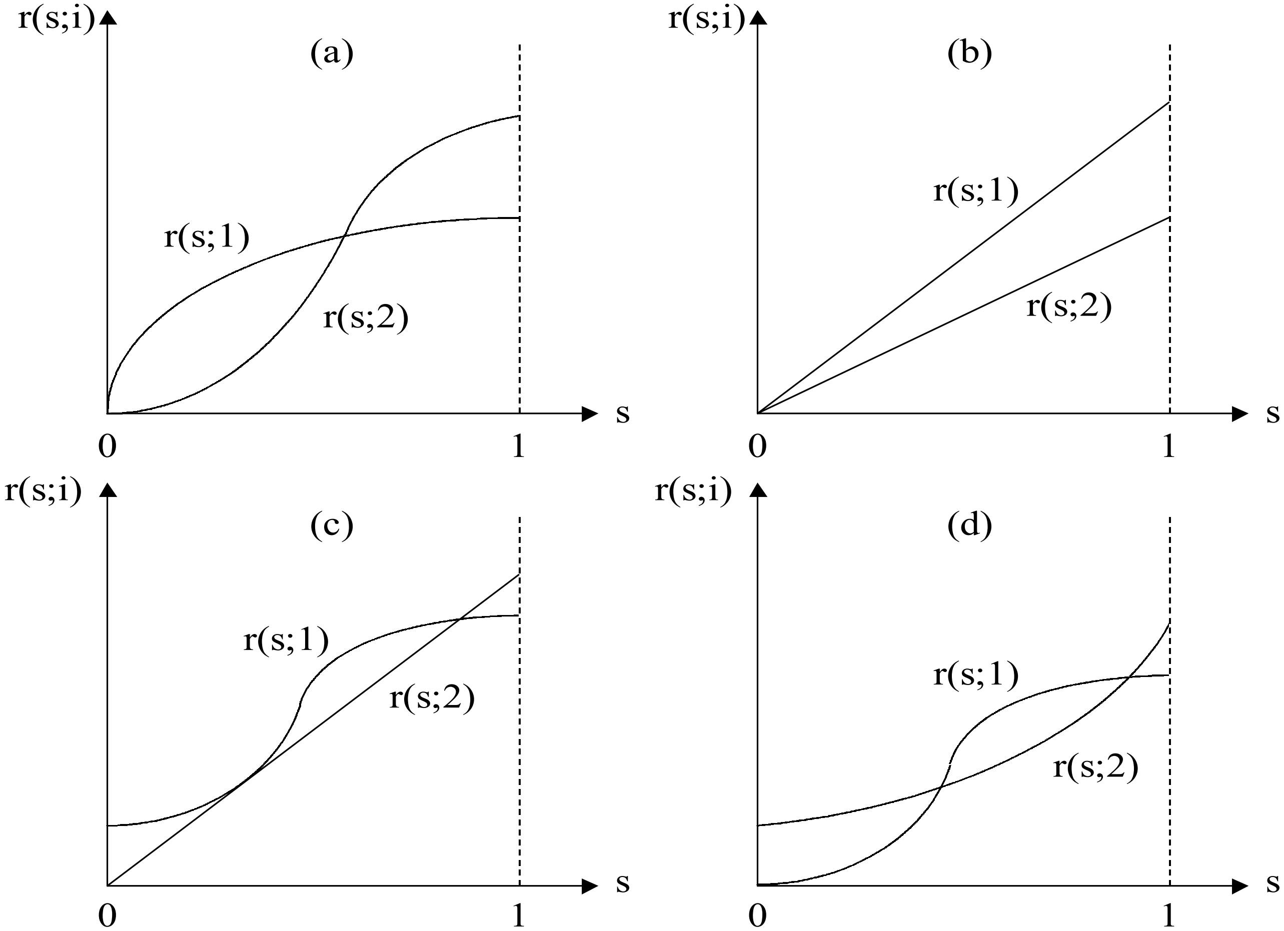
Figure 1



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(c)
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Figure 2

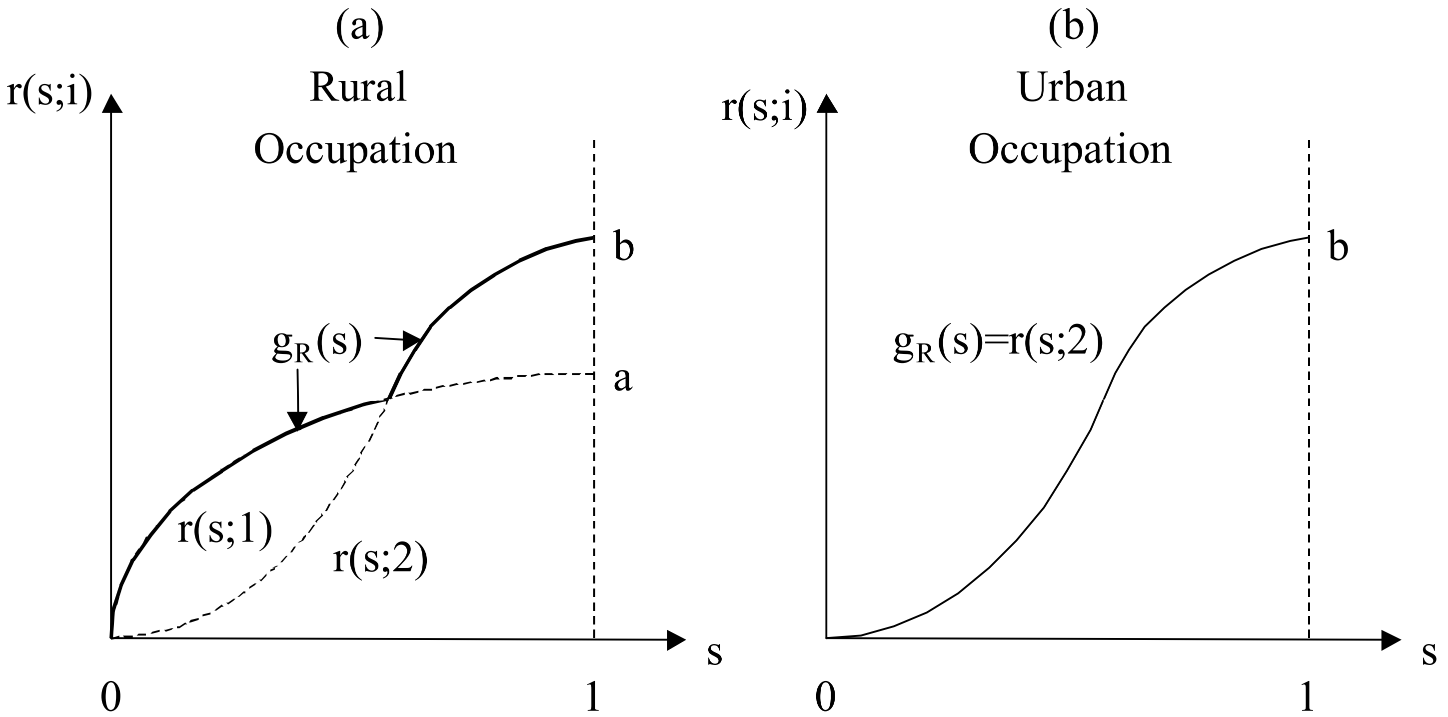
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Figure 3

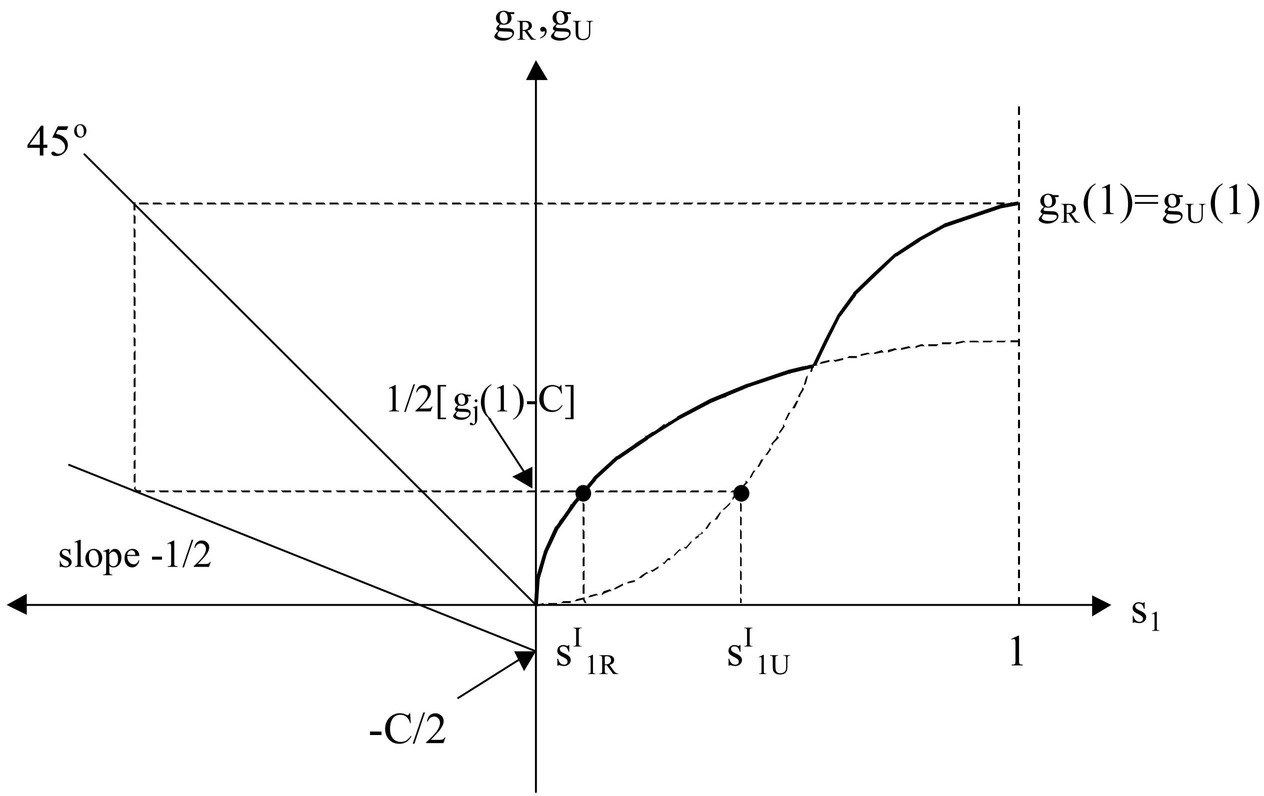
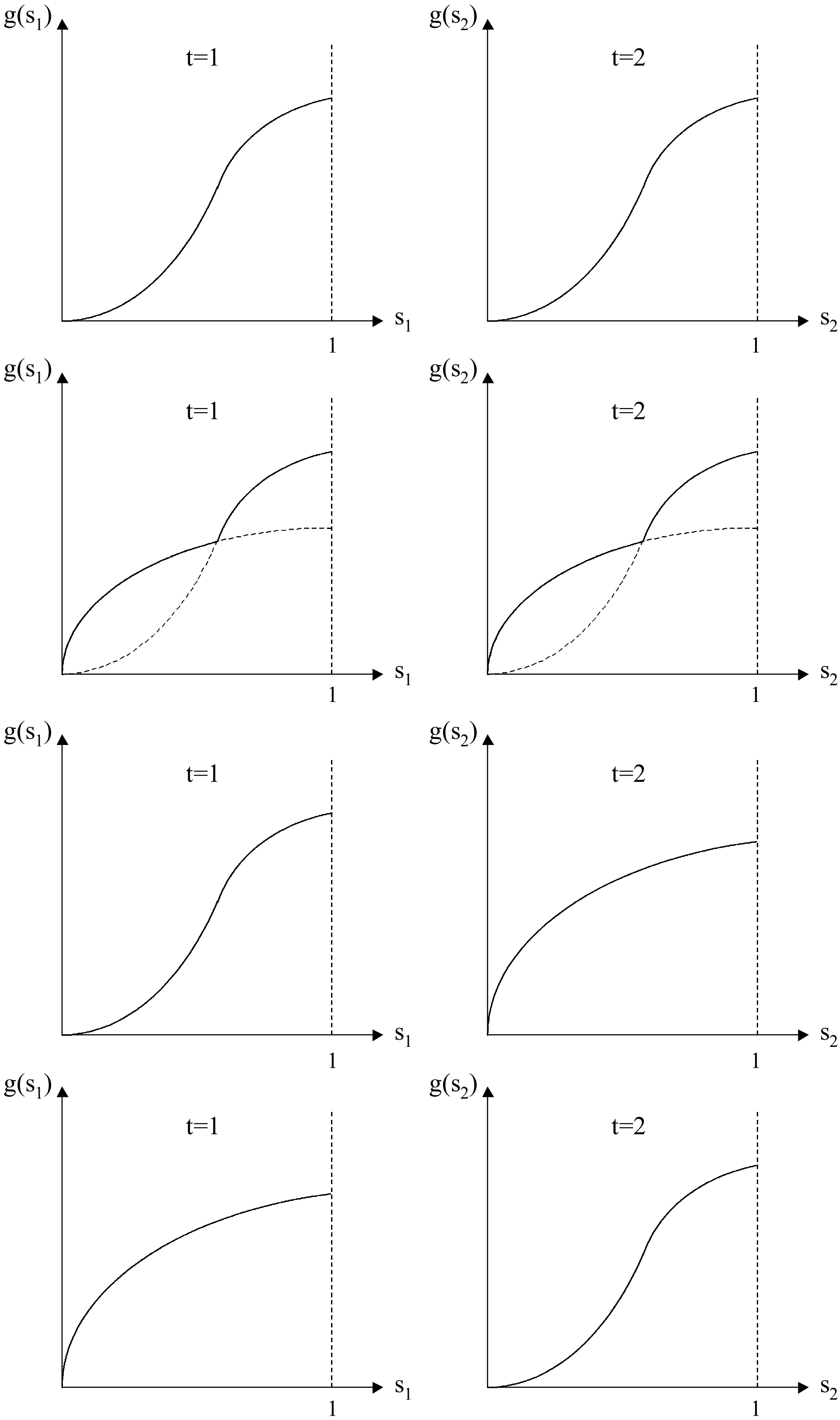


Figure 4



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