The Economic Journal, **96** (*December* 1986), 1011–1034
Printed in Great Britain

INEQUALITY AS A DETERMINANT OF MALNUTRITION AND UNEMPLOYMENT: THEORY*

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'But it was only in the last generation that a careful study was begun to be made of the effects that high wages have in increasing the efficiency not only of those who receive them, but also of their children and grandchildren...the application of the comparative method of study to the industrial problems of different countries of the old and new worlds is forcing constantly more and more attention to the fact that highly paid labour is generally efficient and therefore not dear labour; a fact which, though it is more full of hope for the future of the human race than any other that is known to us, will be found to exercise a very complicating influence on the theory of distribution.'

Alfred Marshall: *The Principles of Economics*
(London: Macmillan, 1920, p. 510)

I. THE ISSUES

Even by conservative estimates well over three hundred million people in the world are thought to be seriously undernourished today.[1] International data on the incidence of malnutrition are in large parts only sketchy. Moreover, those that are available are not readily interpretable, for the science of nutrition is relatively new.[2] In particular, it is known that the food-adequacy-standard for a person depends not only on the sorts of activities in which he is engaged, but

* This work and its sequel were supported by National Science Foundation Grants SES-84-04164 and SES-83-20464 at the Institute of Mathematical Studies in the Social Sciences, Stanford University. Research towards this essay was conducted while Dasgupta was a Visiting Professor at Stanford University during 1983–1984. We have gained much from discussions with Irma Adelman, Beth Allen, Kenneth Arrow, Robert Aumann, Pranab Bardhan, Krishna Bharadwaj, Kim Border, A. K. DasGupta, Paul David, David Donaldson, John Flemming, Mordecai Kurz, Michael Lipton, Dilip Mookherjee, Ugo Pagano, Tibor Scitovsky, Amartya Sen, Robert Solow, T. N. Srinivasan, Paul Streeten, S. Subramanian, Gavin Wright and in particular the insights of Peter Hammond. We are most grateful to the Center for Public Policy Research at Stanford University and the National Science Foundation of the United States for financial support during the summer of 1984 and to the Economic and Social Research Council of the United Kingdom for financial support which enabled this final version to be prepared. We are greatly indebted to the Editor, Charles Feinstein, for his perceptive comments about the organisation of this work and the care with which he has seen through three drafts.

[1] See Lipton (1983). By undernourishment we mean here, following Lipton, calorie deficiency only, recognising of course that a food-adequacy-standard must meet other requirements as well, such as protein, vitamins and minerals, and that a person's *state of health* depends also on education (see Behrman and Wolfe, 1984) and on the medical and sanitation facilities available to him and made use of by him. These, among other reasons, are why Lipton's estimates are conservative.

[2] See FAO (1957, 1963, 1973, 1974) for systematic, downward revisions of the energy needs of the 'reference man'. Their 1973 assessment – a daily need of 2,600 Kilocalories for maintenance and 400 Kilocalories for moderate activity for an average male aged between 20 and 39, weighing 65 kilograms and living in a mean ambient temperature of 10 °C – is now acknowledged to be too high and is, in any case, not the basis on which global estimates of the extent of undernutrition ought to be based. As a consequence the 1973 assessment has been the cause of much heated, and often misdirected, debate. For an assessment of the implication of the clinical literature, see Dasgupta and Ray (1986).

also on his location and on his personal characteristics, of which the last includes his prior history. This makes the subject particularly difficult.[1]

The general effects of malnutrition vary widely. In children they are especially severe. It can cause muscle wastage and growth retardation (thus future capability), increased illness and vulnerability to infection. There is evidence that it can affect brain growth and development. Chronic malnutrition in adults diminishes their muscular strength, immunity to disease and the capacity to do work. Persons suffering thus are readily fatigued. There are also marked psychological changes, manifested by mental apathy, depression, introversion, lower intellectual capacity and lack of motivation (see e.g. Read (1977)). Life expectancy among the malnourished is low, but not nil. Such people do not face immediate death. Malnutrition is this side of starvation. For this reason the world can indefinitely carry a stock of undernourished people, living and breeding in impaired circumstances.

Not surprisingly, an overwhelming majority of the world's undernourished live in the low-income developing countries (see FAO (1974), p. 66). Not a negligible number of economists have gone on to emphasise that it is the absolute-poor who go hungry.[2] But then who *are* the absolute poor? The available evidence suggests that they are among the landless, or near-landless people (see DaCosta (1971), Reutlinger and Selowsky (1976), and Fields (1980, p. 161), for example). Presumably this is because they have no non-wage income, or if they do it is precious little. But then why do they not get employed and earn a wage? One answer is that, they do, but that because the economy is resource-poor, the low level of prevailing wages does not provide the necessary escape from absolute poverty and malnutrition (Leibenstein (1957); see also Fei and Chiang (1966) and Prasad (1970)). But this must be an incomplete answer, for some *do* escape; while others, who are similar in all other respects, do not. To put it another way, the labour market often does not clear in such economies, and the non-clearance manifests itself in the form of involuntary unemployment. Thus, some obtain employment at wages that enable them to purchase an adequate diet while others languish in activities that keep them undernourished. But this begs the question, for why does the labour market not clear? In particular, why do frustrated job-seekers not undercut the employed?

In this essay and its sequel (Dasgupta and Ray, 1986*a*) we will attempt to provide a rigorous theory that links involuntary unemployment to the incidence of malnutrition, relates them in turn to the production and distribution of income and thus ultimately to the distribution of assets. The basic descriptive features of the model used to illustrate the theory will be presented in this essay.

[1] A sustained national case-study on these matters is the continuing series of reports by C. Gopalan and his associates, for India. A brief summary of his group's findings is in Gopalan (1983). A great deal of the controversy generated by the publication of national estimates (such as those in India) of numbers of people below the poverty line has centred on the point that there are inter-regional and interpersonal variations in basic nutrition needs. It should also be noted that there is evidence that a person's metabolic efficiency in the *use* of energy adjusts, *up to a point*, to alterations in his energy intake. But even when such corrections are allowed for, worldwide incidence of undernourishment assumes an awesome figure well in excess of three hundred million people.

[2] One may of course ask in what sense a person can be said to be rich and yet be hungry – unless it is by anorexic or other compulsion.

In the sequel we will for the most part study policy implications. The model used to illustrate the theory is a fully 'general equilibrium' one. Involuntary unemployment will be shown to exist in the construct, not assumed; that is, wage rigidities will be explained, not hypothesised.[1]

We want to emphasise that the concept of undernourishment plays a central, *operational*, role in the model that we will develop here; and it is as well to make clear what we mean by this. Poverty, inequality, malnutrition and involuntary unemployment (or, more generally, surplus labour) have all been much discussed in the development literature. For example, the idea of 'basic needs', as it occurs in Streeten *et al.* (1981), or the more general notion of 'capabilities', as developed in Sen (1983), patently subsume the concept of food-adequacy-standard in their net. Now, malnutrition is not the same as hunger. There is not only discomfort in being malnourished, there is impairment in the capacity to engage in physical and mental activities, through illness or plain weakness. (If this is denied one must accept that malnutrition as a distinct concept is vacuous.) Any theory that incorporates 'basic needs' or 'capabilities' must then as a minimum acknowledge that at low nutrition levels there is some link between food intake and work capacity. For this reason it is a puzzle to us that the recent theoretical literature on absolute poverty has made little use of this link to its advantage when discussing the efficacy of food transfers (that is, their effect on growth of output). Reading this valuable literature is rather like seeing the grin but not the Cheshire Cat. Thus it is a commonplace to argue that food transfers to the very poor may lower growth rates in national product because of their detrimental influence on savings and investment, incentives and so forth. But this is only one side of the picture. The other side is what concepts such as 'basic needs' and 'capabilities' try among other things to capture, that a transfer from the well-fed to the undernourished will enhance output via increased work capacity of the impoverished. One does not know in advance which is the greater effect, but to ignore the latter is certain to yield biased estimates. We are fully aware that these are difficult estimates to make, if only because data are sparse. But to date we do not even possess a theoretical scheme to tell us how we might go about thinking on the matter. For it is not obvious what is the pattern of resource allocation in a decentralised environment if and when the link between nutrition and work capacity assumes potency. The point is that the incidence of both malnutrition and involuntary unemployment need to be endogenous in a model which is used for the purposes of policy debates. One wants the model to identify which category of people will suffer from undernourishment. In particular, one wants it to identify those people who will be denied access to work that pays enough to enable them to produce enough for an employer to wish to hire them in the first place.

So as to keep the formal model as simple as possible we will consider a timeless world in which work capacity is related to food intake in the manner postulated by Leibenstein (1957) in his pioneering work. In Section II we will

[1] There is now, following Harris and Todaro (1970), a large development literature that has studied the implications of wage rigidities on migration decisions But for the most part such wage rigidities are not explained in this literature.

present the ingredients of our construction. The central theorems concerning the existence and general characteristics of involuntary unemployment equilibrium will be presented in Section III. In Section IV we postulate that the food and work capacity relation is a simple step-function and we then present a two-class economy in which equilibrium is unique and can be computed explicitly. Readers wishing to avoid the general arguments in Section III can go direct from Section III.2 (where market equilibrium is defined) to Section IV.

The link between nutrition and work capacity is a most complex one and on reading some of the literature one detects that passions among analysts can run deep. A simple timeless model in this area will be found otiose even by some who find timeless models of normal production theory readily palatable. In Section V we therefore discuss several objections that can be raised about the reasonableness of our basic model and we argue that the general features that are highlighted in Section III are robust against generalisation. Section V contains a summary of our main conclusions. Proofs of theorems are relegated to the Appendix.

The model that we will develop in this essay postulates frictionless markets for all capital assets and a flawless competitive spirit among employers and workers. We wish to emphasise this point, because at the level of *theoretical* discourse it will not do to explain poverty, malnutrition and unemployment by an appeal to monopsonistic landlords, or predatory capitalists, or a tradition-bound working class and leave it at that. That is far too easy, but more to the point, one is left vulnerable to the argument that this merely shows that governments should concentrate their attention on freeing markets from restrictive practices. It does not provide an immediate argument as to why governments, if they are able to, should intervene to ensure directly that people are not malnourished. Our formal model is a classical one. There are no missing markets. In particular, involuntary unemployment arising in it is not due to demand deficiency. To seal this point we will show in the sequel that equilibria in our model are Pareto-efficient. This means in particular that there are no policy options open to the government other than consumption or asset transfers. In the sequel, therefore, we will also study the impact of such policies.

II. THE MODEL

We begin by distinguishing labour-*time* from labour-*power* and observe that it is the latter which is an input in production. We consider a timeless construct and eschew uncertainty (see Section V for extensions). Consider a person who works in the economy under analysis for a fixed number of 'hours' – the duration of the analysis. Denote the labour power he supplies over the period by λ and suppose that it is functionally related to his consumption, I, in the manner of the bold-faced curve in Fig. 1 (*a*). (We should emphasise that we are thinking of labour power as an aggregate concept, capturing not only power in the thermodynamic sense, but also motivation, mental concentration, cognitive faculty, morbidity and so forth.)

The key features of the functional relationship are that it is increasing in the

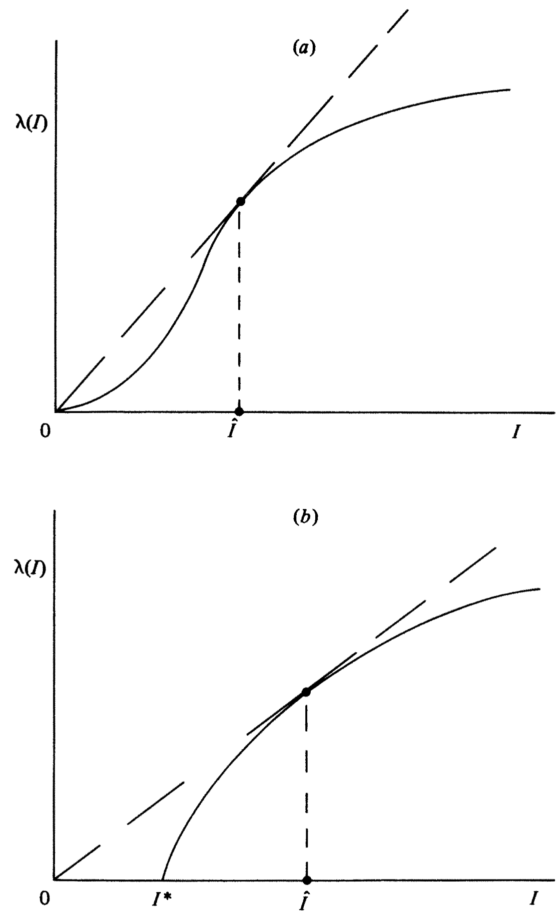

Fig. 1

region of interest, and that at low consumption levels it increases at an *increasing* rate followed eventually by diminishing returns to further consumption.

An alternative specification of the functional relationship, used, for example, by Bliss and Stern (1978*b*), is drawn in Fig. 1 (*b*). Here, λ is nil until a threshold level of consumption, I^*, the resting metabolic rate (RMR). $\lambda(I)$ is an increasing function beyond I^*, but it increases at a diminishing rate.

Two factors, *land* and *labour-power*, are involved in the production of *rice*.[1] Land is homogeneous, workers are not. Denoting by T the quantity of land and by E the *aggregate* labour-power employed in production (i.e. the sum of individual labour powers employed) let $F(E, T)$ be the output of rice, where the aggregate production function $F(E, T)$ is assumed to be concave, twice differentiable, constant-returns-to-scale, increasing in E and T, and displaying

[1] Since we will be thinking of a wage-based economy it would be more appropriate to think of the output as a cash crop which can be traded internationally at a fixed price for rice. It should be added that the one-good structure bars us from addressing a number of important related issues concerning the composition of consumption among different income groups, in particular the silent food wars that are being fought among them On this, see Yotopolous (1985).

diminishing marginal products.[1] Total land in the economy is fixed, and is $\hat{T}$. Aggregate labour power in the economy is, of course, endogenous.

Total population, assumed without loss of generality to be equal to the potential work force, is N. We take it that N is large. We can therefore approximate and suppose that people can be numbered along the unit interval [0, 1]. Each person has a label, n, where n is a real number between 0 and 1. In this interval the population *density* is constant and equal to N. We may therefore normalise and set $N = 1$ so as not to have to refer to the population size again. A person with label n is called an n-person. The proportion of land he owns is $t(n)$, so that $\hat{T}t(n)$ is the *total amount* of land he owns; $t(n)$ is thus a density function. Without loss of generality we label people in such a way that $t(n)$ is non-decreasing in n. So $t(n)$ is the land distribution in the economy and is assumed to be continuous. In Fig. 2 a typical distribution is drawn. All persons labelled 0 to n are landless. From $\underline{n}$ the $t(n)$ function is increasing. Thus all persons numbered in excess of $\underline{n}$ own land, and the higher the n-value of a person the greater the amount of land owned by him.

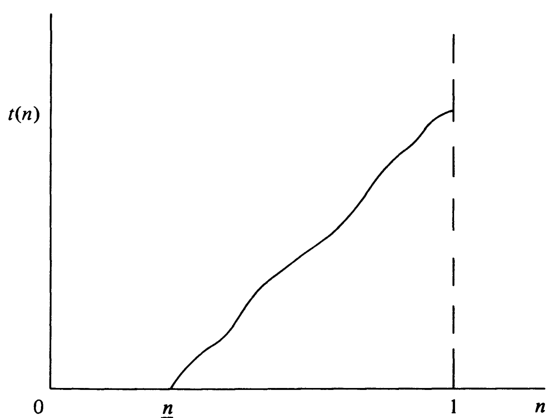

Fig. 2

We will suppose that a person either does not work in the production sector or works for one unit of time.[2] There are competitive markets for both land and labour power. Let r denote the rental rate on land. Then n-person's non-wage income is $r\hat{T}t(n)$. Each person has a reservation wage which must as a minimum be offered if he is to accept a job in the competitive labour market. For high n-persons this reservation wage will be high because they receive a high rental income. (Their utility of leisure is high.) For low n-persons, most especially the landless, the reservation wage is low, though possibly not nil. We are concerned with malnutrition, not starvation. In other words, we are supposing that these are normal times that are being modelled. The landless do not starve if they fail

[1] We also suppose that $F(E, T)$ satisfies the Inada conditions (see Appendix). These are technica conditions designed to streamline proofs. They are innocuous.

[2] 'Smoother' labour–leisure choices can easily be built in, but it would violate the spirit of the exercise so much that we do not introduce it.

to find jobs in the competitive labour market. They beg, or at best do odd jobs *outside* the economy under review, which keep them undernourished. But they do not die. Thus the reservation wage of even the landless exceeds their RMR. All we assume is that at this reservation wage a person is malnourished.

Denote by $\bar{w}(R)$ the reservation wage function, where the argument R denotes non-wage income. We are supposing here that the $\bar{w}(.)$ *function* is exogenously given (continuous and non-decreasing), though of course, non-wage income is endogenous to the model. For a given rental rate on land, $r > 0$, $\bar{w}[rt(n)\,\hat{T}]$ is constant for all n in the range 0 to $\underline{n}$ (since all these people are identical). Thereafter, $\bar{w}[rt(n)\,\hat{T}]$ increases in n (see Fig. 3).[1] Given the options that an individual faces he chooses the one which maximises his income.

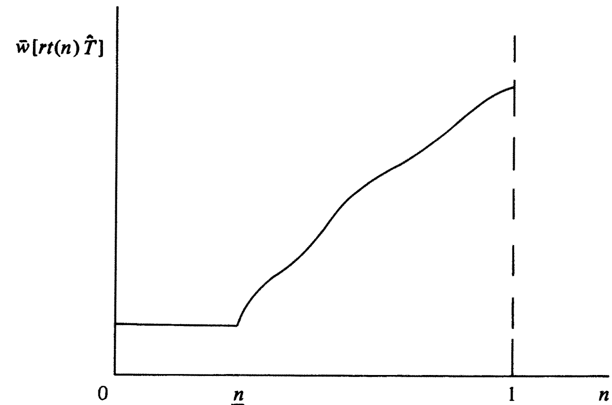

Fig. 3

For our purpose a precise definition of malnutrition is not required, even for the model economy under study. But for concreteness we are going to choose $\hat{I}$ – the consumption level in Fig. 1 (*a*) and 1 (*b*) at which marginal labour power equals average labour power – as the cut-off consumption level below which a person will be said to be undernourished. $\hat{I}$ is then the food-adequacy standard. Nothing of analytical consequence depends on this choice, but since the choice of $\hat{I}$ does have a rationale (see the example in Section IV) we may as well adopt it. All we need, for our purpose, is the assumption that the reservation wage of a *landless* person is one at which a person is undernourished, and thus less than $\hat{I}$.

We are then left with the concept of involuntary unemployment, which has yet to be defined. It is sharper than the notion of surplus labour, much discussed in the development literature. We have postulated the existence of a continuum of people with good reason. Involuntary unemployment in the sense that we want to think about here has to do with differential treatment meted out to similar people. Formally we have:

[1] It would add complications to the notation enormously were we to 'endogenise' the reservation wage by, say, modelling a 'begging market' and it would add nothing by way of insights. So we take the reservation wage schedule as exogenously given. Furthermore, the assumption that the reservation wage is an increasing function of n is not at all important for the model. We postulate it for realism and to allow for the establishment of a leisure-class.

Definition 1. *A person is involuntarily unemployed if he cannot find employment in a market which does employ a person very similar to him and if the latter person, by virtue of his employment in this market, is distinctly better off than him.*

Notice that Definition 1 subsumes the case where the persons in question are identical, in which case dissimilar treatment may arise due to rationing in the labour market (see Section III. 5). But it has been noted that no two persons are ever identical. The natural generalisation of the idea is therefore Definition 1.

III. MARKET OUTCOME

III. 1. *Efficiency Wage*

From the example studied by Mirrlees (1975), Rodgers (1975) and Stiglitz (1976) we may infer that a Walrasian (or Arrow–Debreu) equilibrium does not exist in our model economy under a wide class of cases (see Section III. 5 below). The point is that the labour market may not clear. So we assume in what follows that the market has the ability to *ration* labour power if supply of labour power exceeds its demand. A precise mechanism will be suggested below.

In order to keep the exposition simple we will for the rest of the paper specialise somewhat and suppose that $\lambda(I)$ is of the form given in Fig. 1 (*b*) and is, barring I^*, continuously differentiable at all points.[1] We begin by defining $w^*(n,r)$ as:

$$w^*(n,r) \equiv \arg \min_{w \geqslant \bar{w}[rt(n)\hat{T}]} \{w/\lambda[\bar{w}+r\hat{T}t(n)]\}. \tag{1}$$

In words, $w^*(n,r)$ is that wage rate (i.e. wage per unit of labour-*time*) which, at the land-rental rate r, minimises the wage per unit of labour *power* of n-person, conditional on his being willing to work at this wage rate.[2] $w^*(n,r)$ is the *efficiency-wage* of n-person. It is a function of n. We have introduced labour heterogeneity in the model not by assuming that the λ function differs from person to person, but by allowing different people to possess different land-holdings. This explains why a person's efficiency wage depends in general on the rental rate on land. (A person's efficiency wage depends on his non-labour income.) Since by hypothesis $\hat{I}$ exceeds the reservation wage of the landless, $w^*(n,r) = \hat{I}$ for the landless. For one who owns a tiny amount of land,

$$\bar{w}[rt(n)\,\hat{T}] < w^*(n,r) < \hat{I}.$$

For one with considerable amount of land, $w^*(n,r) = \bar{w}[rt(n)\,\hat{T}]$. Finally, for one who owns a great deal of land we would expect, $w^*(n,r) = \bar{w}[rt(n)\,\hat{T}] > \hat{I}$.[3]

[1] The theory that we are developing here can certainly accommodate Fig. 1 *a*, but it requires additional, fairly complicated exposition. So we avoid it. The reader can extend the arguments that follow to this case Indeed, we will indicate some of these extensions as we go along. In the text we shall continue to describe properties of various functions by the help of diagrams. In the Appendix these properties will be formally stated

[2] Given that the λ function is of the form depicted in Fig. 1 (*b*), the right-hand side of equation (1) has a unique value. If the λ function is of the *s*-shaped form of Fig. 1 (*a*) the right-hand side of (1) is not necessarily unique. When not, we would choose the largest solution (which in fact exists) and define $w^*(n, r)$ as the largest solution.

[3] The reader can easily check this by translating the curve in Fig. 1 (*b*) to the *left* by the amount $r\hat{T}t(n)$ and then using equation (1).

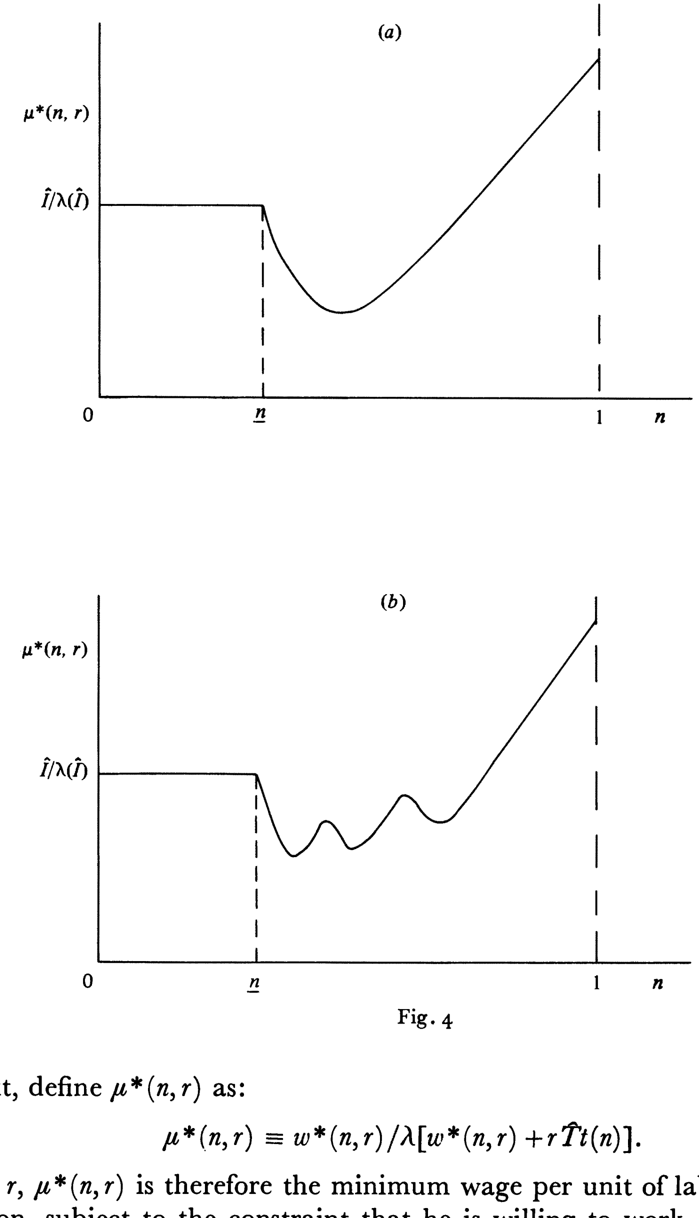

Fig. 4

Next, define $\mu^*(n,r)$ as:

$$\mu^*(n,r) \equiv w^*(n,r)/\lambda[w^*(n,r)+r\hat{T}t(n)]. \qquad (2)$$

Given r, $\mu^*(n,r)$ is therefore the minimum wage per unit of labour power for n-person, subject to the constraint that he is willing to work. In Fig. 4(*a*) a typical shape of $\mu^*(n,r)$ has been drawn. $\mu^*(n,r)$ is 'high' for the landless because they have no non-wage income. (In fact, for such people

$$\mu^*(n,r) = \hat{I}/\lambda(\hat{I}).)$$

It is relatively 'low' for 'smallish' landowners because they *do* have some non-wage income and because their reservation wage is not too high. $\mu^*(n,r)$ is 'high' for the big land-owners because their reservation wages are very 'high'.

While a 'typical' shape of $\mu^*(n,r)$, as in Fig. 4(*a*), is used to illustrate the arguments in the main body of the paper, it must be pointed out that our assumptions do *not*, in general, generate this 'U-shaped' curve. Fig. 4(*b*) illustrates other possible configurations of the $\mu^*(n,r)$ function, which are perfectly consistent with the assumptions we have made.[1] What *is* common to all $\mu^*(n,r)$ functions that are obtained from (2) are these features: for a given r,

(*a*) $\mu^*(n,r)$ is constant for all landless n-persons and falls immediately thereafter.

(*b*) $\mu^*(n,r)$ continues to decrease in n as long as the reservation wage constraint is not binding in equation (1). (Therefore, whenever $\mu^*(n,r)$ increases with n the reservation wage constraint in (1) *is* binding.)

(*c*) Once the reservation wage binds for some n-person it continues to do so for all n-persons with more land.[2]

(*d*) $\mu^*(n,r)$ 'finally' rises as the effect of the increasing reservation wage ultimately outweighs the (diminishing) increments to labour power associated with greater land-ownership.

Having said this, though, we will continue to use the simpler Fig. 4(*a*) for the purpose of exposition. The interested reader is referred to the Appendix and Dasgupta and Ray (1984) for the more rigorous arguments.

Bliss and Stern (1978*a*, *b*) interpreted $\lambda(I)$ as the (maximum) *number* of *tasks* a person can perform by consuming I. In this interpretation we may regard $\mu^*(n,r)$ in equation (2) as the *efficiency-piece-rate* of n-person. In what follows we will so regard it.

III. 2. *Market Equilibrium*

By hypothesis markets are competitive, and there are two factors of production, land and labour power (or tasks). There are thus two competitive factor prices to reckon with. The rental rate on land is r. Let μ denote the price of a unit of labour power, that is, the *piece rate*. (By normalisation, the price of output is unity.) Let $D(n)$ be the market *demand* for the *labour time* of n-person, and let $S(n)$ be his labour (time) *supply*. (By assumption $S(n)$ is either zero or unity.) Let $w(n)$ be the wage rate for n-person and let G denote the set of n-persons who find employment. Production enterprises are profit maximising and each person aims to maximise his income given the opportunities he faces.[3] We now have

Definition 2. *A rental rate $\tilde{r}$, a piece rate $\tilde{\mu}$, a subset $\tilde{G}$ of* $[0, 1]$ *and a real-valued function $\tilde{w}(n)$ on $\tilde{G}$ sustain a competitive equilibrium if (and only if):*

(i) *for all n-persons for whom $\tilde{\mu} > \mu^*(n,\tilde{r})$, we have $S(n) = D(n) = 1$;*

(ii) *for all n-persons for whom $\tilde{\mu} < \mu^*(n,\tilde{r})$, we have $S(n) = D(n) = 0$;*

(iii) *for all n-persons for whom $\tilde{\mu} = \mu^*(n,\tilde{r})$, we have $S(n) \geqslant D(n)$, where $D(n)$ is*

[1] We have not been able to find reasonable assumptions that will generate the U-shape, so we do not impose any such structure in the mathematical arguments of the Appendix. This necessitates the use of some fairly complicated technical arguments.

[2] This is not, in general, true for the more complicated consumption-ability curve of Fig. 1 (*a*), but that does not affect the main arguments.

[3] Or more precisely, he compares his maximal income if he is working in the economy in question to the sum of his reservation wage and maximal non-wage income if he is not working in this economy.

either 0 *or* 1 *and where* $S(n) = 1$ *if* $\tilde{w}(n) > \bar{w}(n, \tilde{r})$ *and where* $S(n)$ *is either* 0 *or* 1 *if* $\tilde{w}(n) = \bar{w}(n, \tilde{r})$; (*here we have written* $\bar{w}(n, \tilde{r})$ *for* $\bar{w}[\tilde{r}\hat{T}t(n)]$);

(iv) $\tilde{G} = \{n/D(n) = 1\}$ *and* $\tilde{w}(n)$ *is the larger of the (possibly) two solutions of* $w/\lambda[w + \tilde{r}\hat{T}t(n)] = \tilde{\mu}$, *for all n with* $D(n) = 1$;[1]

(v) $\tilde{\mu} = \partial F(\tilde{E}, \hat{T})/\partial E$, *where* $\tilde{E}$ *is the aggregate labour power supplied by all who are employed; that is*

$$\tilde{E} = \int_{\tilde{G}} \lambda[\tilde{w}(n) + \tilde{r}\hat{T}t(n)]\, d\nu(n);$$

and

(vi) $\tilde{r} = \partial F(\tilde{E}, \hat{T})/\partial T$.

Now for a verbal account. Since 'production enterprises' are competitive, $\tilde{r}$ must in equilibrium equal the marginal product of land and $\tilde{\mu}$ the marginal product of aggregate labour-power. These are conditions (vi) and (v). Moreover, we should conclude at once from (v) that the market demand for the labour time of an n-person whose efficiency-piece-rate exceeds $\tilde{\mu}$ must be nil. Equally, such a person cannot, or, given his reservation wage, will not, supply the labour quality the market bears at the going piece rate $\tilde{\mu}$. (To see this suppose he were employed at wage $w \geqslant \bar{w}[\tilde{r}\hat{T}t(n)]$. For this to be feasible it must be that

$$w + \tilde{r}\hat{T}t(n) \leqslant \tilde{\mu}\lambda[w + \tilde{r}\hat{T}t(n)] + \tilde{r}\hat{T}t(n),$$

and so $w \leqslant \tilde{\mu}\lambda[w + \tilde{r}\hat{T}t(n)]$. This contradicts the fact about this person that $\mu^*(n, \tilde{r}) > \tilde{\mu}$.) This is stated as condition (ii). But what of an n-person whose efficiency-piece-rate is less than $\tilde{\mu}$? Plainly every enterprise wants his service. Speaking metaphorically, his *wage rate* is bid up by competition to the point where the piece rate he receives equals $\tilde{\mu}$. Demand for his time is positive. Since the wage he is paid exceeds his reservation wage ($\tilde{\mu} > \mu^*(n, \tilde{r})$, and so

$$\tilde{w}(n) > w^*(n, \tilde{r}) \geqslant \bar{w}(n, \tilde{r})),$$

he most willingly supplies his unit of labour time which, in equilibrium, is what is demanded. This is stated as conditions (i) and (iv). Finally, what of an n-person whose efficiency-piece-rate equals $\tilde{\mu}$? Enterprises are indifferent between employing such a worker and not employing him. He is, of course, willing to supply his unit of labour time: with eagerness if the wage he receives in equilibrium exceeds his reservation wage, and as a matter of indifference if it equals it. This is stated in conditions (iii) and (iv). Since the production function is constant-returns-to-scale, production enterprises earn no profits after factor payments have been made. Finally, it is clear that aggregate demand and supply of rice are equal. This follows from Walras' Law which has been incorporated directly into the definition of an equilibrium. We may now state

Theorem 1. *Under the conditions postulated, a competitive equilibrium exists.*

Proof. See Appendix.

[1] All relevant functions such as $D(n)$ are taken to be measurable. Lebesgue measure is denoted by $\nu(.)$. Observe that the two stated conditions regarding $w(n)$ define it uniquely for each employed n-person.

A competitive equilibrium in our economy is not necessarily Walrasian. It is not Walrasian when, for a positive fraction of the population, condition (iii) in Definition 2 holds; see Section III. 5.[1] Otherwise it is. If in equilibrium, condition (iii) holds for a positive fraction of the population the labour market does not clear and we take it that the market sustains 'equilibrium' by rationing; that is, of this group a fraction is employed while the rest are kept out. For concreteness we may think of a lottery system which accomplishes the rationing.

What do individuals need to know in equilibrium? The information structure in our economy is no different from that required in the Arrow–Debreu theory. All observe the market signals $\tilde{r}$ and $\tilde{\mu}$. The production sector knows the production function $F(.)$, knows the quantity of land it rents and can observe the number of tasks performed by all who are employed by it. (For simplicity of exposition we are postulating a single entrepreneur for the moment.) Each individual knows how much land he possesses and knows his own potential; that is, the $\lambda(I)$ function. Finally, as in the Arrow–Debreu theory, all contracts must, by assumption, be honoured. This means in particular that an n-person who finds employment asks for and receives $\tilde{w}(n)$ as a wage and promises to supply $\lambda[\tilde{w}(n)+\tilde{r}\hat{T}t(n)]$ units of labour power (or tasks).

III. 3. *Simple Characteristics of Market Equilibrium*

In what follows we will characterise equilibria diagrammatically. To do this we merely superimpose the horizontal curve $\mu = \tilde{\mu}$ on to Fig. 4 (*a*). There are *three* different types of equilibria, or *regimes*, depending on the size of $\hat{T}$, the parameter we vary in the next three subsections. Specifically, we have

Theorem 2. *A competitive equilibrium is in one of three possible regimes, depending on the total size of land, $\hat{T}$, and the distribution of land. Given the latter:*

(1) *If $\hat{T}$ is sufficiently small, $\tilde{\mu} < \hat{I}/\lambda(\hat{I})$, and the economy is characterised by malnourishment among all the landless and some of the near-landless (Fig. 5 (a)).*

(2) *There are ranges of moderate values of $\hat{T}$ in which $\tilde{\mu} = \hat{I}/\lambda(\hat{I})$, and the economy is characterised by malnourishment and involuntary unemployment among a fraction of the landless (Fig. 5 (b)).*

(3) *If $\hat{T}$ is sufficiently large, $\tilde{\mu} > \hat{I}/\lambda(\hat{I})$, and the economy is characterised by full employment and an absence of malnourishment (Fig. 5 (c)).*

Proof. See Appendix.

We will discuss these equilibrium regimes successively in Sections III. 4–III. 6. But first we note that among those in employment persons owning more land are doubly blessed: they not only enjoy greater rental income, their wages are higher.

Theorem 3. *Let $n_1, n_2 \in \tilde{G}$ with $t(n_1) < t(n_2)$. Then $\tilde{w}(n_1) < \tilde{w}(n_2)$.*

Proof. See Appendix.

[1] Equilibrium, as we have defined it, is equivalent to a *quasi-equilibrium* in Debreu (1962) and is, for our model, also equivalent to the concept of *compensated equilibrium* in Arrow and Hahn (1971). A formal identification would involve an infinity of commodities, each different value of λ (or labour 'quality') being identified as one such commodity.

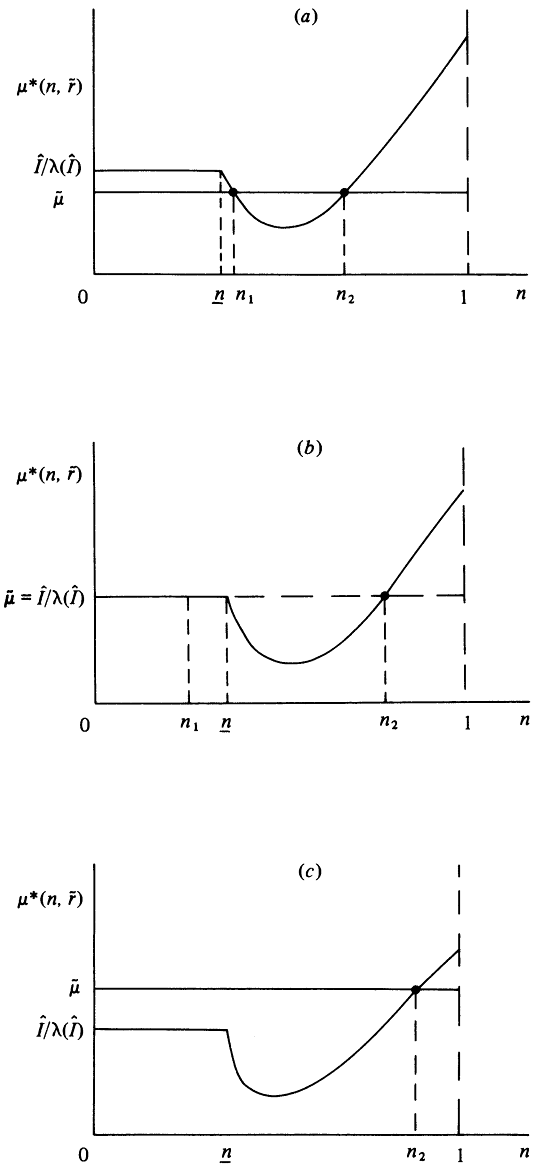

Fig. 5. (*a*) Land-poor economy: incidence of unemployment and malnutrition (*b*) Moderate land endowment: incidence of involuntary unemployment and malnutrition. (*c*) Rich economy: full employment and no malnutrition.

A strong implication of this result is that competition, in some sense, *widens* the initial disparities in asset ownership by offering larger (employed) landowners a higher *wage* income. Contrast this with the results of Bliss and Stern (1978*a*). There, a monopsonist landlord narrows initial asset disparities in his quest to equalise marginal labour power across all labour types. Competition, by placing productive asset-holders at a premium in the job market, has exactly the opposite effect.

III. 4. *Regime 1: Malnourishment among the Landless and Near-landless.*

Fig. 5 (*a*) depicts a typical equilibrium under regime 1. ($\hat{T}$ is small and so from the first part of Theorem 2, $\tilde{\mu} < \hat{I}/\lambda(\hat{I})$.) From condition (i) of Definition 2, one notes that all n-persons between n_1 and n_2 are employed in the production of rice. Typically, the borderline n_1-person will be one for whom the market wage $\tilde{w}(n_1)$ will exceed his reservation wage $\bar{w}[\tilde{r}t(n_1)\ \hat{T}]$. We will assume this in the exposition. From condition (ii) of Definition 2, we observe that all n-persons below n_1 and above n_2 are out of the market: the former because their labour power is too expensive, the latter because their reservation wages are too high – they are too rich.

It should also be noted that in this regime, all the landless are malnourished. Indeed, it can be verified that (if, as we are assuming in this essay, malnourishment incomes are defined to be those below $\hat{I}$) *all* persons between $\underline{n}$ and n_1 are also malnourished, their rental income is too meagre. Finally, note that some of the *employed* are also malnourished, which is verifiable by noting that employed persons slightly to the right of n_1 consume less than $\hat{I}$.

To be sure, there are no job queues in the labour market; nevertheless, there is involuntary unemployment in the sense of Definition 1. To see this note first that $\tilde{w}(n_1) > \bar{w}[\tilde{r}t(n_1)\ \hat{T}]$. This implies that $\tilde{w}(n) > \bar{w}[\tilde{r}t(n)\ \hat{T}]$ for all n in a neighbourhood to the *right* of n_1. Such people are employed. They are therefore *distinctly* better off than n-persons in a neighbourhood to the *left* of n_1, who suffer their reservation wage. This means that the equilibrium income schedule is discontinuous at n_1. Such a discontinuity is at odds with the Arrow–Debreu theory with convex structures.

Finally, observe that n-persons above n_2 are *voluntarily* unemployed. Call them the pure rentiers, or the landed gentry. They *are* capable of supplying labour at the piece-rate $\tilde{\mu}$ called for by the market, but *choose* not to: their reservation wages are too high. They are to be contrasted with unemployed people below n_1, who are *incapable* of supplying labour at $\tilde{\mu}$.

III. 5. *Regime 2: Malnourishment and Involuntary Unemployment among the Landless*

The relevant curves are as drawn in Fig. 5 (*b*). Here $\tilde{\mu} = \hat{I}/\lambda(\hat{I})$. It is not a fluke case: it pertains to certain intermediate ranges of $\hat{T}$. (We are keeping land distribution fixed here.) The economy equilibrates by rationing landless people in the labour market. (We may suppose that it does so by means of a lottery.) In Fig. 5 (*b*) all n-persons between $\underline{n}$ and n_2 are employed, ((i) of Definition 2). All n-persons above n_2 are out of the labour market because their reservation wages are too high ((ii) of Definition 2). A fraction of the landless, $n_1/\underline{n}$, is involuntarily unemployed, the remaining fraction, $1-n_1/\underline{n}$, is employed. The size of this fraction depends on $\hat{T}$. Those among the landless that are employed are paid $\hat{I}$. Those who are unemployed suffer their reservation wage. They are malnourished. The labour market does not clear.

Finally, we observe that, by our definition of malnourishment incomes as being those below $\hat{I}$, the group of unemployed and malnourished people *coincide* under this regime. This is to be contrasted with Regime 1.

III. 6. *Regime 3: The Full Employment Equilibrium*

Fig. 5 (*c*) presents the third and final regime, pertinent for large values of $\hat{T}$. Here, $\tilde{\mu} > \hat{I}/\lambda(\hat{I})$. From part (i) of Definition 2 we conclude that all persons from zero to n_2 are employed. From (ii) we note that those above n_2 are not employed. But, as before, they are not involuntarily unemployed: they are the landed gentry. Thus this regime is characterised by full employment, and no one is undernourished. This corresponds to a standard Arrow–Debreu equilibrium.

III. 7. *Growth as a Means of Reducing the Incidence of Malnourishment and Unemployment*

It is difficult to resist extending the conclusions of the timeless structure and introducing time. So we will not try. One can imagine an economy with a small $\hat{T}$ and a given distribution of land, $t(n)$. An equilibrium is characterised by Fig. 5 (*a*). If the propertied class, which is well-to-do at the equilibrium, accumulates in land improvement – that is, in capital that improves the productivity of land – $\hat{T}$ will increase. Assuming that land distribution, $t(n)$, remains approximately the same, it would follow that with $\hat{T}$ increasing more and more, the economy will after some time enter the regime depicted by Fig. 5 (*b*), and eventually the final regime of Fig. 5 (*c*).[1] It is only in the final regime that no one is undernourished. We take it that this is what 'trickle-down' theory amounts to.

Of course, if we introduce time we must also introduce a capital market and allow peasants to borrow. As accumulation (increase in $\hat{T}$) takes place one expects the equilibrium piece-rate to increase in regime 1. Thus borrowing will, *ceteris paribus*, accelerate the transition from regime 1 to regime 2, since a peasant who borrows and is employed, consumes in excess of his current income and thus increases his productivity. On the other hand, if the economy is a closed one this borrowing must be from high n-persons and loans are an alternative to land improvement. This will lower the progress of the economy. In regime 2, accumulation raises employment rather than the piece-rate. As the end of regime 2 approaches, all landless peasants may wish to borrow. A capital market will modify the 'trickle', but it will not eliminate any of the three regimes.

[1] We have not been able to prove that under general conditions the economy moves monotonically from regime 1 to 2 and then to 3 with increasing $\hat{T}$. The example in Section IV does, however, display this feature.

IV. AN EXAMPLE

We assume

$$\lambda(I) = \bar{\lambda} > 0 \quad \text{if} \quad I \geqslant \hat{I} > 0, \qquad (3)$$
$$= 0 \quad \text{if} \quad I < \hat{I},$$

$$t(n) = 1/(1-\underline{n}) \quad \text{for} \quad n \geqslant \underline{n} \geqslant 0, \qquad (4)$$
$$= 0 \quad \text{for} \quad 0 \leqslant n < \underline{n},$$

$$\bar{w}(R) = 0 \quad \text{for all} \quad R \geqslant 0, \qquad (5)$$

$$F(E, T) = E^a T^{1-a} \quad (0 < a < 1). \qquad (6)$$

In words, (3) says that the food–productivity relationship is a step-function, (4) says that it is a two-class economy, (5) says that the reservation wage is nil for all persons, and (6) postulates a Cobb–Douglas production function. (3) and (4) violate the conditions assumed in Section III. 1. (For example, both $\lambda(I)$ and $t(n)$ have so far been assumed to be continuous.) Clearly, though, we can approximate them by functions satisfying those conditions as closely as we like. The example is thus a valid one to use for illustrating the theory. It also indicates that assumptions of continuity, etc. are essentially simplifying devices for the model.

Using (3)–(5) in equation (1) we find the efficiency-wage of n-person to be

$$w^*(n,r) = \hat{I} \quad \text{for} \quad 0 \leqslant n < \underline{n}$$
$$= \max[0, \hat{I} - r\hat{T}/(1-\underline{n})] \quad \text{for} \quad 1 \geqslant n \geqslant \underline{n}. \qquad (7)$$

Likewise, using (3)–(5) in equation (2) yields the efficiency-piece-rate as

$$\mu^*(n,r) = \hat{I}/\bar{\lambda} \quad \text{for} \quad 0 \leqslant n < \underline{n}$$
$$= \max[0, \hat{I} - r\hat{T}/(1-\underline{n})]/\bar{\lambda} \quad \text{for} \quad 1 \geqslant n \geqslant \underline{n}. \qquad (8)$$

We will first vary $\hat{T}$ so as to illustrate Theorem 2 and the claims made in Sections III. 4–III. 6. It is in fact simplest to write down the equilibrium conditions for regime 2 (Section III. 5 and Fig. 5 (*b*)), because $\tilde{\mu}$ is anchored to $\hat{I}/\lambda(\hat{I})$. So, on using (3)–(8) in Theorem 2 we note that the equilibrium conditions in regime 2 are:

$$\tilde{E} = \bar{\lambda}(1-n_1), \quad \text{where} \quad 0 < n_1 < \underline{n} < 1 \qquad (9)$$

$$\tilde{r} = \bar{\lambda}^a(1-n_1)^a(1-a)\hat{T}^{-a} \qquad (10)$$

$$\tilde{\mu} = a\bar{\lambda}^{(a-1)}(1-n_1)^{(a-1)}\hat{T}^{(1-a)} \qquad (11)$$

and

$$\tilde{\mu} = \hat{I}/\bar{\lambda}.^{1} \qquad (12)$$

Equations (9)–(12) are four in number, and there are four unknowns, $\tilde{E}$, $\tilde{r}$, $\tilde{\mu}$ and n_1, to solve for. Using (11) and (12) we note that

$$n_1 = 1 - [a\bar{\lambda}^a\hat{T}^{(1-a)}/\hat{I}]^{1/(1-a)}. \qquad (13)$$

Now, in regime 2 one must have $0 < n_1 < \underline{n} < 1$. Using this in equation (13) we conclude that *given* $\underline{n}$, for the economy to be in regime 2, $\hat{T}$ must satisfy the inequalities:

$$(1-\underline{n})(\hat{I}/a\bar{\lambda}^a)^{1/(1-a)} < \hat{T} < (\hat{I}/a\bar{\lambda}^a)^{1/(1-a)}, \qquad (14)$$

that is, if $\hat{T}$ is neither too large nor too small (Section III. 5).

[1] Note that $\tilde{G} = [n|D(n) = 1] = [n_1, 1]$.

From (14) we conclude that the economy is in regime 3 if $\hat{T} \geqslant (\hat{I}/a\bar{\lambda}^a)^{1/(1-a)}$, no matter what the distribution of land holdings is, a result which we will generalise in the sequel. Since $n_1 = 0$ in regime 3 (Fig. 5 (c)) competitive equilibrium can be explicitly computed to be

$$\tilde{E} = \bar{\lambda}; \quad \tilde{r} = \bar{\lambda}^a(1-a)\,\hat{T}^{-a}; \quad \text{and} \quad \tilde{\mu} = a\bar{\lambda}^{(a-1)}\,\hat{T}^{(1-a)} > \hat{I}/\bar{\lambda}. \tag{15}$$

From (14) we also conclude that the economy is in regime 1 (Section III.4 and Fig. 5 (a)), if $\hat{T} \leqslant (1-\underline{n})\,(\hat{I}/a\bar{\lambda}^a)^{1/(1-a)}$.

The regime 1 equilibrium exhibits employment of all from $\underline{n}$ to 1 as long as $\hat{T}$ is not too small. To calculate this bound, assume first that the equilibrium set $\tilde{G} = [\underline{n}, 1]$; then

$$\tilde{E} = \bar{\lambda}(1-\underline{n}), \quad \tilde{r} = \bar{\lambda}^a(1-\underline{n})^a\,(1-a)\,\hat{T}^{-a} \tag{16}$$

and

$$\tilde{\mu} = a[\bar{\lambda}(1-\underline{n})]^{a-1}\,\hat{T}^{-a} < \hat{I}/\bar{\lambda}.$$

And this is an equilibrium as long as $\tilde{\mu} \geqslant \mu^*(n, \tilde{r})$ for all $n \in [\underline{n}, 1]$, or if

$$a[\bar{\lambda}(1-\underline{n})]^{a-1}\,\hat{T}^{1-a} \geqslant [\hat{I} - \tilde{r}\hat{T}/(1-\underline{n})]/\bar{\lambda}. \tag{17}$$

Substituting for $\tilde{r}$ and rearranging, one obtains

$$\hat{T} \geqslant a^{1/(1-a)}\,(1-\underline{n})\,(\hat{I}/a\bar{\lambda}^a)^{1/(1-a)}. \tag{18}$$

Note that, since $a < 1$, the R.H.S. of (18) is smaller than the L.H.S. of (14), which is the borderline for regime 1.

If $\hat{T}$ does not satisfy (18), then we are in regime 1 where only a subset of $[\underline{n}, 1]$ is employed. No generality is lost by choosing this subset to be $[n_1, 1]$, where $n_1 > \underline{n}$.

For such equilibria, $\tilde{\mu} = \mu^*(n, \tilde{r})$; in other words, defining

$$\tilde{E} = \bar{\lambda}(1-n_1), \quad \tilde{r} = \bar{\lambda}^a\,(1-n_1)^a\,(1-a)\,\hat{T}^{-a}, \tag{19}$$

and

$$\tilde{\mu} = a[\bar{\lambda}(1-n_1)]^{a-1}\,\hat{T}^{1-a} < \hat{I}/\lambda$$

as the equilibrium magnitudes, we solve for n_1 by using (8) and (19) to obtain

$$a[\bar{\lambda}(1-n_1)]^{a-1}\,\hat{T}^{1-a} = [\hat{I} - \tilde{r}\hat{T}/(1-\underline{n})]/\bar{\lambda}. \tag{20}$$

Rearranging, n_1 is the solution to

$$a\bar{\lambda}^a(1-n_1)^{a-1}\,\hat{T}^{1-a} + [(1-a)\,\bar{\lambda}^a\,(1-n_1)^a\,\hat{T}^{1-a}]/(1-\underline{n}) = \hat{I}. \tag{21}$$

This describes the regimes.

V. COMMENTARY

How robust are our general conclusions against relaxation of the underlying assumptions in the model? Five obvious extensions suggest themselves and we discuss them briefly.[1]

[1] We will not discuss relaxation of the competitive hypothesis for reasons that we mentioned in Section I. Bliss and Stern (1978a) have discussed some of the consequences of there being a monopsonistic landlord.

(*a*) *Heterogeneity*. People differ. So the food-productivity relation $\lambda(.)$ should depend on the characteristics of the person in question, including his history. (Climate matters too, but we are keeping that fixed for all people.) Let m (for simplicity, a real number) denote an additional index characterising an individual and let the function λ depend on the parameter m. A person is then denoted by a pair of numbers (m, n) and in the obvious notation, $\lambda = \lambda(I_n, m)$ where $I_n = w + r\hat{T}t(n)$. We may now define the population to be a uniform bivariate distribution on (m, n) pairs and reconstruct our analysis. Nothing of substance will change.

(*b*) *Household Decisions*. Notice that this device can also be used to distinguish people by their family size and thus their family commitments. A person with a family does not consume the entire income he collects. He shares with his family. *Ceteris paribus* the larger is his family the less he consumes of the income he collects. If it is reasonable to simplify and suppose that members in a household share total income in some fixed manner, the foregoing index scheme will suffice. If not, we will need to formulate the manner in which a typical household decides to share its income and then label people as well by their household size. The number of dependants (and this will of course be endogenous in the model because the person in question may have a spouse or a sibling who also is in search of a job outside) and the sharing rule will (endogenously) tell us how much of a person's income will be consumed by him. The rest of the argument is monumentally tedious, but routine.

It is often thought that the concept of involuntary unemployment is of necessity restricted to a wage economy and that a recognition that people do household chores and cultivate family plots, will spell ruin for the concept and that we will need to rethink the entire issue. Not so. The concept has to do with *work options* open to a person and to those who are *similar* to him. It is a special case of a concern with consumption options open to a person and to those who are similar to him. The concept has to do with *localised* inequality in available options, or horizontal inequity in work options. Definition 1 can easily be generalised for non-market environments.

It is a profound tragedy that a family in absolute poverty not only has to make do with so little, it cannot even afford to share its poverty equally. In his highly original analytical work Mirrlees (1975) pointed out that a poor family is forced to divide its consumption unequally among its members when the relation between food intake and work capacity assumes the forms we have considered in this essay. These considerations and the related issue of gender-bias in nutrition-status within the household bear on household decisions. Including them in an analysis will not affect our general conclusions regarding *interfamily* transactions, the subject of this essay.

(*c*) *Moral Hazard*. How can an employer tell how much of his income the worker will himself consume? Should he not expect leakage? Furthermore, what guarantee is there that the worker will not shamefully waste his calories by playing and dancing in his spare time? Neither matters for our theory if, as we have assumed, contracts are always honoured. An employer does not care *what* a worker does with his calories so long as the piece-rate that he is paid does not exceed the market rate. (Of course, the employer must be able to observe the number of tasks the worker actually completes. Otherwise, piece rates cannot be implemented.) Recall that we are here discussing *competitive* markets. A *monopsonistic* landlord *will* care and will take steps to see that wages are not frittered away in frivolous activities.[1] But that is a different matter.

(*d*) *Noisy* λ. People cannot possibly know their own $\lambda(.)$ function. So then how can a person commit himself to performing the tasks he undertakes to accomplish? He cannot of course. He, like his employer, will be taking risks when agreeing on a contract. Their attitudes to risk, the availability of risk markets and so forth, will influence the final outcome. These are familiar terrains, similar to the uncertainty one faces in production theory. Protestations notwithstanding, food-productivity relations are no more an abstraction than are production functions, input–output tables and 'books of blue-prints'. The fact that we may *think* we know less about them does not make them any the less real. (We have explored these issues further in Dasgupta and Ray, 1987.)

(*e*) *Time and History*. Sukhatme (1978), among others, has argued that a person's metabolic efficiency in the *use* of energy adjusts over time to alterations in his energy intake. Put another way, there are multiple metabolic equilibria for a person; in particular, even hungry people operate sometimes with 'metabolic slack'. It is easy to misuse this observation. It does *not* say (and it would be totally absurd if it said otherwise) that this adjustment can occur indefinitely with vanishing food intake. The food-productivity relation used in this paper captures in the simplest manner possible the fact that humans are biological entities. Of *course* a person's history matters; that is, λ at any date for a person depends on his entire nutrition and work history. This complicates things, but does not alter our general conclusions; so long, that is, as the λ function has regions of increasing-returns.

A person's past nutritional status is like a capital asset and when this affects present and future productivity there is a problem of intertemporal externality. Unless long-term labour contracts can be signed – and the existence of casual labour suggests that they often are not – employers will not be able to appropriate all the future benefits from employing persons. As one would expect, such missing markets will tend to depress wages. (See Mazumdar (1959).) But nothing of substance will be affected in our analysis.

A person's history can be telling and very pernicious for him. For example, it has been suggested to us by a referee that if our model economy of Section III languishes in a stationary state (no accumulation) in regime 2 then our concept of involuntary unemployment is useless because *on average* all the landless will be employed the same *number* of periods. (This would be so if in each period a lottery

[1] An extreme case is slavery On the constraints imposed on the activities of slaves see Genovese (1974). Rodgers (1975) and Stiglitz (1976) analysed an economy in which the landowners' reservation wage is in effect infinity. Thus the only possible workers are the landless. But in this case it makes no difference whether there is a single employer (i.e. labour monopsony) or many: *the outcome is the same*! Because of this happy analytical coincidence Rodgers and Stiglitz did not need to develop the apparatus required to discuss non-monopsonistic markets, a need which cannot be avoided if one wishes to explore the implications of land reform (see the sequel); for, *after* a reform the labour market cannot be monopsonistic.

is used to ration the labour market.) So then over the long haul there is equality among the landless. This is certainly so. But now introduce a tiny bit of history. Suppose a person's nutrition status in one period affects his λ function in the next period. Suppose the landless are all identical to begin with. In the first period a fraction will be employed. Which particular people we cannot tell in advance because a lottery is in use. But in the next period the previously-employed have a slight advantage (because of their better nutrition history). From then on, most of these same people will find employment, and all of those who languished in the first period, through bad luck, will continue to languish; no longer through bad luck but through *cumulative causation*. The evils of malnutrition and involuntary unemployment cannot be exorcised by mathematical sophistry.

VI. CONCLUSIONS

People without assets are doubly cursed. Not only do they not enjoy non-labour income, they are at a disadvantage in the labour market relative to those who do possess assets. If the efficiency-piece-rate of a wealthy man is too high for anyone to wish to hire him it is because his reservation wage is too high. He is not unemployed. Not so for the assetless. Such a man's efficiency-piece-rate is high not because he does not *want* to work but because his entire food intake must be wage-based. Thus he either cannot offer the labour quality the market demands and so must languish in a state of malnourishment (Section III.4, Regime 1), or can, but is, if unlucky, prevented from joining the labour force because of rationing (Section III.5, Regime 2). In the latter case he is involuntarily unemployed and malnourished. The central purpose of this essay has been to illustrate these points and to explore their ramifications.

We have argued in this essay that the market may force identical persons to be treated differently – in particular to award some a job and adequate nutrition and to keep others out in a state of malnourishment – and in the sequel we will show that this can happen even if the economy is rich enough in assets to feed all adequately. The reason is that because a large fraction of the population is landless the market cannot 'afford' to employ all. Inequality as such is not the worst of evils. But malnourishment in the midst of potential plenty (as in Theorem 4 of the sequel) is not far from being one. While it is true that if accumulation – e.g., via an improvement in land – proceeds, unemployment, and thus malnutrition, will be eradicated in the model economy in time (Theorem 2). However, it may be a long while coming. For the immediate future the 'quantity' of land cannot be altered much. But the extreme inequality in food consumption which the market inflicts *can* be countered. For economies not generously endowed with physical assets the competitive market mechanism must be judged an unmitigated disaster. The policy implications in the model economy are clear enough and will be explored in the sequel.

At the mathematical level it is easy to see why, despite pure competition, there is involuntary unemployment when the number of landless people is large. It is because of the inherent increasing-returns-to-scale in the food–productivity relation of a person at low consumption levels (Fig. 1 (*a*), (*b*)).[1] It is because of this that the theory outlined here is so different from the Arrow–Debreu theory of perfect competition with convex structures. We have argued that given the land distribution function $t(n)$, it is only when the total quantity of land is large (when $\hat{T}$ is large) that pure competition in the economy in question merges with the standard Arrow-Debreu theory (Theorem 2, regime 3). In the sequel (Theorem 4) we will show that if there is sufficient land to feed all but it is not a land-rich country then competitive equilibrium in our model economy merges with the standard Arrow–Debreu equilibrium only if land distribution is sufficiently equal. In the sequel we will also show (see Theorem 5 in the sequel) that if the aggregate quantity of land is very large land distribution does not matter as regards employment and malnutrition: an equilibrium is a conventional Arrow–Debreu one. We take this to mean that the Arrow–Debreu theory pertains only to an economy which is asset-rich. This is not to say that an Arrow–Debreu equilibrium has much to commend it from the point of view of the distribution of welfare. There is, however, nothing new in this point and it is not the one we want to make here. The point we *are* making here is that the Arrow–Debreu theory does not have a *vocabulary* either for malnutrition or for involuntary unemployment.[2] The central purpose of this essay has been to provide here a simple theory that can accommodate these notions, and in particular to expose their link with the inequality in asset ownership.

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Date of receipt of final typescript: May 1986

Appendix

In what follows we present proofs of the theorems stated in the text. On occasion we will, for brevity, only sketch an argument. For details, see Dasgupta and Ray (1984), Appendix.

We assume that the food–productivity curve, $\lambda(I)$, has the properties displayed in Fig. 1 (*b*); that is, $\lambda(I) = 0$ for $0 \leqslant I \leqslant I^*$, with $I^* > 0$, $\lambda(I)$ is increasing and strictly concave on $[I^*, \infty)$, and barring I^*, λ is continuously differentiable at all points. Finally, assume that $\lambda(I)$ is bounded above.

We turn to the production function $F(E, T)$. We take it that in addition to the assumption made in the text, $F(E, T)$ satisfies the Inada conditions, that is, $F_E(E, \hat{T}) \to 0$ as $E \to \infty$, $F_E(E, \hat{T}) \to \infty$ as $E \to 0$, $F_T(E, \hat{T}) \to 0$ as $\hat{T} \to \infty$ and $F_T(E, \hat{T}) \to \infty$ as $\hat{T} \to 0$.

Proof of Theorem 1. For each $r > 0$ define $E(r)$ by the condition

$$r \equiv F_T[E(r), \hat{T}]. \tag{22}$$

[1] This in conjunction with the fact that the initial endowment points of the landless lie on the boundary of their consumption-possibility sets.

[2] The Arrow–Debreu theory does not ever claim to do so. It is of course the great power of the Arrow–Debreu analysis to have found (sufficient) conditions under which involuntary unemployment will *not* occur.

Note that $E(r)$ is unique for each r and that $E(r) \to 0$ as $r \to 0$ and $E(r) \to \infty$ as $r \to \infty$. Likewise, for each $r > 0$ define $\mu(r)$ by the condition

$$\mu(r) \equiv F_E[E(r), \hat{T}]. \tag{23}$$

Note that $\mu(r)$ is unique for each r and that $\mu(r) \to \infty$ as $r \to 0$ and $\mu(r) \to 0$ as $r \to \infty$.

Let $B(r) \equiv [n|\mu^*(n,r) < \mu(r)]$ and $G(r) \equiv [n|\mu^*(n,r) \leqslant \mu(r)]$. Notice that $G(r)$ is *not*, in general, the closure of $B(r)$. Now define

$$H(r) \equiv \{G \subseteq [0,1] | G \text{ is closed and } B(r) \subseteq G \subseteq G(r)\}. \tag{24}$$

If $G(r)$ is non-empty, then for each $n \in G(r)$ it is possible to define $w(n,r)$ uniquely by the pair of conditions

$$w(n,r)/\lambda[w(n,r) + r\hat{T}t(n)] = \mu(r) \tag{25}$$

and

$$w(n,r) \geqslant w^*(n,r).$$

Note that $w(n,r)$ is continuous in n and r. Finally, define the correspondence $M(r)$ as follows:

$$M(r) = \begin{cases} \{E \in R^1 | E = \int_G \lambda[w(n,r) + r\hat{T}t(n)]\, d\nu(n),\ G \in H(r)\} & \\ \qquad\qquad\qquad\qquad \text{if } G(r) \text{ is not empty,} \\ \{0\} \qquad\qquad\qquad\quad \text{if } G(r) \text{ is empty.} \end{cases} \tag{26}$$

It is possible to show that for all $r > 0$, $M(r)$ is an *interval* (possibly a degenerate interval, a singleton). (See Dasgupta and Ray (1984, appendix, lemma 1).) It is also possible to show that if $\{r^l\}$ is a positive sequence, with $r^l \to r > 0$ as $l \to \infty$, and if $E^l \in M(r^l)$, with $E^l \to E$ as $l \to \infty$, then $E \in M(r)$. (See Dasgupta and Ray (1984, appendix, lemma 2).)

Now, for $r > 0$ but sufficiently small, we have

$$\text{for all} \quad n \in [0,1],\ \mu^*(n,r) \leqslant \mu^*(n,0) = \hat{I}/\lambda(\hat{I}) < \mu(r).$$

Using this we note that for r small enough, $\min M(r)$ is bounded away from zero, so that near zero, $\min M(r) > E(r)$, for recall that $E(r) \to 0$ as $r \to 0$. Since $\lambda(.)$ is bounded, so is $\max M(r)$ for all r.

Furthermore, since $E(r) \to \infty$ as $r \to \infty$ we have for large r, $\max M(r) < E(r)$. It is easy to verify that there exists a $\tilde{r} > 0$ and $\tilde{E} \in M(\tilde{r})$ such that $\tilde{E} = E(\tilde{r}) > 0$. Thus $G(\tilde{r})$ is non-empty. Now pick $\tilde{G} \in H(\tilde{r})$ such that

$$\tilde{E} = \int_{\tilde{G}} \lambda[w(n,\tilde{r}) + \tilde{r}\hat{T}t(n)]\, d\nu(n), \tag{27}$$

and define $\tilde{w}(n) \equiv w(n,\tilde{r})$ for all $n \in \tilde{G}$. Finally define $\tilde{\mu} = \tilde{\mu}(\tilde{r})$ from (23). The quartet $\{\tilde{r}, \tilde{\mu}, \tilde{w}(n), \tilde{G}\}$ sustain a competitive equilibrium, as can easily be checked from Definition 2. ❙

Proof of Theorem 2. Parts (1) and (3) follow directly from the Inada conditions on the production function, $F(.,.)$ and the fact that $\tilde{E}$ in (27) is bounded above (since $\lambda(.)$ is bounded above). What remains to be proved is that regime 2 occurs over at least one non-degenerate interval of values for $\hat{T}$. This can be confirmed by noting that the proof of Theorem 1 can be easily extended to demonstrate that the equilibrium correspondence is upper hemicontinuous in $\hat{T}$. ∎

Proof of Theorem 3. Write $I(n) = w(n) + r\hat{T}t(n)$ for $n \in G$. Clearly $\lambda[I(n)] > 0$. Since $\lambda(I)$ is strictly concave when $\lambda(I) > 0$, we have

$$\begin{aligned}\tilde{w}(n_2) - \tilde{w}(n_1) &= \tilde{\mu}\{\lambda[\tilde{I}(n_2)] - \lambda[\tilde{I}(n_1)]\}\\ &> \tilde{\mu}[\tilde{I}(n_2) - \tilde{I}(n_1)]\,\lambda'[\tilde{I}(n_2)],\end{aligned}$$

which on rearrangement, yields

$$[\tilde{w}(n_2) - \tilde{w}(n_1)]\,\{1 - \tilde{\mu}\lambda'[\tilde{I}(n_2)]\} = \hat{T}\tilde{\mu}\lambda'[\tilde{I}(n_2)]\,[t(n_2) - t(n_1)]\,\tilde{r} > 0. \tag{28}$$

Now, the first-order condition for the maximisation problem (1) in the text is, $\lambda(w^* + \bar{R})/w^* \geqslant \lambda'(w^* + \bar{R})$ for all $\bar{R} \geqslant 0$. This and the fact that $\tilde{w}(n_2) \geqslant w^*(n_2, \tilde{r})$ imply

$$\lambda[\tilde{I}(n_2)] \geqslant \tilde{w}(n_2)\,\lambda'[\tilde{I}(n_2)]. \tag{29}$$

It is simple to check from characteristics (*b*) and (*c*) of $\mu^*(n, r)$ in the text that if $n_1, n_2 \in \tilde{G}$ and $t(n_2) > t(n_1)$ then *either* $w^*(n_2, \tilde{r}) = \bar{w}(n_2, \tilde{r})$ *or* $\tilde{w}(n_2) > w^*(n_2, \tilde{r})$. In either case (29) is a *strict* inequality. Using this and condition (iv) of Definition 2 it follows that $1 > \tilde{\mu}\lambda'[\tilde{I}(n_2)]$ in (28). ∎

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