Labour Markets, Adaptive Mechanisms, and Nutritional Status

Debraj Ray

[2]

December 1991

Published in *Essays in Honour of K.N. Raj*, P. Bardhan, M. Datta-Chaudhuri and T.N. Krishnan (eds), Oxford University Press, 1992.

1. Introduction

That markets operate to determine nutritional status in a fundamental way is obvious enough. But it is a point that is important enough to be made, and made repeatedly. While administrative bodies such as colonial and local governments have always been aware of the profound market inequities that cause famine or endemic hunger, this knowledge needs to be classified systematically and communicated to a far wider audience. This is why works such as Sen [1981] and Drèze and Sen [1990] need to be written and deserve to be read. They emphasize a reality that is particularly shocking in the Indian context: neither aggregate production of foodgrains, nor the presence of a buffer stock, nor the fact of a country being a net exporter of foodgrain, can serve as indicators of nutritional well-being among the population at large.

This paper is a modest contribution to a literature that seeks to understand the interplay between market forces and nutritional status. I focus on a narrow set of issues, but I believe that they are important, and that they have been relatively neglected. I wish to study the interplay between the degree of "casualness" of labour markets, and the nutritional status of the employed population in these markets. Of particular interest is the effect of adaptive mechanisms in the body on the functioning of these markets. The outcome is a set of results, some of which are intuitive, and some of which are striking enough to merit further scrutiny.

I start by specifying what I believe to be a simplified but fairly accurate nutritional model. The model is rich enough to include static and dynamic effects of food intake, and to encompass possible adaptive reponses of the body to the past history of intakes. I then consider a labour market, which is parametrized by its degree of *flexibility*; that is, the ease with which employers can replace one labourer by another. I observe that such markets are *not*, in general, equivalent to casual labour markets, but I shall argue that it is precisely this feature of flexibility, and not casualness *per se*, which will be crucial in our understanding of the various processes involved.

I analyze various aspects of the model. I consider, first, the effects of changing flexibility. I show that as markets become more flexible, the nutritional status of the employed working population worsens, where for a fixed genotype I use body mass as an indicator of status. On the other hand, this process is not necessarily evident from the change in wages, for wages may actually rise in the steady state of the model. I show that in the process, not only is the working class worse off (in the sense of a lowered

[2]Boston University and the Indian Statistical Institute. This paper is dedicated with admiration and affection to Professor K. N. Raj. An earlier version was presented at a conference on "Health and Development" organized by the NCAER and Harvard University, New Delhi, January 1992. I am grateful to the seminar participants for their comments.

nutritional status), the deterioration of productive labour may make *employers* worse off too. This is, of course, of the employers' own making, but it arises from an externality that the competitive market cannot internalize.

I turn, next, to the effects of adaptation. Adaptation to low intakes have been advanced by some as a costless and healthy response, at least within limits. As I indicate in Section 2, the evidence on costless adaptation is doubtful. But the normative significance of adaptation is not my main focus here. Of course, it is almost a truism that *given the environment*, it is better to possess adaptive mechanisms than not. My intention, however, is to see how these mechanisms might affect the economic environment, and *then* to return to an evaluation of its feedback on the individual. In a labour-surplus economy, the results are striking. Increased adaptation unambiguously worsens the nutritional status of the population, as the market reacts by skimming off the surplus so generated. But in all the various cases I study, the effects on wage rates are more complex, suggesting that one should *not*, perhaps, look for a one-to-one correspondence between wage rates (or even food intake) and nutritional status. The point is that work intensities in the marketplace also vary endogenously, and these need to be taken into account. It is far better, though perhaps more difficult, to proceed via anthropometric measurement.

One important implication of the theory, as advanced here, is that contrary to the standard efficiency-wage models, there is no innate tendency for long-term relationships to form on nutritional grounds alone, *even though the employer may be perfectly aware of the nutritional model*. Whether such a relationship forms or not depends on other characteristics of the labour market. I discuss this in some detail in Section 4. There is a genuine market failure here, and Coase-like arrangements will not spontaneously crop up. This point is important not only conceptually, but also has relevance for proper empirical testing of the theory. I also note that this point is reinforced by the existence of adaptive mechanisms.

I discuss a simplified energy-balance equation in Section 2. In Section 3, I introduce the labour market, along with a precise description of its characteristics, and proceed to derive certain conclusions. I then turn to a detailed examination of the underpinnings of the theory in Section 4.

2. The Energy Balance Equation

To fix ideas, I start by considering a simplified version of the energy balance equation. I shall not consider every nuance of this complex relationship, but focus only on those essential aspects needed for the main arguments of the paper. It is possible that the discussion in this section is relatively well-known. Nevertheless, I include it for completeness and to remove possible misinterpretations of terminology. At a number of points, the discussion will draw upon the material in Dasgupta and Ray [1990] and Ray and Streufert [1990].

Divide time into discrete periods $t = 0, 1, 2, \ldots$, and consider an individual who must divide his energy intake between maintenance of the body and physical activity of various types. I shall be assuming that the relevant variable for analyzing nutrition has a *scalar* representation — calories.[1] Let x_t denote the

[1] The neglect of protein requirements is not a serious omission in the Indian case, as an Indian diet that meets calorie requirements usually suffices for adequate protein intake. See Sukhatme [1972, 1974] and Gopalan [1983]. Nevertheless, insofar as I am not considering the ingestion of other nutrients, such as vitamin A, iron and the B-group vitamins, the analysis above certainly represents a simplification.

energy intake of the individual at time t, r_t his *basal metabolic rate* (BMR)[2], q_t the energy expended on physical activity, and b_t the energy released from (or stored in) the body. We may then write the fundamental energy balance equation as

$$\delta_t x_t = r_t + q_t - b_t, \qquad t \geq 0 \tag{1}$$

where δ_t is a factor between 0 and 1, and represents the efficiency of energy metabolism at time t.

I observe that b_t may be a positive or a negative quantity. If positive, b_t represents "borrowing" from the body. If negative, b_t represents an addition to the body, in some storage form. There are limits, of course, on the amount of *net* borrowing that the human body will tolerate. I postpone a discussion of these issues for the moment.

The individual has an initial body mass (m_0). Body mass will evolve in the model, and influence a number of its basic parameters in ways that I describe below.

The intake sequence $\{x_t\}$ presumably comes from some economic environment which we shall presently consider in some detail. In this section, I will regard the intake sequence as exogenously given and turn to an examination of the other components of the energy balance equation.

2.1. **Basal metabolic rate.** Consider, first, the term r_t in equation (1), which we have defined to be the *basal metabolic rate*. BMR is essentially the energy required (under fasting conditions) to maintain body temperature, to sustain heart and respiratory action, to supply the minimum energy requirement of resting tissues, and to support ionic gradients across cell membranes. The BMR represents a large fraction of energy expenditure by the body.[3] There are, of course, a number of factors that influence the BMR in a particular individual. Leaving aside genetic differences, the most important is certainly body mass. From (1), furthermore, it should be clear that the body mass of an individual depends, in turn, on the *intake history* of that individual. In particular, *ceteris paribus*, a history of low intake leads to lower body mass and consequently a lower BMR.

This adaptive feature of the human body has been well-documented, and Partha Dasgupta and I have surveyed the evidence and its normative implications elsewhere.[4] I am not, however, concerned with the normative features of such adaptation in this paper, though there are serious issues of poverty measurement that emerge from these and other adaptive features. These issues are complex and have generated much controversy.[5] The controversy does not arise so much from doubts regarding the *existence* of adaptive mechanisms, but their social and ethical implications. My task here is simpler. I shall focus on the implications such mechanisms have for market behaviour. Fortunately (for my task), ethics play no role in the marketplace.

---

[2] I discuss this concept in some detail below.

[3] The figure given by the FAO [1973] for the BMR is approximately 1,700 Kcal per day for its reference man, though this is perhaps an overstatement for the Indian case.

[4] See Dasgupta and Ray [1990], the companion piece by Osmani [1990], and the references therein. The classic experiment by Keys and his colleagues (see Keys *et al.* [1950] and Taylor and Keys [1950]) is a basic starting point. See also Young and Scrimshaw [1971] and Edmundson [1977, 1979].

[5] See Sukhatme [1978, 1981a, 1981b, 1982], Seckler [1982, 1984], Dandekar [1981, 1982], Gopalan [1983], Dasgupta and Ray [1990], Osmani [1990], and the numerous other references cited in the last two papers.

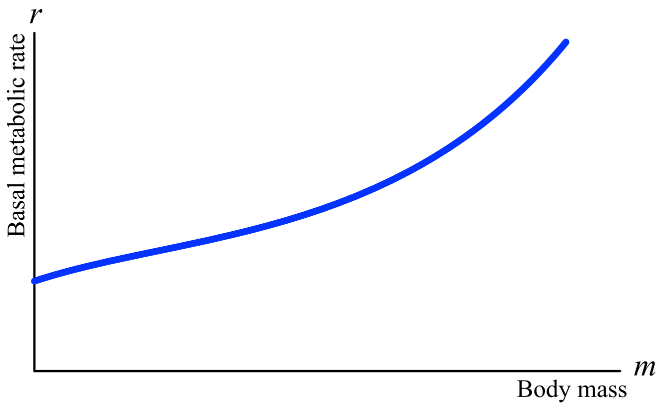

DIAGRAM 1. Adaptation in BMR.

I postulate, therefore, that the BMR at time t is an increasing function of the body mass of the individual at that time:

$$r_t \equiv r(m_t) \tag{2}$$

Diagram 1 depicts a typical function for BMR adaptation.

I make two remarks about (2). First, the functional *form* $r(.)$ depends on the genotype of the individual, an explicit consideration of which I have suppressed in the equations.[6] Second, the BMR may possess adaptive features which depends on individual history in ways that are more complicated than the simple consideration of body mass can capture (see the discussion in Dasgupta and Ray [1990, section 7.3 (a)]). But there appears to be little doubt that body mass is the critical feature, and I focus on this. In any case, my observations will be robust to the introduction of such complications.

2.2. **Physical activity.** I turn next to the energy requirement for physical activity (q). For our purposes, it will be useful to imagine the individual as a participant in productive economic activity, involving *physical* effort. Such effort requires the expenditure of energy. The FAO's 1973 estimate, applied to their reference man, prescribed 400 Kcal per day for "moderate activity". Unfortunately, as Clark and Haswell [1970, p.11] have pointed out, the FAO reference man "appears to be a European weighing 65 kg. and who spends most of his day in a manner rather ambiguously defined, but not apparently working very hard". For the poor in less-developed countries, subject to hard labour of the most strenuous kind, this may be a somewhat conservative estimate.[7] I take some figures at random from the interesting and informative study by Clark and Haswell, to illustrate this point. For some West African agricultural

[6] In particular, (2) does *not* assert that two genetically different individuals with the same body mass will have the same BMR. But I see no value in cluttering the discussion with an inclusion of factors that are absolutely exogenous to the entire analysis.

[7] Indeed, there is every indication that through the 60s and 70s, the FAO *overstimated* the basic requirements (BMR, etc.), while simultaneously *underestimating* the energy requirements for work. While these appear to be self-correcting errors for the purpose of measurement, they have quite distinct implications for market participation, as we shall soon see.

activities, computed in the standard way from the rate of oxygen consumption while engaged in such activities, Phillips [1954] estimates 213 Kcal/hr for carrying a log of 20kg, to 274 Kcal/hr for hoeing, to 372 Kcal/hr for bush clearing, and up to 502 Kcal/hr for tree felling. Of course, these are activities that cannot be performed continuously, but the European reference man with his allotment of calories for physical activity might be hard pressed to carry out any of these at minimal levels. For continuous labour, Banerjea *et al.* (1959) report that men in a South Indian textile mill (average weight 47 kg.) consumed energy at the rate of 203 Kcal/hr, averaged over an eight hour shift. For more information, see Clark and Haswell [1970].

The point is clear enough but needs to be emphasized. The labour of the poor is often physical labour, and physical labour requires significant amounts of energy. I now list the main factors determining this energy requirement.

First, there is, of course, the *kind* of physical activity. For my purpose, it will be enough to consider one type of abstract physical activity, to be referred to as (manual or physical) labour. I should point out, though, that once the entire analytical framework is explained, there are extensions possible, and one of them concerns the market division of activity types among individuals with differing nutritional levels. For the present, I ignore these finer points.

Next, one must consider the *level* or intensity (l) at which the individual is engaged in labour. It will be important to carry this variable explicitly in our analysis. Obviously, the higher the level, the greater the energy required. Somewhat less obvious is the assertion that such a relationship must be *convex*, in the sense that fixed increases in the required level of the activity demand higher and higher increments in energy consumption. In a general sense, this statement is intuitive. After all, as the individual nears his maximal work capacity, increases in activity levels call forth (by definition) prohibitively large increments in energy. But experimental work is required to estimate the energy-labour relation over larger ranges. This issue is of some economic significance, as we shall see.

Third, one must consider possible adaptive mechanisms that may be present in the energy-labour relation. To the best of my knowledge, such mechanisms appear to affect the energy-labour relationship in a complicated way. There is some evidence (see Edmundson [1979] and other references in Dasgupta and Ray [1990]) that at intermediate levels of activity, a history of low intake *increases* the efficiency of energy metabolism. Certainly, to the extent that such a history is associated with lower body mass, there is a tendency to expend less energy when engaged in moderate levels of physical activity.[8] On the other hand, the evidence is fairly strong that the upper bound to physical activity, or *maximal work capacity*, unambiguously falls (see, e.g. Areskog *et al.* [1969], Desai *et al.* [1984] and Dutra de Oliveira *et al.* [1985]).

With the observations made so far, it is not difficult to reconcile these seemingly contradictory findings.

Diagram 2a depicts what I call the *capacity constraint*. This diagram essentially plots a combination of (1), together with a direct consideration of activity levels, artificially suppressing the borrowing term to

[8] Hansson, Lindholm and Birath [1966] note that in logging, the rate of calorie consumption per minute is 16.5 for Swedish and 9.8–11.7 for Indian loggers. My source for this information, Clark and Haswell [1970], notes that these outputs are almost exactly proportional to relative body weights. However, there is a logical distinction to be drawn between reduced energy needs arising from a fall in the BMR, and reductions arising from a genuine efficiency increase in the energy-labour relation as I have defined it. See my discussion following Diagram 2.

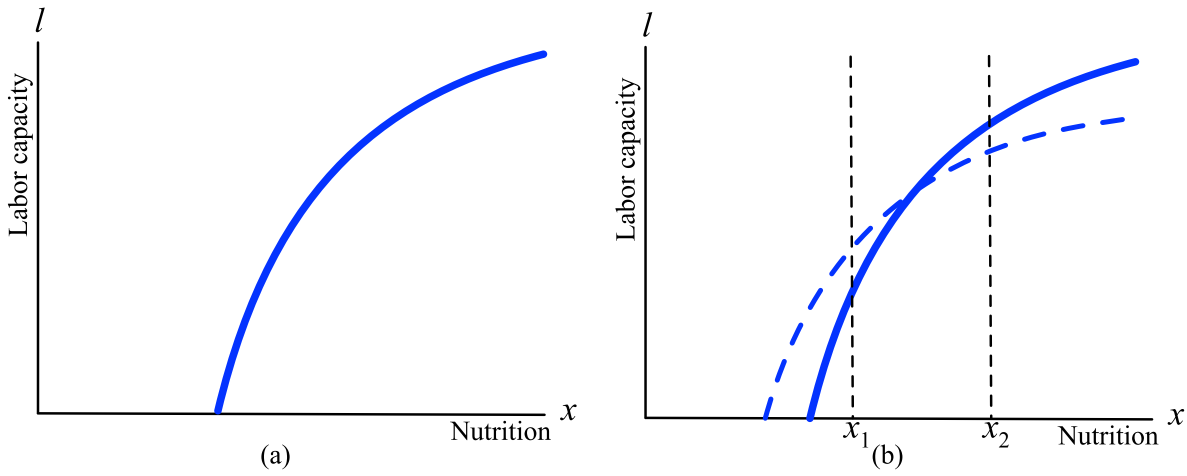

DIAGRAM 2. The Capacity Constraint.

be zero. Think of it as a "short-term" relationship between the intake of nutrition and labour capacity. Diagram 2b superimposes two such curves, the dashed curve denoting the capacity constraint of the same individual but at a lower intake history relative to the solid line. Observe that at nutrition levels such as x_1, the low-intake history actually generates a higher ratio of labour to energy. This comes from two features. The first we have already noted: BMR falls, reducing the intercept on the horizontal axis. A second possibility is that the energy-labour relation *itself* becomes steeper at low activity levels, reinforcing the first factor. However, as the activity level is increased, the studies cited suggest that the efficiency gain is ultimately swamped by a reduction in maximal work capacity (see nutrition levels such as x_2. So the dashed capacity constraint crosses the solid version "from above".

For later reference, I include these features in the algebraic model. I postulate an energy-labour relationship as follows: The activity level, or labour output (l), may be written as a function

$$l = \lambda(q, m) \tag{3}$$

where q and m, it will be recalled, represent the energy devoted to the activity and the body mass respectively.[9] For *given* body mass, l is increasing and concave in q (in line with our discussion), while a reduction in m "twists" this relation, certainly lowering l for high levels of q, and possibly raising it for low levels of q.[10]

2.3. **Borrowing and storage.** The borrowing term b_t in (1) determines the time path of body mass. If there is borrowing at some date, body mass falls. On the other hand, if there is storage ($b_t < 0$), body mass tends to rise. We summarize this by noting that body masses at two adjacent dates and borrowing are connected by the relation

$$b_t = b(m_t, m_{t-1}) \tag{4}$$

---

[9] Here too, the intake history may affect the energy-labour relation in ways that are more complex than are captured by body mass. But this simple specification will suffice for the exposition, and extensions may be accomodated.

[10] More formally, I take it that $\lambda(q, m)$ is differentiable, with $\lambda(0, m) = 0$, $\lambda_q(q, m) \geq 0$ and $\lambda_{qq}(q, m) < 0$, and with $\lambda_m(q, m) > 0$ for all q less than some $\hat{q}$, the opposite inequality holding when $q > \hat{q}$.

which embodies the properties discussed above. In particular, I note that when $m_t = m_{t-1}$, $b(m_t, m_{t-1}) = 0$,[11] and that b_t is decreasing in m_t and increasing in m_{t-1}. Observe that the functional *form* depends on the individual's genotype, specifically, in the form in which energy is stored.[12] For our purposes, it is more important to know that storage and borrowing are *not* symmetric activities: in general, storage costs more energy than those very stores release (see Heim [1985]). Dasgupta and Ray [1990:228–230] consider some implications of this asymmetry.

2.4. **Efficiency of energy metabolism.** I comment briefly on the the term that remains in (1): the factor δ representing the efficiency of energy metabolism. The main component here comes from the increased metabolic rate resulting from the ingestion of food, or what is known as diet-induced thermogenesis (DIT). It has been suggested (see Rand, Scrimshaw and Young [1985]) that DIT mechanisms might have a significant adaptive role to play, but to my knowledge, this issue remains controversial. While my analysis is capable of including simple adaptive responses in δ, I will invoke a mixed excuse (ignorance of the subject and expositional ease in the present discussion) and normalize δ to equal 1 for the remainder of the paper.

2.5. **Breakdown.** We now have at hand almost all the ingredients that are needed for the discussion to follow. A critical feature still remains, however: we must "close" the system by specifying what happens when body mass reaches very low levels for a given genotype. The most tractable (and certainly not unrealistic) scenario is catastrophic breakdown at low values of body mass. At the current state of knowledge, such breakdowns are best modelled in a probabilistic way, for we are nowhere close to specifying exact threshold levels for each conceivable genotype. By the notion of breakdown, I have in mind any physiological change (including serious illness or death) that fundamentally impairs the capacity of the body to carry out productive labour.

There is, of course, little doubt that the probability of breakdown depends in a complicated way on the nutritional history of the individual, as well as many other factors unconnected with nutrition. For my purpose, however, these other factors, while important, are exogenous to the analysis and nothing is gained by including them. On the other hand, I will simplify matters a great deal by using body mass as a rich enough proxy for nutritional history, and postulate that the probability of breakdown at any date depends on the body mass at that date. Accordingly, I specify my final (nutritional) equation:

$$p_t = p(m_t) \tag{5}$$

where p_t represents the probability of breakdown at time t. Clearly, we must think of $p(.)$ as a decreasing function in body mass, approaching a value of unity for very low mass and decreasing to some baseline or "healthy" value for larger values of m_t (see Diagram 3).[13]

---

[11] When body mass is held constant, there is no net storage or borrowing apart from that required to maintain the body. But this is already accounted for in the specification of BMR.

[12] Energy may be stored in the form of fat or protein, and the "metabolic fatness" or "leanness" of individuals may depend on their genetic predispositions towards one or the other form of storage (see, e.g. Dugdale and Payne [1977]).

[13] Of course, *excessive* body mass wil also increase the probability of breakdown! But for obvious reasons, we need not consider that case here.

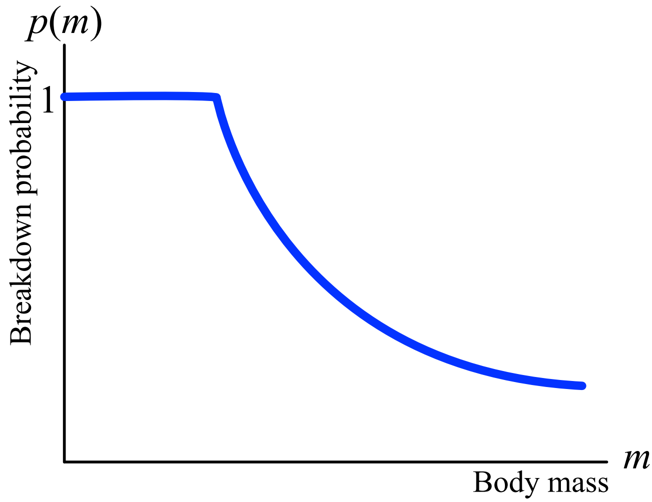

DIAGRAM 3. A Typical Breakdown Function.

2.6. **Summary.** I summarize the discussion in this section.

The energy balance equation for a given individual has two major components: intake and expenditure. I regard the intake sequence as exogenous to the nutritional model (but not to the economic model, to follow). Expenditure has three major subcategories.

First, there is the energy devoted to basic metabolism (BMR). BMR varies, of course, with genetic characteristics, a feature regarding which we have little to say. More important, BMR varies with the nutritional history of the individual. This is captured here in a simplified way, by postulating that BMR depends positively on body mass, and recognizing that body mass is influenced by history.

Next, there is the energy devoted to physical activity. I introduce the energy-labour relation, and recognize that this relation, like BMR, may also be influenced by nutritional history.

Finally, there are the storage and borrowing functions. The body may release energy from its stores of fat and protein. Conversely, excess intakes may be stored in the body. These functions determine the time path of body mass, and in this manner generate feedback effects on the way in which the body uses energy in later time periods.

The energy balance relation, as I have described it, does not represent a closed system. In particular, one needs to accomodate the fact that at low levels of body mass there is an increasingly large probability of bodily breakdown, defined as any occurence (including death) which fundamentally impairs the capacity of the body to perform physical labour. I include this feature at the end of the discussion.

I now turn to an integration of the nutritional structure with economic considerations.

3. Nutrition and the labour market

Beginning with the observations of some Fabian socialists[14] that employers would be better off adequately feeding their workers, economists have been aware of a causal link running from the general well-being of individuals to their performance on labour markets. The seminal paper of Harvey Leibenstein [1957] showed that such links could lead to *involuntary* unemployment in a market economy, and since then there has been an explosion of literature on "efficiency wage" theory. This literature has based itself on nutritional considerations (see, e.g. Bliss and Stern [1978a,b],[15] Mirrlees [1976], and Stiglitz [1976]) as well as other effects of wages on labour productivity (see, for example, Weiss [1990] and the collection of essays edited by Akerlof and Yellen [1986]). This literature has, in turn, combined with general equilibrium theory to provide a number of insights into macroeconomic aspects (see Foster and Wan [1984], Shapiro and Stiglitz [1984], Dasgupta and Ray [1986, 1987], Baland and Ray [1991] and Ray and Streufert [1990]). I will not go into a detailed description of this literature. Instead, I wish to consider a related issue in some detail. This has to do with the nutritional status of workers and the degree of "casualness" of the labour markets in which they function.

At one level, there is an obvious connection between the two. One feels that a "more casual" labour market will have more undernourished workers. While this proposition is certainly obtained within our framework, I hope in the process to expose explicitly the underlying premises on which such an intuition is based. We will see that the notion of casualness that is commonly employed in the literature is *not* the appropriate one that generates this prediction. In Section , I will consider such notions in detail. I therefore use the concept of *flexible employment*, which, I shall argue, is the relevant explanatory variable for empirical work. Secondly, I wish to consider the effect that adaptive mechanisms have on the nutritional status of workers, via their interaction with the labour market. To my knowledge, this issue has not been considered before (though in Dasgupta and Ray [1990, Section 7.4] there are some initial steps taken towards the development of such a theory).

A typical study on the subject (Bromley and Gerry [1978]) defines casual work as "any way of making a living that lacks a moderate degree of security of income and employment". This is a good definition for a concept that derives its driving force from a partition of workers into those that enjoy stable employment and those that face continual risk. This partition is useful, and indeed in many cases of great social importance.[16] But I shall presently argue that it is not the appropriate definition for our purpose.

I propose, instead, the concept of a *flexible labour market*. This is a market where employees can be replaced by the employer at little or no cost to the latter. I note that a casual labour market is likely to be a flexible labour market, but the converse is *not* true. I shall return to this distinction in Section 4.3. In this section, my objective is to study the interaction between the nutritional model of Section 2 and labour markets possessing various degrees of flexibility.

---

[14]Beatrice and Sidney Webb emphasized the positive effects of high wages on productivity.

[15]Bliss and Stern [1978b] represents a particularly valuable contribution. To my knowledge, it is the first serious attempt to deeply study nutritional issues with a view to analyzing the economic implications.

[16]Of the many interesting studies that exist, I cannot resist referring the reader to a fascinating account of casual employment in the longshore industry (Morewedge [1970]), which discusses the basic macroeconomic implications of casual labour with a great deal of clarity.

The concept of flexibility introduced above will be considered jointly with the degree of *tightness* in the labour market. The latter has to do with the value of the *alternative* opportunities available to a labourer when facing a particular employer. In an economy with widespread unemployment, labour is in surplus and the degree of tightness is low. I will begin by considering such labour markets, and examine the effects of varying degrees of flexiblity.

To this end, consider an employer who needs to hire a quantity L of labour.[17] She faces a pool of labour, and I shall assume that *she is cognizant of the nutritional mechanisms that I have described in Section 2*. Be patient with this seemingly absurd assumption: I shall return to a discussion of it in Section 4.1.

The employer must choose the number of labourers, the wage she pays to each of them, and set the level of physical activity for each labourer. To some extent, these stipulations are constrained by the degree of tightness of the labour market. As stated above, I assume for the present that the economy exhibits surplus labour, so that these alternative opportunities do not constrain the decisions of the employer.

There are various configurations of choices that permit the employer to obtain a total labour supply of L. Her objective is to pick the configuration that minimizes the cost of doing so.

I conceive of the labour market as being composed of a large number of such employers. The issue at hand is: what implications does such labour market behaviour have for the nutritional status of workers, and how is this status affected by the various parameters of the system, such as the adaptive ability of the human body?

Imagine that the current population is composed of a large number of identical individuals, who have some "baseline" body mass $\hat{m}$.[18] Their interaction with the labour market leads to a *new* body mass m^* in the current contractual period, in a way that I shall now describe.

Consider the representative employer. Suppose that she prescribes a work intensity of l for each of her employees. This intensity is compatible with certain combinations of energy devoted to physical activity (q) and body mass (m) during the contractual period. These combinations are given by the energy-labour relation (3), reproduced here:

$$l = \lambda(q, m). \tag{6}$$

Suppose that she pays a wage (w) to each of her employees. Measure this wage in units equal to the amount of energy intake the wage can buy, and assume that all wages are consumed as food.[19] Then from (1), this leads to *another* set of possible (q, m) pairs:

$$w = r(m) + q - b(m, \hat{m}). \tag{7}$$

Combining (6) and (7), we see that the decision to pay a wage w and extract work effort l leads to a determinate result for q and m:

$$l = \lambda(w - r(m) + b(m, \hat{m}), m). \tag{8}$$

---

[17] This is labour *power* in efficiency units and not the number of labourers, as we shall soon see.

[18] My assumption that all individuals are identical is only made to simplify the analysis. There is no change in the results if one were to redo the same exercise by postulating a statistical distribution of body masses in the economy. Heterogeneity of employers may also be accomodated at no cost. My goal here is to achieve some expository clarity, and this is not compatible with a fully general model.

[19] In the present context, this is a harmless assumption. But I return to this point later (Section).

If m is the body mass during the contractual period, and if n is the total number of workers hired, then, using the breakdown function (5), we see that approximately $p(m)n$ workers will have to be replaced at the end of the contractual period. In general, replacement is costly to the employer, and the magnitude of this cost is my measure of the degree of flexibility of the market. Denote the unit cost of replacement (per labourer) by c. So the *total cost* to the employer is

$$C \equiv cp(m)n + wn. \tag{9}$$

Of course, n and l are related by the constraint that nl must equal the labour requirement L. Combining this with (8) and substituting in (9), we arrive at the basic expression of interest for total cost:

$$C = \frac{[cp(m) + w]L}{\lambda(w - r(m) + b(m, \hat{m}), m)}. \tag{10}$$

The problem faced by our employer may now be stated in the following equivalent form:

"Choose (m, w) to minimize the expression in (10)."

I note in passing that the employer does not really "choose" body mass! It is just that the act of setting wages, choosing work intensities and deciding on the size of the labour force is operationally *equivalent* to the statement above.

I now write down a system of equations describing the solution to this problem.[20] Such a system is not of interest *per se*. But the conditions they represent have reasonably simple interpretations, and what is more important, these equations are the key to our understanding how the labour market reacts to various changes in the parameters of the model.

Denoting by star superscripts the solution values, and derivatives by primes or by the appropriate subscripts on functions, we have the first-order conditions

$$\lambda(q^*, m^*) = [cp(m^*) + w^*]\lambda_q(q^*, m^*) \tag{11}$$

and

$$-cp'(m^*) = r'(m^*) - b_m(m^*, \hat{m}) - \frac{\lambda_m(q^*, m^*)}{\lambda_q(q^*, m^*)}. \tag{12}$$

Along with the equation

$$w^* = r(m^*) + q^* - b(m^*, \hat{m}), \tag{13}$$

these conditions solve for the cost-minimizing values of w^*, q^* and m^*, and then yield the other values — l^* and n^* — in the obvious way.

The expressions (11) and (12) look technical but have simple interpretations. The condition (11) describes the cost-minimizing level of the wage rate, as labour intensities are adjusted to hold body mass constant at the level m^*. In an approximate sense, this value can be interpreted as being chosen to minimize the ratio of energy intake to labour output, and readers familiar with the literature cited at the

[20] Under the assumptions of Section 2 and the shapes of the typical functions illustrated there, these first-order conditions are necessary and sufficient for a solution. I omit the technical details.

beginning of this section will see that (11) is a complicated analogue of the standard "efficiency wage" condition. The condition (12) describes how the employer chooses between combinations of labour intensity and body mass, holding the wage rate fixed at w^*. The tendency to make workers work as hard as possible is tempered by the increased probability of breakdown (and therefore a higher replacement cost). The balance between these two forces is captured by (12).[21]

The system is closed at the macroeconomic level by observing that in the long-run, there will be a tendency for the baseline body weight $\hat{m}$ to come into equality with the cost-minimizing body weight m^*. The idea is simple: if $\hat{m}$ exceeds m^*, then over time we would expect the average body weight in the economy to *fall* in the direction of m^*. On the other hand, if $m^* > \hat{m}$, then over time body weights will rise. The system is in macroeconomic equilibrium when

$$\hat{m} = m^*, \tag{14}$$

and (14), along with (11)–(13), completely describes the labour market and nutritional characteristics of the system.

3.1. **Labour market flexibility and nutritional status.** The usefulness of conditions (11)–(14) is that they permit insight into the effects of various parametric specifications that we might be interested in. In this subsection, I will focus on the degree of flexibility of the labour market, captured by the replacement cost parameter c.

The easiest way to see the effects of changing flexibility is to specialize to the case in which there is no adaptation at all, though by working through the equations it may be checked that allowing for adaptive responses makes no difference to what I am going to say.

I first note, using the macro-equilibrium condition (14) and the fact that $b(m,m) = 0$ for all m, that (13) simplifies to the condition: $w^* = r(m^*) + q^*$. Now I use this and the postulated lack of adaptive mechanisms to obtain the following simplified system from (11)–(13):

$$\frac{\lambda(q^*)}{cp(m^*) + r + q^*} = \lambda'(q^*) \tag{15}$$

$$cp'(m^*) = b_m(m^*, m^*). \tag{16}$$

Consider the term $b_m(m^*, m^*)$ on the RHS of (16). What does it mean? It is the amount of energy released from the body when one unit of energy stores is depleted, evaluated at some point where body masses are time invariant. This is a *negative* ratio — call it α — which is presumably largely independent of the body mass at which it is being evaluated.[22] Consequently, we obtain the basic equation

$$cp'(m^*) = \alpha. \tag{17}$$

[21] Recall that we are describing a situation where labour is in surplus. If, on the other hand, the labour market is tight, an additional constraint may be imposed. I return to this point in Section 4.

[22] Heim[1985] states that to draw down a gram of protein from body stores release 4 Kcal, while a gram of fat releases 9 Kcal. The assumption, that these ratios are largely independent of the body mass, is only made to simplify the exposition.

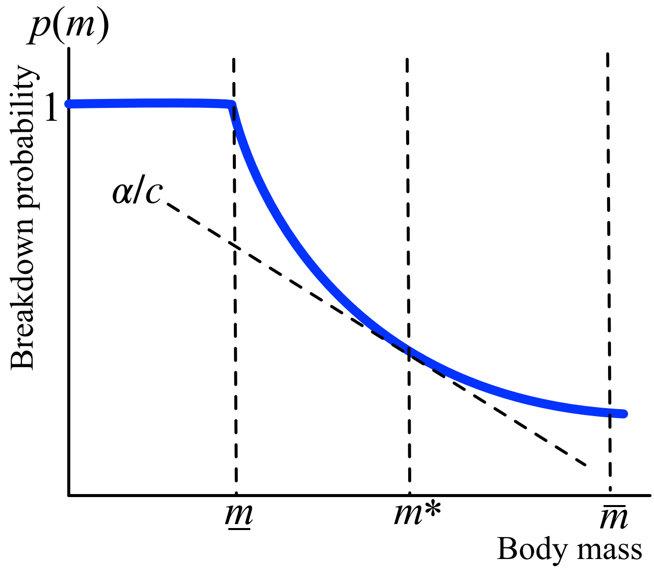

DIAGRAM 4. Determination of Equilibrium Body Mass.

Diagram 4 illustrates how this equation determines equilibrium body mass.

Diagram 4 reproduces a typical breakdown function (see Diagram 3). At low levels of body mass approaching some lower limit $\underline{m}$, the probability of breakdown quickly approaches unity. On the other hand, as body mass approaches some threshold "healthy" value $\bar{m}$, the probability of breakdown settles down to a low minimal value. The equilibrium body mass of the system is given by the point m^* where the slope of the breakdown function equals the ratio of α to the replacement cost c.

It is now easy to see that if the replacement cost falls, then the equilibrium body mass of individuals in the economy must fall too.[23] In other words, the more flexible the labour market, the higher is the incidence of undernutrition likely to be, and the lower will be the level of average body weight of individuals living in that economy.

The effect on labour intensities and wage rates can be seen by studying equation (15). This is done in Diagram 5.

I plot the energy-labour relation in Diagram 5. The slope of the straight line in the diagram is exactly equal to the ratio on the LHS of (15); by (15), this slope must equal that of the energy-labour relation. Diagram 5 does exactly this.

To understand the impact of a lower replacement cost, it is first necessary to examine the effect of a reduction in c on the term $cp(m^*)$. Using the condition (17), it is easy to check that a lower value of c will *raise* $cp(m^*)$ if $p(m^*)p''(m^*) < \alpha^2/c^2$, and will *lower* it if the opposite inequality holds.

[23] The reader might object that this result is due to the assumed curvature of the breakdown function, but this is not the case. The assumed curvature (which, by the way, I also consider to be the relevant shape) is useful for graphical exposition, but the result itself is independent of curvature.

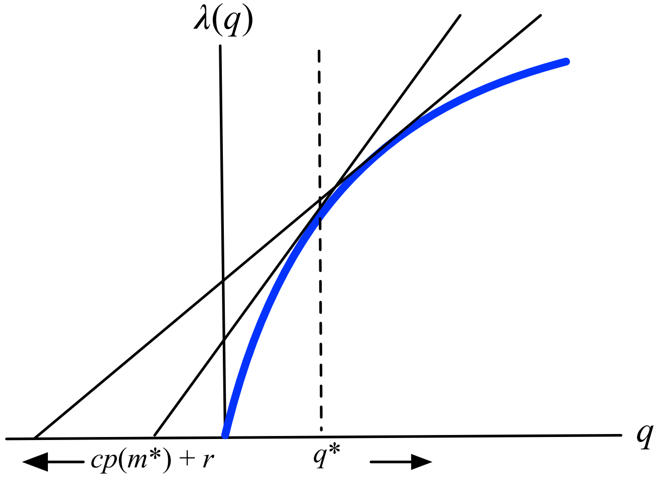

DIAGRAM 5. Flexibility, Wages and Labour Intensities.

A priori, either case is possible. However, in markets that are relatively flexible (c is low), and in which the probability of breakdown is not too high (p is low too), the former situation is more likely to prevail. We discuss this case here, postponing the other scenario to Section 3.2 below.

In the former case, then, $cp(m^*)$ will go *up* as c falls, this effect occuring via the increased probability of breakdown arising from reduced body mass. Returning to Diagram 5, we see that the result of all this is that the "intercept" term in that diagram increases. The new equilibrium must therefore involve a *higher* amount of energy going to physical activity, a higher work output, *and higher* wages!

One might ask: if wages are higher, how is it that body mass has fallen? To see this this, one might imagine a transition from the earlier scenario to the new one. First, replacement costs fall. The population is still at the old, higher body mass. It can be verified that in such a situation, wages will fall abruptly, while work intensity is increased simultaneously. This will lead to a progressive reduction in nutritional standards. Along this path, wages start to rise once again, to compensate for the deteriorating nutritional endowment, but (it can be checked that) the rise never fully compensates for the fall in body mass (work requirements continue to be high). In the "new equilibrium", body mass has permanently settled at the lower level, and wages in this final state must be higher to compensate for the higher energy devoted to work.

Flexible labour markets cannot see into the future. This very blindness creates ruthless exploitation. While workers may be paid more, the intensity of work more than accounts for this. Their nutritional status, measured by body mass, has unambiguously worsened. Indeed, the total demand for labourers might also fall, creating even more unemployment.[24]

Somewhat subtler is the observation that these changes can also adversely affect *employers* in the longer run. Their very own actions lead to a situation where the quality of the labour force is adversely affected.

---

[24] This, in fact, *will* happen in the present model, but I do not emphasize this point because I am taking total labour demand to be fixed.

The observation that nutritional status worsens is robust to the consideration of adaptive mechanisms in the body. However, whether wages rise or fall is no longer so clear, as we shall see in the next subsection. The introduction of adaptation, supposedly a beneficial characteristic that ameliorates one's condition of malnutrition, actually opens up a hornet's nest of perverse consequences. To these I now turn.

3.2. **Adaptive mechanisms and nutritional status.** The issue of possible adaptation to low nutritional intakes is an important one. As I have observed in Section 2, the discussion in this area has revolved around the *normative* implications of adaptation, in particular, its significance for the measurement of poverty. In this paper, I do not consider such issues, though I pause to take note of a related point. It has been argued (see, e.g. Seckler [1982, 1984]) that adaptation has certain salubrious consequences for the human body, permitting it to face a harsh nutritional environment with a greater degree of resilience. While the extent to which adaptation is costless is *far* from clear, there is no doubt that *given the environment*, it is better to possess adaptive mechanisms than not. There is no great mystery here. What I wish to point out is that the consequences of dropping the emphasized phrase in the previous sentence have been left completely unexplored. Especially in the case where nutrition comes from the workings of an *economic* environment, it is imperative to study the "reaction" of such an environment to these adaptive mechanisms, and *then* to return to the impact of such a reaction on the well-being of the individual. As I shall argue, the implications may be dramatically different.

I first analyze the case where there is adaptation in the BMR. To focus clearly on this case, I shall assume that the energy-labour relation is not adaptive (so that l depends on q alone). I have already noted that adaptation in the BMR (to a low body mass) is significant, if for no other reason than the fact that lower amounts of energy are needed to maintain the body at a lower body mass. What I will do is *parametrize* the degree of adaptation in some way, and then examine the implications as the degree of adaptation is exogenously changed. the easiest way to do this is to suppose that the function $r(m)$ takes the following linear form

$$r(m) = r_0 + \theta m \tag{18}$$

where r_0 represents some minimal level of (genotype-dependent) BMR, and θ is the degree of adaptation. For instance, the case $\theta = 0$ represents a situation where there is no adaptation at all in BMR.

Just as in Section 2.1, I now proceed to simplify (11)–(14). We obtain the following system, with the aid of (18):

$$\frac{\lambda(q^*)}{cp(m^*) + r_0 + \theta m^* + q^*} = \lambda'(q^*) \tag{19}$$

$$cp'(m^*) = \alpha - \theta. \tag{20}$$

I now wish to examine the effect of an increase in adaptibility. One way to do this to to simply raise the value of θ and see what happens. However, this approach is conceptually flawed because an increase in θ for *fixed* r_0 is *also* tantamount to raising the BMR. To separate these two different effects and only study the effect of adaptation, it is necessary to "swivel" the BMR function around, making it steeper but causing it to pass through the same level of BMR as before. Formally, we consider a new BMR function $r = r_0' + \theta' m$, such that evaluated at the initial solution, the two BMR levels are the same; i.e.,

$r_0' + \theta' m^* = r_0 + \theta m^*$. Now we ask: what is the new solution like, once adaptation rates increase from θ to θ'?

To study this, return to Diagram 4. Note from (20) that that slope of the breakdown function equals $\alpha - \theta$. Because $\alpha < 0$, the *absolute value* of this slope must *increase* as adaptation increases. From Diagram 4, it is now clear that equilibrium body mass must *fall*, showing that the presence of adaptation actually worsens nutritional status, once the reactions of the labour market are taken into account.

A little reflection will be sufficient to see the intuitive basis of this result. In a labour-surplus economy, the ability to adapt is simply incorporated into the workings of the market as additional flexibility on the part of the labourers. This incorporation has the effect of transferring the potential benefits of adaptation from the workers to the employers. The market economy is powerful enough to transform the ability to adapt into a commodity, which can be (and is) sold like any other.

I shall now examine the effects on the other variables of interest. Diagram 5 will be useful. The argument is exactly the same as the one I made for increased labour market flexibility. Replace the intercept term in that diagram by the expression $cp(m^*) + r_0 + \theta m^*$ (see (19)). As adaptation is increased, we observe an ambiguity, just as in the earlier analysis. Note, first, that $cp(m^*)$ certainly rises. However, given that by definition, $r_0' + \theta' m^* = r_0 + \theta m^*$, it must be the case that because of reduced body mass, the remaining expression in the intercept must *fall*. If the degree of adaptation is high to begin with, this fall will outweigh the increase in $cp(m^*)$. I consider this case, not because I think it is *a priori* more likely, but because the alternative has exactly the same features as those that I have described due to increased labour market flexibility.[25]

If adaptation in BMR is of a high degree to start with, and there is a further increase in adaptive abilities, the effect of this will be to *lower* the energy going to physical activity (use Diagram 5 with the intercept term reduced). In the new equilibrium, then, physical energy use will be lower, BMR will be lower, and wages are lower too. So comparing with Section 4.1, we see that in these dimensions, a higher degree of adaptation in BMR has effects that differ from those of increased labour market flexibility. However, both these features unambiguously worsen nutritional status.

Finally, I comment on adaptation in the energy-labour relation itself. To do so, I return to the system (11)–(14), but now I isolate this feature by setting adaptation in the BMR equal to zero. Doing this, I obtain:

$$\text{(21)} \qquad \frac{\lambda(q^*, m^*)}{cp(m^*) + r + q^*]} = \lambda_q(q^*, m^*)$$

$$\text{(22)} \qquad cp'(m^*) = \alpha + \frac{\lambda_m(q^*, m^*)}{\lambda_q(q^*, m^*)}.$$

Look at (22). The term $\lambda_m(q^*, m^*)$ signals the extent of adaptation, for it tells us how work output changes at a *fixed* energy level, when body mass is altered. From our discussion in Section 2, it should be clear that this term may be of either sign. If the original equilibrium involves intermediate levels

[25] There is one difference — the effect on wage rates is ambiguous. Work intensities *must* rise, though.

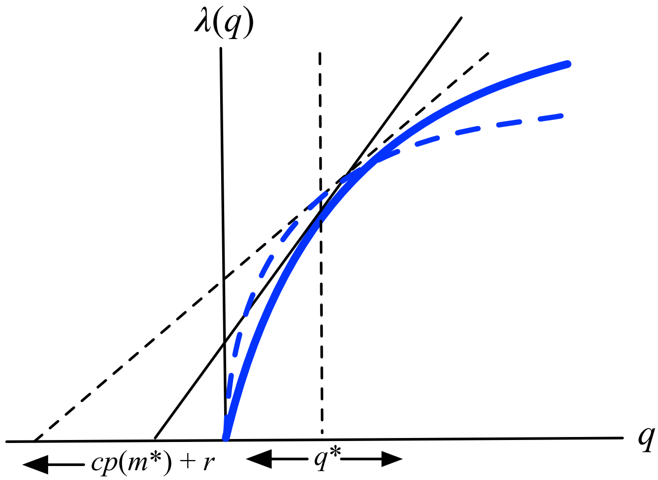

DIAGRAM 6. Increased Adaptation in the Energy-Labour Relation.

of physical activity, $\lambda_m(q^*, m^*) < 0$, signalling "positive" adaptation. On the other hand, if the original equilibrium involves activity levels that are close to the maximal work capacity of the individual, $\lambda_m(q^*, m^*) > 0$, meaning that a reduction in body mass now lowers output. The case of positive adaptation interests us more, so I shall briefly remark on it, leaving the other case to be worked out by the interested reader.

If there is positive adaptation, an increase in adaptive abilitites means that the energy-labour relation swivels "clockwise", with outputs going up around the earlier equilibrium and falling for higher levels of body mass. Diagram 6 makes this a bit more precise.

In terms of (12), this means that the (negative) term $\frac{\lambda_m}{\lambda_q}$ has increased in *absolute* value. Using (12), one can now verify that equilibrium body mass must now fall. Here too, the presence of adaptation is internalized by the labour market in a way that worsens the nutritional status of the individuals active in it.

The effect on wage rates and energy devoted to physical activity are ambiguous, though the two must move in the same direction. In Diagram 6, the intercept term rises owing to the increase in $cp(m^*)$. This effect tends to raise q and therefore w. On the other hand, the increase in the steepness of the energy-labour relation has a tendency to lower q and therefore w.

3.3. **Summary.** I summarize.

My goal has been to explore the interaction between a plausible energy balance equation, fundamental to the human body, and the labour market for physical activity. This interaction is expected to be particularly pronounced in economies where labour is in surplus and wages are low. In such economies, it is a simple but basic truth that the labour market and its workings are the keys to the understanding of nutritional status. Aggregate statistics, such as the overall supply of food in the economy, have little to do with the process, unless we are concerned with those elusive examples of developing economies where food is plentiful enough to be almost free.

While the observation that the labour market is a basic determinant of nutritional status is fairly self-evident, the causal chains that lead to the final outcome require careful analysis. I have tried to show that in a fundamental sense, it is the flexibility of the labour market, defined as the ease of replacing a lost labourer, that is the critical feature. I show that increased flexibility creates a deterioration in the nutritional status of the workforce, where this status is measured by body mass (for a *fixed* genotype. Somewhat surprisingly, this deterioration may be accompanied by a situation where food intakes are higher and people are made to work harder. This apparent paradox is resolved by noting that in the transition to a more flexible labour market, food intakes will fall before rising, creating the deterioration. The higher steady-state intakes cannot reverse this trend, the difference being taken away for physical activity.

If one extends the analysis to include adaptive mechanisms in the body, the consequences are even more severe. With adaptation, the market reacts in a way that lowers equilibrium body mass *even further*. Furthermore, in such cases, one is confronted with the additional possibility of a decrease in wages and energy going into physical effort. These results differ from arguments that stress the positive features of adaptation to a *given* environment by actually endogenizing the reactions of the environment (the labour market) to the presence of adaptation. In a labour-surplus economy, these reactions have the effect of transferring the potential benefits of adaptation from one side of the labour market to the other.

4. Examination of the basic assumptions

The arguments of the previous section rest on some basic assumptions which require closer scrutiny. The discussion in this section has two objectives. First, by examining the postulates of the model I hope to convince the reader that the basic ingredients make good sense. And second, by providing a sharper definition of the environment within which the model works I hope to outline the route which empirical analysis might take in this context.

There are three features I wish to stress. The first is a behavioural postulate: I shall argue that it is sensible to assume that employers are cognizant of links between nutrition and productivity, even though in the labour markets I have described, they exploit these links in a way very different from that predicted by standard efficiency wage theory. The second and third features have to do with characteristics that the labour market must satisy in order for the processes described here to function. I have labelled them *tightness* and *flexibility*.

4.1. **Knowledge of the energy balance equation.**

The preceding section relied on the assumption that employers in poor economies have some knowledge of the energy balance equation and use it to their advantage.[26] How reasonable is this assumption?

From the discussion in the preceding subsections, it should be clear that one must look for evidence in labour markets that are relatively *inflexible*. The evidence can come in two ways:

(1) *Direct:* Employers involved in inflexible labour markets are generally aware of nutrition-labour relationships, and act or are advised to act to exploit such relationships.

[26] I have indeed assumed a precise knowledge of the relationship. But this is not needed for the results at all.

(2) *Indirect:* Employers compensate their employees in ways that suggest that they are aware of such relationships. This has not only to do with the *level* of wages but the *way* in which such wages are paid.

There is a third argument, the empirical relevance of which has been emphasized by Bliss and Stern [1978a,b]. This asserts that whenever there are important links between current wages and future work capacities, "we might expect to observe long-term employment contracts which would enable employers to take advantages of such links. The institution of permanent labour provides for that possibility. Indeed it is one of the implications of the theory that we would expect to see a prevalence of long-term employment contracts or arrangements..." (Bliss and Stern [1978a]). In [1978b], they go on to observe that the incidence of permanent labour contracts "does seem very much less than would be predicted by the theory, for many parts of India...". My analysis, however, suggests that once the theory is propoerly reformulated to accomodate its fundamentally dynamic features, this is *not* an implication.

Consider a flexible labour market, where employers pay low wages, demand high effort levels, and where the "breakdown rate" of employees is high. Suppose that employers are perfectly aware of the energy balance equation described in Section 2. Even so, why would they ever want to set up a long-term contract with their employees on the grounds of the nutrition-labour relation *alone*? If labour is surplus and replaceable at little cost, then, indeed, the short-term strategy is the preferred one. Inded, insofar as adaptive mechanisms are important, there is even less of a reason to adopt long-term contracts. For the "efficiency unit payments" to such labourers are even lower!

I am suggesting, in other words, that in a relationship where nutrition is used positively by the employer to build up work capacity on the part of her employee, *there must be a separate factor, or set of factors, which makes the relationship an inflexible one, in the sense that the employee is costly to replace*. Nutritional factors in and of themselves will not create such relationships. In particular, the absence of permanent labour cannot be viewed as a rejection of the theory, nor as an indicator that the employer is unaware of the links between nutrition and productivity. Being aware of such relationships, and yet being unwilling to do anything about it are two attitudes that can coexist only too well in a flexible labour market.

So the true test of such awareness must lie in markets where such knowledge can be profitably transformed into action. These are the inflexible markets (see below, Section 4.3). I consider three examples very briefly.

(1) **The slave economy**: Slavery is perhaps the best example of an inflexible market with high replacement costs. Slaves had to be bought, and therefore each act of replacement brought with it a large outlay, apart from the daily costs involved in keeping slaves. Indeed, in the American South, slave prices rose steeply in the decades before the Civil War (Fogel and Engerman [1974: 94–102]). It turns out that slave diets were plentiful and varied.[27] The diet actually exceeded U.S. 1964 levels of recommended daily allowances for all the chief nutrients. Perhaps more to the point, the calorific value of the average slave diet exceeded that of all "free men" in 1879 by more than 10/the health of slaves was

[27] Fogel and Engerman [1974: 111] point out that among the "plantation products that slaves consumed were beef, mutton, chickens, milk, turnips, peas, squashes, sweet potatoes, apples, plums, oranges, pumpkins and peaches', in addition to corn and pork.

repeatedly emphasized in overseer manuals as a central objective (Fogel and Engerman [1974:117]). These observations speak for themselves, and no comment is necessary.

(2) **Industry:** The effect of adequate nutrition on the productivity of workers has been repeatedly emphasized in manuals. The monograph by Keyter [1962], for example, contains many such references,[28] and a closing section with fifty four recipes. This book focusses on industrial feeding, and in so doing squarely addresses the obvious reasons for feeding in the workplace: by changing the composition of wages in this manner, it forces the worker to consume a greater proportion of his wage as food.[29]

(3) **Domestic servants:** This is another good example of a labour market that is likely to be inflexible. Servants are associated with characteristics acquired on the job that make them hard to replace. Not only is the loss of a servant an important one, the acquisition of a new servant with minimally acceptable characteristics is often an arduous process. I would be interested in seeing studies of this market in the Indian context; casual empiricism tells me that they would prove quite supportive to my thesis.[30] I refer the reader, instead, to an excellent monograph on the subject by McBride [1976], which cites various housekeeping manuals written for English and French housewives in the nineteenth century. While the diet of servants was found by her to be generally parsimonious (relative to that of master and mistress), more than one manual explicitly suggests means to assure servants a high level of energy. For instance, the manual of Madame Pariset (Pariset [1821]) recommends that servants be made to abandon the traditional Parisian practice of *café au lait* in the mornings, substituting instead a breakfast of soup made from the meat left over from the previous night, so that the servant would have enough energy to work until 5 p.m. without stopping. And Booth's study of life among the London labourers (Booth [1903, vol. 8: 219]) concluded that "the quality of food given to domestic servants...is usually very good, and in all but very rare cases greatly superior to that obtainable by members of the working-class families from which servants are drawn".

The examples given above do not in any way represent hard empirical fact, though they are clearly suggestive of the validity of my basic presumption. In the desire to extract a surplus in the marketplace, individuals will use all possible information. Just because the interaction of nutrition and economics is a relatively little-studied area does not make this any less plausible in real life. However, there is much work to be done in this area before one can come to any definite conclusion.

4.2. **Tightness.** A labour market is *tight* if the alternatives to working with any particular employer are relatively plentiful and attractive. Standard supply and demand theory tells us that for a labour market to be tight, there must either be a low supply relative to demand *in that market itself*, or opportunities in *other* labour markets must be attractive. Because I am taking a broad view of productive activity, I

[28] I even recall reading an excellent manual written for British colonists in the Indian context, but the reference does not come to mind!

[29] In this context, see also the study by Rodgers [1975] of some Bihar villages, though in this study the reasons for on-the-job feeding are considerably more ambiguous.

[30] The middle and upper-class Indian households appear to display an extremely high degree of paternalistic concern regarding the nutrition and medical care available to their servants. Such concern seems particularly out of line with the monetary wages paid to servants. While this paternalistic care has been moulded by social custom to appear as genuine caring, there is little doubt regarding the fundamental motives behind such behaviour.

would like to think of there being a single integrated labour market, and so the two factors just listed can be thought of as one: low supply relative to demand.

Now, if the labour market is tight, the chances are high that the employer's cost minimization problem as described in Section 3 is largely irrelevant. The limits to which a worker can be pushed depend not on biological considerations but on the opportunities available to that worker elsewhere in the labour market. If these latter considerations are binding, then the particular links that I have described between the workings of the labour market and the nutritional status of its participants are broken and the theory ceases to have validity. On the other hand, to the extent that the labour market is in surplus, the limits to employment contracts will be determined by the factors that I have outlined. At any rate, that is what the theory has to say.

The tightness of labour markets is an issue that can only be settled by detailed and careful empirical work. In the Indian case, one's attention turns naturally to the *rural* labour market, where the majority of the labour force participates. There seems to be little doubt that such markets are characterized by large and persistent levels of unemployment, at least for significant fractions of the year. The evidence comes from a number of sources. For example, Krishnamurty [1988] observes from NSS data that rural unemployment rates were high *and* increasing in the 70s, though there was significant inter-state variation. Visaria [1981] and Sundaram and Tendulkar [1988] observe, moreover, that for agricultural households that are primarily engaged in the rural labour market, these rates are very high indeed. Mukherjee's thesis [1991] contains a careful review of the relevant literature, and in addition carries out a detailed study of Palanpur village, which reinforces the above findings. High unemployment appears to be such an accepted feature for researchers studing the Indian case that theoretical analysis of labour markets is often driven by the objective of explaining and understanding this one crucial feature. The excellent survey by Drèze and Mukherjee [1989] of theories of rural labour markets illustrates this point well.[31]

I (tentatively) assert, therefore, that the arguments outlined above may have some validity in the Indian case. To test such a hypothesis, it is important to obtain a cross-section of labour markets with varying degrees of flexibility. This necessitates further discussion of exactly what it is I mean by flexibility.

4.3. **Flexibility.** The distinction I am drawing between a casual labour market and a flexible one is best made by means of an example. I look at a particular agrarian phenomenon: the tying of labour. Mukherjee [1991] surveys the extensive literature on the subject, and I refer the reader to her thesis for details and references. The tying of labour is a common feature in rural India, and appears to occur for two broad reasons. First, tied labour may be assigned special tasks, such as supervision and the carrying-out of tasks that are intrinsically difficult to monitor. Eswaran and Kotwal [1985] provides an analysis of this phenomenon. Second, employers may wish to provide insurance to their employees, and in so doing extract a larger surplus from them. This is the implicit contract argument, which relies on the plausible hypothesis that employers are more risk-averse than their employees. This aspect is studied by Bardhan [1984] and Mukherjee and Ray [1992b]. Tied labourers are associated in a definite way with their employees, so this particular market would *not* be regarded as casual. But is it a flexible

[31] I should note that even in the presence of unemployment, employers may need to keep wages high for reasons that are unconnected with the biological model. In the agrarian context, there may be serious incentive issues involved (see Eswaran and Kotwal [1985]), or it may be that seasonal tightness in the labour market may spill over into the slack season (Mukherjee and Ray [1992a]).

market, in the sense that I have defined? The answer is not clear. In a labour surplus economy, a tied labourer of the second type can be *costlessly* replaced if necessary.[32] In my classification, such a market is not casual, but it *is* flexible, and I would assert that my theory does apply to this group of labourers. On the other hand, a labourer of type 1 may often have to be paid a higher "loyalty wage" for entirely different reasons, and this may obscure the workings of the nutritional model.

My point is this: if labourers can be costlessly replaced, there is no in-built tendency to pay high wages for nutritional reasons. In particular, a tied labourer of the second type willl receive insurance against income fluctuations, but there is no presumption that he will be better off from a nutritional standpoint.[33] This goes back to my point in Section 4.1, which is that *other* factors making for a certain degree of employee indispensability will have to kick in before nutritional considerations are invoked.

I do not wish to make too much of the distinction between flexibility and casualness, and in any case it is not central to my argument. I only wish to clarify that there a logical distinction to be made between the two concepts, and while it makes sense to think of casual markets as being flexible, the converse may not necessarily be true in some significant cases.

In general, a number of factors can create the base for a non-casual relationship:

(1) *The need to provide incentives when tasks cannot be monitored:* In such situations, employers may wish to use the carrot of a long-term profitable relationship, to be wielded as a stick if the employee is found to default on some obligation (for studies relevant in the agrarian context, see, e.g., Shapiro and Stiglitz [1984], Eswaran and Kotwal [1985], Singh [1983] and Dutta, Ray and Sengupta [1989]).
(2) *Job-specific characteristics or investments:* A good example here is the market for domestic servants, where familiarity and knowledge of the job at hand make it very costly to dispense with an incumbent servant. I will return to this particular market in Section 5.
(3) *High costs of obtaining a new labourer*
(4) *The provision of insurance:* The reader should refer to the implicit contract literature that I have discussed above.

Which of these are relevant in the Indian agrarian context? While a number of rural tasks are non-monitorable (including, perhaps, the act of monitoring itself), it does not appear that such tasks are assigned to the majority or even a large fraction of the labour force. Item (ii), dealing with job-specific characteristics, is also likely to be of minor relevance in agriculture. If one sets aside the basic knowledge of farming that is available to every rural labourer, there is little left that is specific to a *particular* employer. It is unlikely that (ii) can form the basis for a significantly inflexible market. Item (iii) is of some interest in the rural context, particularly in regions of intense seasonal activity. There, the possibly high search costs of labour recruitment in the peak season may create a tendency for inflexibility, and perhaps even for the tying of labour (see, e.g., Bardhan [1983]), but in the face of overall labour surplus this is unlikely to affect the *wages* paid to such labourers (though some smoothening of payments is a probable outcome). Item (iv) is likely to be of great relevance, given the seasonal and uncertain nature

[32]Of course, the replacement will have to be paid too! What I mean is that there is no *additional* cost in the act of replacement.

[33]However, to the extent that the energy costs of a fluctuating food intake may be high (see Dasgupta and Ray [1990]), the tied labourer may be better off.

of agricultural activity, but as I have argued above, the lack of *casualness* that this creates cannot be interpreted as a lack of *flexibility*.

I conclude, then, that there is much room in the Indian case for a serious empirical study of the phenomena I have described.

On the other hand, this very suitability of Indian agriculture for empirical analysis of the theory leaves one with a feeling of dejection regarding the nature and scope of government policy. There is little doubt that widespread undernutrition and poverty is a *distributional* phenomenon, one not generated by scarcity in the aggregate but by the inequalities of economic assets. For governments that work within the domain of the market economy, the question is: how does one influence the functioning of markets in a way that will contribute to their tightness and inflexibility, *without* contributing to the destruction of work incentives that such inflexibility might bring?

References

(1) G. AKERLOF AND J. YELLEN (eds) (1986), *Efficiency wage models of the labor market*, Cambridge: Cambridge University Press.

(2) N. ARESKOG *et al.* (1969), Physical work capacity and nutritional status in Ethiopian male children and young adults, *American Journal of Clinical Nutrition* **22**.

(3) J-M. BALAND AND D. RAY (1991), Why does asset inequality affect unemployment? A study of the demand composition problem, *Journal of Development Economics* **18**.

(4) J. BANERJEA *et al.* (1959), *Indian Journal of Medical Research* **47**, 657.

(5) P. BARDHAN (1983), Labor tying in a poor agrarian economy, *Quarterly Journal of Economics* **98**, 501–514.

(6) P. BARDHAN (1984), *Land, labor and rural poverty: essays in development economics*, Delhi: Oxford University Press/ New York: Columbia University Press.

(7) C. BLISS AND N. STERN (1978a), Productivity, wages and nutrition, Part I: the theory, *Journal of Development Economics* **5**.

(8) C. BLISS AND N. STERN (1978b), Productivity, wages and nutrition, Part II: some observations, *Journal of Development Economics* **5**.

(9) C. BOOTH (1903), *Life and labour of the people in London*, vol. 8, London.

(10) J. BROMLEY AND C. GERRY (eds) (1978), *Casual labor and poverty in third world cities.*

(11) C. CLARK AND M. HASWELL (1970), *The economics of subsistence agriculture.*

(12) V. DANDEKAR (1981), On measurement of poverty, *Economic and Political Weekly* **16**, 25 July.

(13) V. DANDEKAR (1982), On measurement of undernourishment, *Economic and Political Weekly* **17**, 6 February.

(14) P. DASGUPTA AND D. RAY (1986), Inequality as a determinant of malnutrition and unemployment: theory, *Economic Journal* **96**.

(15) P. DASGUPTA AND D. RAY (1987), Inequality as a determinant of malnutrition and unemployment: policy options, *Economic Journal* **97**.

(16) P. DASGUPTA AND D. RAY (1990), Adapting to undernourishment: the biological evidence and its implications, in J. Drèze and A. Sen (eds), *The political economy of hunger*, Clarendon Press, Oxford.

(17) J. DRÈZE AND A. MUKHERJEE (1989), Rural labour markets in India, in S. Chakravarty (ed), *The balance between agriculture and industry in economic development, vol. 3: manpower and transfers*, Macmillan Press, London.

(18) I. DESAI *et al.* (1984), Marginal malnutrition and reduced physical work capacity of migrant adolescent boys in Southern Brazil, *American Journal of Clinical Nutrition* **40**.

(19) J. DRÈZE AND A. SEN (1990), *Hunger and Public Action*, Clarendon Press, Oxford.

(20) A. DUGDALE AND P. PAYNE (1977), Patterns of lean and fat deposition in adults, *Nature* **266**, March.

(21) J. DUTRA DE OLIVEIRA *et al.* (1985), Commentary, in O. Brunser *et al.* (eds), *Clinical Nutrition of the Young Child*, New York: Raven Press.

(22) B. DUTTA, D. RAY AND K. SENGUPTA (1989), Principal-agent theory with eviction, in P. Bardhan (ed), *The economic theory of agrarian institutions*, Clarendon Press, Oxford.

(23) W. EDMUNDSON (1977), Individual variations in work output per unit energy intake in East Java, *Ecology of Food and Nutrition* **6**.

(24) W. EDMUNDSON (1979), Individual variations in basal metabolic rate and mechanical work efficiency in East Java, *Ecology of Food and Nutrition* **8**.

(25) M. ESWARAN AND A. KOTWAL (1985), A theory of two-tiered labour markets in agrarian economies, *American Economic Review* **75**, 162–177.

(26) F.A.O. (1973), *Energy and protein requirements*, Rome.

(27) R. FOGEL AND S. ENGERMAN (1974), *Time on the cross: the economics of American Negro slavery*, Little, Brown and Co., Boston and Toronto.

(28) J. FOSTER AND H. WAN, JR. (1984), Involuntary unemployment as a principal-agent equilibrium, *American Economic Review* **74**, 476–484.

(29) C. GOPALAN (1983), Small is healthy: for the poor not the rich, *Economic and Political Weekly* 18/15.

(30) HANSSON, LINDHOLM AND BIRATH (1966), *Men and tools in Indian logging operations*, Skogshögskolan, Stockholm.

(31) T. HEIM (1985), Energy metabolism: theoretical and practical aspects, in O. Brunser *et al.* (eds), *Clinical nutrition of the young child*, new York: Raven Press.

(32) A. KEYS *et al.* (1950), *The biology of human starvation*, vols. i and ii, Minneapolis: University of Minnesota Press.

(33) C. KEYTER (1962), *Industrial feeding of African workers*, South African Institute of Race Relations.

(34) J. KRISHNAMURTY (1988), Unemployment in India: the broad magnitudes and characteristics, in T. N. Srinivasan and P. Bardhan (eds), *Rural poverty in South Asia*, New York: Columbia University Press.

(35) H. LEIBENSTEIN (1957), *Economic backwardness and economic growth*, New York: Wiley.

(36) T. MCBRIDE (1976), *The domestic revolution: the modernization of household service in England and France 1820–1920*, Holmes and Meier.

(37) J. MIRRLEES (1976), A pure theory of underdeveloped economies, in L. Reynolds (ed), *Agriculture in Development Theory*, New Haven: Yale University Press.

(38) H. MOREWEDGE (1970), *The economics of casual labor: a study of the longshore industry*, Berne: Herbert Lang and Co. Ltd.

(39) A. MUKHERJEE (1991), *Rural labour markets and seasonality*, Ph.D. dissertation, Indian Statistical Institute, New Delhi.

(40) A. MUKHERJEE AND D. RAY (1992a), Wages and involuntary unemployment in the slack season of a village economy, *Journal of Development Economics* **37**, 227–264.

(41) A. MUKHERJEE AND D. RAY (1992b), Labor tying, mimeo., Department of Economics, Boston University.

(42) S. OSMANI (1990), Nutrition and the economics of food, in J. Drèze and A. Sen (eds), *The political economy of hunger*, Clarendon Press, Oxford.

(43) MME. PARISET (1821), *Manuel de la maîtresse de la maison, ou lettres sur l'économie domestique*, Paris.

(44) P. PHILLIPS (1954), The metabolic cost of common West African activities, *Journal of Tropical Medicine and Hygiene* **57**.

(45) W. RAND, N. SCRIMSHAW AND V. YOUNG (1985), Retrospective analysis of data from five long-term metabolic balance studies: implications for understanding dietary nitrogen and energy utilization, *American Journal of Clinical Nutrition* **42**.

(46) D. Ray and P. Streufert (1990), Dynamic equilibria with unemployment due to undernourishment, forthcoming, *Economic Theory*.

(47) G. Rodgers (1975), Nutritionally based wage determination in the low-income labour market, *Oxford Economic Papers*, March.

(48) D. Seckler (1982), Small is healthy: a basic hypothesis in the theory, measurement and policy of malnutrition, in P. Sukhatme (ed), *Newer concepts in nutrition and their implications for policy*, Pune: Maharashtra Association for the Cultivation of Science.

(49) D. Seckler (1984), The "small is healthy?" hypothesis: a reply to critics, *Economic and Political Weekly* **19**, 3 November.

(50) A. Sen (1981), *Poverty and famines: an essay on entitlement and deprivation*, Oxford: Oxford University Press.

(51) C. Shapiro and J. Stiglitz (1984), Equilibrium unemployment as a worker discipline device, *American Economic Review* **74**, 433–444.

(52) N. Singh (1983), The possibility of nonrenewal of a contract as an incentive device in principal-agent models, University of California at Santa Cruz, Working Paper 117 (Economics).

(53) J. Stiglitz (1976), The efficiency wage hypothesis, surplus labour and the distribution of income in L.D.C.'s, *Oxford Economic Papers* **28**.

(54) P. Sukhatme (1978), Assessment of adequacy of diets at different income levels, *Economic and Political Weekly* **13**, Special Number.

(55) P. Sukhatme (1981a), On measurement of poverty, *Economic and Political Weekly* **16**, 8 August.

(56) P. Sukhatme (1981b), On the measurement of undernutrition: a comment, *Economic and Political Weekly* **16**, 6 June.

(57) P. Sukhatme (1982),Measurement of undernutrition, *Economic and Political Weekly* **17**, 11 December.

(58) K. Sundaram and S. Tendulkar (1988), Toward an explanation of interregional variations in poverty and unemployment in rural India, in T. N. Srinivasan and P. Bardhan (eds), *Rural Poverty in South Asia*, New York: Columbia University Press.

(59) H. Taylor and A. Keys (1950), Adaptation to caloric restriction, *Science* **112**.

(60) P. Visaria (1981), Poverty and unemployment in India: an analysis of recent evidence, *World Development* **9**(3).

(61) A. Weiss (1990), *Efficiency wages*, Princeton: Princeton University Press.

(62) V. Young and N. Scrimshaw (1971), The physiology of starvation, *Scientific American* **225**.