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FOOD RISK AND THE POOR

This paper analyzes food insecurity in rural areas from the point of view of poverty alleviation. By developing a conceptual framework and a general class of poverty measures, the paper analyzes the implications of food risk, low incomes and unequal distribution for wage laborers and small farmers. A cross country analysis confirms that production risk and average access to food tend to be the most important and pervasive determinants of poverty.

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FOOD RISK AND THE POOR

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FOOD RISK AND THE POOR

Introduction

1. Famines have been a part of the human lot for at least as long as recorded history. Many of mankind's productive and organizational activities can be construed as deliberate attempts to minimize the occurrence of famine and to reduce the suffering of hunger. In spite of many advances, the risk of starvation has not yet been relegated to history - as evidenced by several catastrophes of the 1970s.

2. The problem of insecurity of food supplies can be broached at several levels, logically first from an international or global perspective. Here, while supplies of food (especially of staple grains) are only delicately advancing on demands by growing populations with growing incomes, the problem is essentially one of distribution among potential consumers in the face of considerable market instabilities. Much instability derives from the inexorable uncertainties of climate and agricultural production - but these are greatly exacerbated by the insulating policies of many countries. Such policies serve to de-stabilize the residual market and create added difficulties for importing (often developing) countries.

3. In principle, the difficulties can be overcome (at some cost) by an internationally managed stockpile of grains, but the prospects for agreement on the support and management of world buffer stocks seem bleak. An approach of nearly equivalent effectiveness and probably much lower cost is to enhance a trading solution through a system of flexible financial assistance to countries experiencing foreign exchange difficulties in times
of food crises. This seems to be a more feasible development in the near future. Another possibility of an international character - possible because of her predominance of the international grain export trade - is for the U.S. to attempt to stabilize the world market through her own and bi-
laterally negotiated stocking arrangements. A further possibility is also to expand developing country's access to hedging, option buying and future contracts.

4. At the national level, many and diverse approaches are adopted to planning for greater food security. Naturally, the scope for governmental initiatives in this matter is closely conditioned and constrained by competing priorities for scarce developmental resources. In a sense, food security is but one facet of a much wider issue of enhancing nutritional achievements and the performance of the food sector. Some countries have attached high priorities to food security per se (e.g., Sri Lanka) while others have tackled the problem indirectly by emphasizing growth per se (e.g., Taiwan).

5. India has had a long history of active concern for food security. The modern phase of Indian food policy dates from pre-Independence and features a complex of procurement, storage, rationed distribution, commercial imports, food aid, export bans and numerous pricing and movement interventions. Although this system is costly, it generally seems to work in achieving many of the apparent objectives. However, people do still starve in India and, of course, with even greater frequency in countries with greater poverty or less sophisticated security systems. To discover why, it is important to focus below the national level to particular regions, groups and people, and individuals.

6. At these disaggregated levels, the problems of inadequate food and nutrition are even more transparently problems of poverty - inadequate command over sufficient resources to exchange for sustaining food. Case studies of recent disasters in Bangladesh and Ethiopia highlight the central
role of transitory slumps in real income (exchange entitlement) preventing people from acquiring their basic requirements.\textsuperscript{18} This sad reality is also illustrated in the following conceptualization of the food problems of two important rural groups, the wage laborers and the small farmers.

\textbf{Conceptual Framework}

\textbf{Wage Laborers}

7. The fragility of the landless, potentially employed people and their dependents hinges on two features of their economic situation: (a) the impoverishingly low level that prevents their accumulation of reserves that could buffer their uncertain future, and (b) the risk of low levels of employment and low effective earnings which serves to expose them to malnutrition, suffering and starvation.

8. The following discussion centers on the plight of rural laborers whose livelihood is directly depending on events in agriculture. Excepting for the introductory linkage to crop successes or otherwise, the framework seems also to accommodate in a general way the position of urban laborers. However, the income distributions faced by urban employees are probably not as dispersed as those depicted here and they may be better protected by issue of food at fixed prices, than are their country counterparts.

9. Rural laborers face three main sources of uncertainty: the 'local' (say district or region) harvest, employment, and real wages. Associated with the harvest effects are local prices, which are negatively correlated with both the size of the harvest and the level of employment. The real earnings of laborers can be measured as the product of employment level by the wage rate divided by an index of local prices. In food security terms, the same earnings can be expressed best in units of "exchange entitlement" or sustenance purchasing power by calculating the amount of grains
(or calories) corresponding to any given level of real earnings. The "exchange entitlement" is thus a measure of the food buying capacity of generated employment.

10. A poor harvest occurring locally will create an upward pressure on food prices while employment and wages will tend to decrease. Vice versa, a good harvest will result in lower prices and higher employment and wages. Because of the fact that shortfalls in production are followed by adverse changes in prices, employment and wages, exchange entitlement fluctuations tend to be wider than fluctuations in yields. As a consequence, laborers' livelihood is likely to be much riskier than food output per se. For example, a 10% reduction in output is likely to result in a larger than 10% increase in food price because of the inelasticity of the demand for food. The ensuing fall in exchange entitlements will be even larger, as the loss of purchasing power is compounded by any fall in employment or wage rates.

11. Even if food supplies are rushed in from other producing areas or a buffer stock policy prevents excessive increases in prices, the effect on employment and wages of a local production shortfall may still lead to a drastic reduction in exchange entitlements and even jeopardize sustenance of subsistence levels of consumption.

Small Farmers

12. Farmers with resources sufficient to market a surplus of food and other produce in most seasons may still be impoverished but are seldom at risk of malnutrition. Accordingly, attention here is addressed to those farmers who basically produce for their own needs - the subsistence or small farmers. Occasionally, at times of fortuitous harvest, they may produce
a surplus for sale but, in general, they operate independently of commercial markets. To the extent that they do trade their production to agents from whom they subsequently purchase (or hope to purchase) their food requirements (presumably at higher costs), their situation is effectively that already depicted for the rural laborers. Indeed, such farmers will compete with landless laborers for the available employment.

13. The small farmer who sustains his family from his own stored production faces a risky future which is in principle less fragile than that of the labor because his exchange entitlement is subject to countervailing changes. If a poor harvest occurs, even though earnings tend to fall because of decreased marketable surplus, the fall is likely to be tempered by price increases and by lower wage costs.

14. The advent of the market economy and the opening up of trade with other areas tends to erode the risk advantage of the small farmer over the landless laborer and may make his food security problem more acute. If most of the farmers' production is marketed and the market is large, a poor harvest may diminish the farmers' purchasing power without any compensating changes in the higher prices of his produces.

Measurement of Poverty and Food Risk

15. As argued in the introductory review, food risk is intimately related to poverty. Indeed, it is likely that the motivation for much of the voluminous work on measurement of poverty is to derive an informed description of the fragility of the positions in which the poor find themselves.

16. No attempt is made here to take a balanced view of the vast literature on income distribution. Rather, interest is confined to procedures and methods of poverty measurement popular in the World Bank.22
Features of income distribution are used for many purposes, such as comparing degrees of equality of distribution, and assessing the extent of poverty or deprivation. In most such applications, the approach taken is to describe the situation over a particular interval of time such as a specific year. Indeed, this alone is demanding of data and is a challenging enough task. Summary measures are produced, such as Gini co-efficients, fractile data from fitted Lorenz curves, proportions or head-counts of populations enduring a defined level of poverty, indexes of poverty or deprivation, and so on.

17. A concern that arises from the foregoing sections is that food risk involves something more than poverty as so measured. In the single period or snapshot approach, investigators are missing the important dimension of temporal variation arising from random phenomena such as climate and other elements of the natural and economic environments. Thus, unless they were 'lucky' in choosing a period characterized by extreme crises, it seems inevitable that the downside risk of inadequate access to food would be under-estimated in most investigations.

18. Put another way, the student of food security cannot afford to neglect either the lower tail of the distribution of income or the lower tail of the probability distribution of crop and other staple food production. An adequate operational concept of food risk must somehow integrate both of these fundamental considerations. The probability of an individual not having enough food is, approximately, the product of an individual not there being inadequate food available for 'normal' requirements to be met (i.e. in the below-requirements tail of the food production distribution), and the probability of his being 'poor' (i.e. in the impoverished left
hand tail of the income distribution). This approximation of the joint probability is based on a plausible assumption of approximate statistical independence of the two risks. This idea can be summarized in the identity

\[ \text{Food risk} = (\text{Distributional risk}) \times (\text{Environmental risk}) \]

10. In most agrarian societies, environmental risk would stem mainly from natural phenomena impacting on agricultural production. In practical terms, distributional risk can be measured by proportion of poverty or an index of poverty which involves an appropriate weighting of greater degrees of deprivation and suffering. Environmental risk is less obviously and easily measured. One possibility is the probability of production falling below a total 'average' requirement.

20. Alternatively, one might use *ad hoc* measures of environmental variations in attempts to capture this influence in assessment of relative food security risk. More specifically, the vulnerability to food access may be captured by some measure of poverty. Following Kakwani (1980) and Seu (1980) axiomatic approach, we can state the following property/axioms that a poverty measure of food security (food risk) should satisfy:

**Axiom 1.1** (Distributional Monotonicity) - Other things remaining the same, reduction in mean income of a person (at any time) below the poverty line must increase the value of the food risk measure.

**Axiom 1.2** (Environmental Monotonicity) - Other things remaining the same, an increase in the variability of income of a person (at any time) below the poverty line must increase the value of the food risk measure.

**Axiom 1.3** (Transfer) - Other things remaining the same, a pure transfer of income from a person below the poverty line to anyone who is richer must increase the value of the food risk measure.
Axiom 1.1 is intuitively obvious. Axiom 1.2 states that an increase in the variability of income of a person which happens to be at any time below the poverty line increases the risk that he will find himself short of the minimum income more often and for larger amounts. While the association between higher individual variability (environmental risk) and lower food security is direct, however, the link between distributional risk and decreased access to food has to be justified separately. Accordingly, Axiom 1.3 states that an increase in inequality at the expense of the poor must also result in an increase in food risk.

21. Following Scandizzo and Knudsen (1980), we define as the socially desirable income distribution the one that would bring all the poor up to the poverty level while maintaining the non poor at the same level of income. The expected value $Y_s$ of such a distribution would be:

\[ Y_s = Y_p F(Y_p) + \int_{Y_p}^{\infty} ydF(y) \tag{1} \]

where $F(y)$ is the distribution function for personal income and $Y_p$ is the poverty level. Adding and subtracting $\int_{Y_p}^{Y*} ydF(y)$ from the right hand side of (1) yields, after some simple transformations:

\[ P = \frac{Y_s - EY}{EY} = \left( \frac{Y_p - EY*}{EY} \right) F(Y_p) \tag{2} \]

where $P$ is a special case of the poverty measures proposed by Kakwani (1980) and Sen (1980), $EY$ indicates expected income for all and $EY*$ expected income for the poor.
22. Because expressions (1) and (2) treat the poor as though they were all receiving the same mean income $EY^*$ at all times, the measure in (2) meets only Axiom 1,1 and violates 1,2 and 1,3. In order to incorporate variability considerations both over states of nature (Axiom 1,2) and over individuals (Axiom 1,2), the following general class of poverty/food risk measures can be defined:

$$P^* = \left[ \frac{Y_p - EY^* (g[G^*,V])}{EY} \right] F(Y_p)$$

(3)

where $g$ is monotonically increasing function of an appropriate measure of distributional risk $G$ (e.g. the Gini co-efficient) and, (ii) of environmental risk $V$ (e.g., the co-efficient of variation). Intuitively, expression (3) states that a measure of food risk is given by the percentage of expected income which would be necessary to transfer in order to close the poverty gap, once allowance is made for (i) the inequality of income distribution among the poor and, (ii) the variability of the income of the poor.

23. A simple approach to incorporate environmental risk in a poverty measure in a way that is comparable across diverse distributions of agriculture output, is to inflate "riskless" poverty measures to allow for risk. Intuitively what seems to be required to inflate those measures which are increasing functions of impoverishment, is a multiplicative expression which is also an increasing function of the degree of variability inherent in the agricultural sector. Ideally, the expression should emphasize the downside risk effects (e.g. negative semi-variance). However, if distributions are more or less symmetric, a standardized statistic such as the coefficient of variation (cv) seems to capture the efforts well enough.
24. To arrive at a suitable multiplicative (arbitrary) expression, some function of the cv should be added to unity. From the empirical mark on India that follows, the arbitrary rule proposed is to inflate statistics positively related to poverty by a factor \((1 + 2 \text{ cv})\). Such multiplicative inflation of axiomatically based concepts of poverty will not violate the desirable underlying postulates. The process of inflation can be conceived as a 'quick and dirty' method of extending conventional statistics on people at risk. For instance, suppose that 'the' probability of being poor in India [Bihar] is 0.5 [0.7]\(^{23}\) and that the co-efficient of variation of foodgrain production is 0.06 [0.1]\(^{24}\) then food risk, the appropriate probability of people facing the prospect of food shortfalls, can be expressed as \((0.5)(1.12) = 0.56 ([0.7](1.2) = 0.84)\).

25. Such a measure captures more vividly the risk exposure of individuals who experience uncertain employment and the results of uncertain crop prospects. In this way, 'snapshots' of poverty can mimic somewhat studies in which the proportion of population at risk is tracked over time and thus over the domain of agricultural experience. Naturally, such studies are even more demanding of data and analysis, which may explain their apparent scarcity. One feature typically not revealed in such time series work is the 'stability' or persistence of membership of the group at risk. The perception of an individual of his personal vulnerability will crucially depend on his chance of rising out of the lower tail while, presumably, another takes his unfortunate place in the distribution.

26. Some opposite evidence on the random nature of the incidence of poverty is provided in a recent study of rural poverty in India.\(^{25}\) Several estimates of headcount percentage poverty and Sen's Poverty Index were
presented for India (as a rural whale) and individual states. Over the 11 to 13 year periods considered, these measures all exhibit considerable volatility with co-efficients of variation of about 0.11 for the headcount and of about 0.18 for the index. These data are summarized in Table 1.

27. In computing a measure of poverty from data which appear to be 'normal' or 'typical', it may be desired to contemplate a measure of how 'bad' things can become when, say, agricultural and economic luck run out. Such an adjustment is reported in the final row of Table 1. It can be seen that these adjusted measures are slightly larger than the worst observed - which is appropriate since the chance of observing in a short series something approaching the worst possible is necessarily small. Hence, a first rule of thumb is proposed for assessing food risk on the basis of scanty data: multiply the summary measure, such as headcount deprivation or a poverty index, by \((1 + 2 \times cv)\) and, if \(cv\) is unknown for the particular case at hand use the co-efficient of variation for food or cereal production about trend, or, if that statistics is unavailable, an even more arbitrary value of \(cv = 0.1\).

28. Further evidence on the direct impact of the fortunes of agriculture on measures of impoverishment (and thus risk to survival) can also be gleamed from the study of rural poverty in India. Several expressions are presented which indicate a statistically significant negative relationships between headcount and poverty index, and agricultural output per person. The mean elasticities are \(-1.2\) and \(-2.3\), respectively, indicating the intuitively anticipated greater impact on the index that captures degree as well as extent of poverty. The state-level impacts seem even more dramatic although without additional data, elasticities cannot be computed.
### TABLE 1

Features of Measures of Rural Poverty in India over Time

<table>
<thead>
<tr>
<th></th>
<th>Headcount Percentage</th>
<th>Sen's Poverty Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NSS(^a)</td>
<td>NAC(^b)</td>
</tr>
<tr>
<td>Mean ((\bar{x}))</td>
<td>48.5</td>
<td>41.3</td>
</tr>
<tr>
<td>Coefficient of variation (cv)</td>
<td>0.12</td>
<td>0.11</td>
</tr>
<tr>
<td>Highest observed(^c)</td>
<td>56.6</td>
<td>49.6</td>
</tr>
<tr>
<td>(\bar{x} (1 + 2cv))</td>
<td>60.3</td>
<td>50.7</td>
</tr>
</tbody>
</table>


\(^c\)/ All these were for 1966/67.
A Cross-Country Analysis of Food Risk

29. The basic hypothesis to emerge from foregoing sections is that fragility of food supplies depends fundamentally on (a) the resource situation in general, (b) the degree of inequality and extent of poverty and (c) the inherent uncertainty in food production. Other factors may also play an important part in particular circumstances. For instance, the extent of industrialization may be such that a country can simply buy its way into a secure food position. Alternatively, a policy of social security may embody instruments (especially cheap and ample food for work) to protect citizens, if not the economy, from shortfalls in production. Yet again, armed conflicts and revolutions may play havoc with food supplies. Generous and timely food aid may alleviate such problems.

30. With these qualifications, the main hypothesis can be expressed simply as

\[ \text{Food risk} = f (\text{Normal food availability, Distributional risk, Production risk}) \]

or, equivalently,

\[ \text{Food vulnerability} = f (\text{Average access to food, Inequality, Environmental risk}) \]

or, somewhat more specifically,

\[ P (\text{starvation}) = f (\text{Average income, Index of poverty, Variation production}) \]

Naturally, there are difficulties inherent in attempts to measure all these conceptual variables, let alone in specifying plausible inter-relationships. Unfortunately, data are least satisfactory for the left-hand side of the functions. There is a dearth of reliable data on mortality and suffering
from starvation. A few case studies of famine in particular countries are available\(^{26}\) but, seemingly, no cross-country data of any comprehensive-ness.

31. One is thus obliged to resort to surrogate measures of malnutrition and famine. The following are experimented with here.

Food risk (FR) measures:

\[ FR_1 = \text{Life shortfall} = 80 - \text{life expectancy at year 1 (aver Sen 1980\(^b\))} \]

\[ FR_2 = \text{Child mortality in 1977 (World Bank 1979)} \]

\[ FR_3 = \text{Physical Quality of Life Index (Morris 1979)} \]

40. The explanatory variables employed are as follows:

Average resource situation (RS) variables:

\[ RS_1 = \text{GNP per head, in 1977 US\(^{\dagger}\) (World Bank 1979)} \]

\[ RS_2 = \text{GNP per head in 1975 with Kravis adjustment (Ahluwalia, Carter and Chenery 1979)} \]

\[ RS_3 = \text{Apparent consumption of cereals per head, in kg/year (FAO Production Data)} \]

Distribution/inequality (DI) variable:

\[ DI_1 = \text{Gini co-efficient, circa 1970 (Kakwani 1980)} \]

\[ DI_2 = \text{Percentage of population in poverty in 1975 (Ahluwalia, Carter and Chenery 1979)} \]

\[ DI_3 = \text{Poverty Index (Kakwani 1980)} \]

\[ DI_4 = \text{Percentage of population in poverty, mid 1970s (Kakwani 1980)} \]

Production Risk Variables

\[ PR_1 = 1 + \text{Co-efficient of variation about trend of cereal production (from FAO data 1961-70)} \]
PR_2 = 1 + Coefficient of variation about trend of cereal consumption per head (FAO)

PR_3 = An estimate of the probability (per cent) of shortfall of cereal consumption head below an arbitrary 'target' of 210 kg per year

Combined Resource and Distribution Variables:

RD_1 = share of population with probabilistic calorie deficit (Reutlinger and Alderman 1980)

32. Even with these few alternative measures of the key variables there are many combinations that could be included in plausible and potentially interesting associations. Too many different algebraic specifications could be assembled to multiply greatly the number of potentially estimated regressions. Accordingly, a parsimonious approach to specification and estimation seems appropriate and here a few simple regressions are reported to mirror in a few different ways the general hypotheses advanced above.

33. The main data linkage is to Sen (1980) who employed the data of Ahluwalia, Carter and Chenery (1979) to good purpose. Those data on 34 countries have been supplemented where possible by additional statistical data from other countries not included in the 34 classified as 'Low Income Countries' by World Bank (1979) bringing the total to 59. The cereal production and consumption data from FAO were added where possible (58 of the 59, 33 of the 34). The data reported by Kakwani (1980) were included, but these were only available for 18 of the 59. Similarly, the data from the tabulations of Reutlinger and Alderman (1980) covered only 24 of the 59. Thus, the number of observations used in a regression depends on the variables included in a specification and, for example, is typically 33 for the Sen-Ahuwalia regressions and 18 for the Kakwani regressions.
### Table 2:

Summary of Data Used in Cross-Country Regressions

<table>
<thead>
<tr>
<th>Variable</th>
<th>Short name</th>
<th>Units</th>
<th>Max. no. of observations used</th>
<th>Mean</th>
<th>Standard deviation</th>
<th>Min.</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Life shortfall</td>
<td>years</td>
<td>33</td>
<td>25</td>
<td>8</td>
<td>13</td>
<td>41</td>
</tr>
<tr>
<td>FR&lt;sub&gt;2&lt;/sub&gt;</td>
<td>child mortality</td>
<td>no. per 10&lt;sup&gt;3&lt;/sup&gt;</td>
<td>33</td>
<td>16</td>
<td>9</td>
<td>2</td>
<td>37</td>
</tr>
<tr>
<td>FR&lt;sub&gt;3&lt;/sub&gt;</td>
<td>PQLI</td>
<td>index</td>
<td>33</td>
<td>52</td>
<td>24</td>
<td>18</td>
<td>84</td>
</tr>
<tr>
<td>RS&lt;sub&gt;1&lt;/sub&gt;</td>
<td>GNP/person</td>
<td>1977 US$</td>
<td>33</td>
<td>613</td>
<td>511</td>
<td>110</td>
<td>2160</td>
</tr>
<tr>
<td>RS&lt;sub&gt;2&lt;/sub&gt;</td>
<td>GNP/person</td>
<td>1975 INT$</td>
<td>33</td>
<td>669</td>
<td>392</td>
<td>213</td>
<td>1429</td>
</tr>
<tr>
<td>RS&lt;sub&gt;3&lt;/sub&gt;</td>
<td>cereals/person</td>
<td>kg/year</td>
<td>33</td>
<td>228</td>
<td>119</td>
<td>37</td>
<td>670</td>
</tr>
<tr>
<td>DI&lt;sub&gt;1&lt;/sub&gt;</td>
<td>Gini coefficient</td>
<td>0-1 scale</td>
<td>24</td>
<td>0.462</td>
<td>0.086</td>
<td>0.330</td>
<td>0.612</td>
</tr>
<tr>
<td>DI&lt;sub&gt;2&lt;/sub&gt;</td>
<td>headcount poverty</td>
<td>percent</td>
<td>33</td>
<td>31</td>
<td>20</td>
<td>5</td>
<td>68</td>
</tr>
<tr>
<td>DI&lt;sub&gt;3&lt;/sub&gt;</td>
<td>poverty</td>
<td>index</td>
<td>18</td>
<td>4.0</td>
<td>4.7</td>
<td>0.03</td>
<td>16.89</td>
</tr>
<tr>
<td>DI&lt;sub&gt;4&lt;/sub&gt;</td>
<td>headcount poverty</td>
<td>percent</td>
<td>16</td>
<td>20</td>
<td>16</td>
<td>0.9</td>
<td>58.2</td>
</tr>
<tr>
<td>PR&lt;sub&gt;1&lt;/sub&gt;</td>
<td>(1 + cv) production</td>
<td>-</td>
<td>33</td>
<td>1.12</td>
<td>0.06</td>
<td>1.04</td>
<td>1.29</td>
</tr>
<tr>
<td>PR&lt;sub&gt;2&lt;/sub&gt;</td>
<td>(1 + cv) consumption/person</td>
<td>-</td>
<td>33</td>
<td>1.11</td>
<td>0.04</td>
<td>1.04</td>
<td>1.23</td>
</tr>
<tr>
<td>PR&lt;sub&gt;3&lt;/sub&gt;</td>
<td>probability of shortfall</td>
<td>percent</td>
<td>20</td>
<td>63</td>
<td>35</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>RD&lt;sub&gt;1&lt;/sub&gt;</td>
<td>headcount calorie deficit</td>
<td>percent</td>
<td>20</td>
<td>60</td>
<td>9</td>
<td>39</td>
<td>71</td>
</tr>
</tbody>
</table>
The first group of regressions reported is for the Sen-Ahluwalia variables. The first 3 illustrate consistency across the first two members of the set of alternative dependent variables. Respective standard errors and other summary statistics are reported in parentheses.

(1) \( \text{FR}_1 = -18 \quad - 0.001 \text{RS}_1 \quad + 0.27 \text{DI}_2 \quad + 33 \text{PR}_1 \)
\( (n=33, R^2 = 0.53, s = 6) \quad (0.003) \quad (0.07) \quad (17) \)

(2) \( \text{FR}_2 = -45 \quad - 0.002 \text{RS}_1 \quad + 0.27 \text{DI}_2 \quad + 48 \text{PR}_1 \)
\( (n=33, R^2 = 0.49, s = 17) \quad (0.003) \quad (0.09) \quad (20) \)

(3) \( \text{FR}_3 = 103 \quad + 0.01 \text{RS}_1 \quad - 0.26 \text{DI}_2 \quad - 41 \text{PR}_1 \)
\( (n=33, R^2 = 0.13, s = 24) \quad (0.01) \quad (0.29) \quad 69 \)

Death and suffering from malnutrition are believed to be strongly positively associated with \( \text{FR}_1 \) and \( \text{FR}_2 \), and negatively with \( \text{FR}_3 \). The headcount poverty percentage (\( \text{DI}_2 \)) and the production risk (\( \text{PR}_1 \)) can be seen to have strong and significant positive associations with first two surrogate measures of malnutrition. The per capita GNP (\( \text{RS}_1 \)) effect is generally opposite in sign but here is small and is statistically insignificant.

These conclusions are essentially preserved in alternative functional specifications. Consider, for example, the log-linear analyses of equations (1) and (2):

(4) \( \log \text{FR}_1 = 1.75 \quad - 0.02 \log \text{RS}_1 \quad + 0.37 \log \text{DI}_2 \quad + 1.37 \log \text{PR}_1 \)
\( (n=33, R^2 = 0.54, s = 0.26) \quad (0.10) \quad (0.11) \quad (0.87) \)

(5) \( \log \text{FR}_2 = -1.1 \quad - 0.11 \log \text{RS}_1 \quad + 0.80 \log \text{DI}_2 \quad + 3.70 \log \text{PR}_1 \)
\( (n=33, R^2 = 0.49, s = 0.58) \quad (0.22) \quad (0.25) \quad (1.96) \)

The equations suggest that policies directed at food-risk problems should concentrate first on alleviating poverty, second on reducing the impact of production uncertainty and, only incidentally, on boosting average income.
36. The next set of regressions illustrate the effect of varying the measure of poverty and inequality and can be compared directly with equation (2):

\[ FR_2 = -80 - 0.01 RS_1 + 33 DI_1 + 78 PR_1, \]
\[ (n=23, R^2 = 0.51, s = 8) \]

\[ FR_2 = -105 - 0.003 RS_1 + 1.15 DI_3 + 105 PR_1, \]
\[ (n=18, R^2 = 0.61, s = 7) \]

The aforementioned effects are generally supported by equations (6) and (7) with one exception. From equation (6) it can see that the GNP effect (RS_1) is significantly negatively associated with child mortality when the distributional effect is captured by the Gini co-efficient (DI_1) rather than the alternate measures of poverty which depend on level of incomes, and thus 'rob' the RS_1 variable of the influence that would otherwise be revealed.

It was found that all the foregoing results are insensitive to the particular measure of GNP use (e.g. in different years and with or without the Kravis adjustment). To return to the hypothesized general models that introduced this section, it thus seems that some were rather 'hybridized' and should instead be written as either

Food risk = f (Resource level, Inequality, Environmental risk)

or

Food risk = f (Poverty, Environmental risk).

37. The next group of regressions is addressed to alternative measures of 'production' risk.

\[ FR_1 = -46 + 0.27 DI_2 + 57 PR_2 \]
\[ (n=33, R^2 = 0.56, s = 5.5) \]
(9) $FR_2 = -83 + 0.28 DI_2 + 82 PR_2$
   $(n=33, R^2 = 0.53, s = 6.5) (0.06) (27)$

(10) $FR_1 = 9.0 + 0.78 DI_4 + 0.14 PR_3 - 0.007 DI_4 PR_3$
   $(n=16, R^2 = 0.64, s = 6) (0.22) (0.06) (0.003)$

(11) $FR_2 = 1.9 + 0.87 DI_4 + 0.17 PR_3 - 0.003 DI_4 PR_3$
   $(n=16, R^2 = 0.57, s = 7) (0.29) (0.07) (0.004)$

Equations (8) and (9), when compared with (1) and (2), suggest that the results are relevant with respect to different co-efficients of residuals variation based on the aggregate production data. This was confirmed also by experimenting with other measures and transformations of the cvs. In specifying the multiplicative as well as additive effects in equations (10) and (11), the anticipation was that the interaction would be positive, indicating that simultaneous high income risk and production risk would be associated with an even greater food risk. Such seems not to be the case, at least for this sample of countries and the measures of the risk. Thus, in equation (10) and (11), there is partial compensation in food risk for increases in probability of poverty ($DI_4$) while increasing probability of food shortfalls ($PR_3$), through the negative interaction.

38. The combined influences of 'caloric poverty' and risk in food availability are examined in the next group of regressions. Here the Reutlinger-Alderman (CDP*) data on proportion of population facing a probabilistic calorie deficit ($RD_1$) and residual variability of per capita cereal consumption ($PR_2$) are blended in constant elasticity (log-linear) relationships

(12) $\log FR_1 = -1.2 + 0.96 \log RD_1 + 4.9 \log PR_2$
   $(n=24, R^2=0.42, s=0.29) (0.34) (1.7)$

(13) $\log FR_2 = -5.1 + 1.6 \log RD_1 + 11 \log PR_2$
   $(n=24, R^2=0.36, s=0.64) (0.7) (4)$
These equations seem to impute an extraordinary degree of sensitivity to changes in production risk—allogously to equations (4) and (5). However, in interpreting these equations, it must be recalled that risk is measured here as $1 + cv$, so that to decode an elasticity with respect to PR$_2$ or PR$_1$ as an elasticity with respect to the respective cv, the first elasticity should be multiplied by cv/($1 + cv$). The mean data reported in Appendix 3 reveal mean cvs as about 0.11 for these countries so an appropriate factor is $0.11/1.11 = 0.1$. Thus the elasticities with respect to the cv in equations (12) and (13) are approximately 0.49 and 1.1, respectively, and are seen to be somewhat smaller in magnitude and importance than the corresponding elasticities with respect to RD$_1$.

39. Evidently, it is possible to 'explain' over half of the observed cross-country variation in child mortality and life shortfall (or expectancy) by simple regressions including crude measures of poverty and variability in agricultural output. Presumably, careful incorporation of other important dimensions of mortality, such as food aid, the state of health care and social security systems, and the prevalence of war or revolution, could doubtless increase greatly the explanatory power of such cross-country regressions.

40. However, the picture that has emerged does seem to be generally consistent with the a priori reasoning of earlier sections. Variability in the food sector, when taken into consideration along with the more overwhelming problems of poverty of people, does appear to play a statistically significant role in influencing social indicators that reflect, inter alia, mortality effects of malnutrition. Needless to say, great scope prevails for refining this perception.
Conclusion

41. The tragic effects on poor people and the general difficulties arising from low-performance risks on agriculture cannot readily, if at all, be separated from the broader issues of world development, especially as it infringes on production and marketing of food, and on growth of incomes of consumers everywhere. The most pressing priorities for broad attack on the world food 'problem' doubtless lie in policies and research to enhance investment and productivity in food production systems, and growth and equity of incomes.

42. An inherent feature of most agricultural markets is their instability in production and consequent risk in prices, and returns to farmers. Farmers will account for such risks in their planning and may consequently not employ technologies that are more productive on average, and which policy makers see as being desirable. Several forms of intervention may serve to alleviate the disincentives and frictions associated with risk. Price stabilization, insurance and risk-protected credit policies can work to encourage greater agricultural output and thus complement other policies aimed more directly at boosting production.

43. However, even with an optimistic outlook on future trends in aggregate food production and in economic growth, it is regrettably inevitable that serious problems of the food insecurity type will persist. It is conjectured here that the inevitability arises from the unhappy conjunction of markets that are intrinsically risky, at least in production, and income distributions which foreseeably are uneven and, in much of the world, low.
44. This preliminary investigation has been intended to begin to bridge the apparent gap between studies in which risk in agricultural markets is analyzed and studies in which differences among consumers, especially in incomes, and among regions of a country, especially in food distribution infrastructures, are analyzed.

45. Given this background, our results can be summarized as follows: First, poverty and food risk are intimately related both for landless workers and small farmers. Any measure of poverty, therefore, would have to include some index of food insecurity or otherwise would miss one of the crucial problems of the poor in rural areas. Second, a general class of poverty measures including food risk is specified as an extension of the usual deterministic measures based on the average availability of food. "Rules of thumb" to adjust the latter measures to account for risk are also proposed. Third, the association between poverty and food risk is empirically tested by examining the statistical relation between these indicators of development on one hand, and measures of food risk, poverty, income distribution and wealth on the other. The results of this exercise suggest (i) a statistical significant and strong relationship, and (ii) that policies directed at food-risk problems should concentrate mainly on alleviating average poverty and on reducing the impact of production uncertainty.
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Footnotes

1/ Dando (1980) has an overview of 8000 famines in 6000 years and de de Castro has a modern focus.

2/ Glantz (1976), George (1977), Moore Lappe and Collins (1978), Reutlinger Selowsky (1976), Sen (1980 b), Shepherd (1975)


10/ Bigman and Reutlinger (1979), Reutlinger (1978), Siamwalla and Valdez (1980).

11/ Groenewegen and Cochrane (1980)


13/ ESCS (1978), Lane (1980), National Research Council (1975, 1977)

14/ Gavin and Chandrasekera (1979), Timmer (1980)

15/ Swamy (1979)

16/ Scandizzo and Swamy (1980), Wall (1978), Kumar (1979), Accurate assessment of effectiveness is plagued by the perceptual biases discussed by Chambers (1980).
17/ Chernichovsky (1979), Foster (1978), George (1979), Jodha (1978),
Srinivasan (1977), Visaria (1980)

18/ Joy (1979), Sen (1980 a)

19/ It is possible to gain further insight to the risks involved by an
algebraic representation of the various relationships. Consider a
random grain harvest \( H \) which 'drives' a constant elasticity employ-
ment function

\[
L = a_o H^{a_1} \quad a_o > 0 \text{ and probably } a_1 > 1, \text{ while}
\]

\[a > 0\] would tend to be larger for less poor families, and a constant
elasticity grain demand function, producing prices \( P \),

\[
P = (H/b_o)^{1/b_1} \quad 0 < b_o > b_1 = 1.
\]

Then \( L/P \) is a measure of the grain buying capacity of generated employ-
ment and, by an appropriate unit change \( k \) can be expressed in units
such as calories of metabolizable energy or other convenient measure
of \( G \) as

\[
G = k a_o (1/b_o)^{1/b_1} H^{a_1 - 1/b_1}
\]

The probability distribution of \( G \) clearly depends on that for \( H \),
although the precise nature will be determined by the form of the \( H 
\) distribution, and in general will be complex. However, it can be noted
that an approximate relationship between the respective coefficients
of variation exists (Anderson 1979),

\[
\text{cv}(G) = (a_1 - 1/b_1) \text{cv}(H).
\]

Thus, if, for example, \( a_1 = 1.5, b_1 = 0.5 \) then \( \text{cv}(G) = 3.5 \text{cv}(H) 
\),
so that, if \( \text{cv}(H) = 0.1 \), then \( \text{cv}(G) = 0.35 \) and, in this sense,
laborers livelihood would be much riskier then grain output per se.

The main point to emerge here is that, in recognizing variation
in the basic productive environment, there may be a need to inflate
further assessments of food risk that do not take such variation into
account.

20/ Knudsen (1980), Pinstrup-Anderson (1980). Indeed, the very determination
of the target standard \( R \) is also subject to considerable uncertainty
(Srinivasan 1980).

21/ Lele and Candler (1981).

22/ These are centered on the work of Kakwani, collected in his seminal
wherein much of his earlier work is rendered, and of Teutlinger and
Scholovsky (1976).


24/ Lipton (1980).

26/ Using the slopes reported (Ahluwalia 1977, p.309) for Estimate I percentage and the Index, and contemporaneous only net domestic agricultural product per head.

27/ Ahluwalia (1978, p.33)

28/ This probability is estimated from the apparent consumption per head data reported by FAO. The distribution of this measure is characterized first by two parameters, namely the mean (over 1961-79) and the coefficient of variation based on deviations about constant growth rate trends. The mean (M) and implied standard deviation are then used to fit a symmetric triangular distribution with range R = cv X MX γ/24 from A = M - R/2 to B = M + R/2. Finally, given a 'target level of T, say = 210, P( x ≤ T) = P is found as follows:

\[
\begin{align*}
\text{if} & & T & ≤ A & & P = 0 \\
\text{if} & & T & > B & & P = 1 \\
\text{if} & & A & ≤ T & ≤ M & & P = (Z - A)^2 / [M_0 - A)(B - A)]; \\
\text{and if} & & M & < T & < B & & P = 1/2 + (B - Z)^2 / [(B - M)(B - A)].
\end{align*}
\]

29/ The FR_3 or 'PQLI' is a composite of life expectancy at age one, a negative function of infant mortality and rate of literacy. As such, it is probably the least satisfactory of the three dependent variables for capturing malnutrition effects per se. It is for these reasons not used in subsequent regressions.