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INCOME RISK IN AGRICULTURE:
A CROSS-COUNTRY COMPARISON

By

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Much of the recent literature in the development economics field has sought to identify the factors that have contributed to relatively low levels of growth of the agricultural sector in the less developed countries (LCD's). It is generally agreed that low growth rates result from low rates of investment in the agricultural sector rather than from inefficient use of resource committed to agriculture. There is less agreement concerning the factors explaining the low-investment rate.

Attempts to explain why investment in agriculture in the LDC's is low generally fall in one of two groups. The first group may be represented by Schultz's hypothesis that, "the price of the sources of income streams from agricultural production is relatively high in traditional agriculture." [10, p. 84] That is, the rate of return to investments in LCD agriculture is relatively low in comparison to that which can be earned in the developed areas where investments in agriculture have been substantial. This hypothesis is that there are few profitable investment opportunities, thus there is little investment and thus little growth.

The alternative hypothesis proposed states that the expected return to investment in traditional agriculture, especially in non-traditional capital forms, is high relative to both the cost of capital and to returns in agriculture in developed countries. However, this hypothesis continues, risk associated with investment in traditional agriculture is high relative to that encountered in alternative investment opportunities in the LDC's or to that encountered in agricultural investment in the developed countries. Thus, rational entrepreneurs do not invest even though expected levels of return are greater than the existing price of available investment funds.1/

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1/ We follow the lead of Prof. F. H. Knight in distinguishing between risk and uncertainty. Risk is defined as a variability in outcomes for which objective probabilities can be assigned. Uncertainty refers to those events to which probabilities cannot be assigned.

The feasibility of each investment alternative is dependent on the expected return from that investment and the variability of that return. Given a risk preference function for the individual, it is possible to express the returns to alternative investments as certainty equivalents: "The expected value that in combination with zero variance is indifferent to a given combination of expected value and (positive) variance." [6, p.34] If we assume a well-behaved risk preference function, then for a given level of expected return to alternative investments those alternatives with low levels of risk are preferred to those with high levels of risk.

Mellor [7, p. 291-3] points out that investments in agriculture are subject to three types of risk. First, there is the technical risk that the recommended investment will not be profitable under existing climatic and market conditions. This type of risk derives from a lack of knowledge about the performance of the investment under existing conditions. The second type is yield risk which derives from the variability in physical productivity associated with the investment. Third, there is price risk or price variability.

To some extent technical risk associated with an investment is endogeneous to the management decision making process. That is, the investor can reduce the level of technical risk associated with an investment by obtaining more information. Price and yield risk associated with a specific investment are largely exogeneous to the firm being determined by climatic conditions on the one hand, and policy and market behavior on the other. [5, p. 412-15]

Objective

In general, the rate of investment in agriculture in the developed countries (DCs) is higher than that found in the LDCs.[4, p. 421] If efficient investment decisions are made in both areas, then it is apparent that the certainty equivalent return to investments in the developed areas is higher than in the underdeveloped areas. Therefore, either the expected returns to investments in traditional agriculture are low, or the risk associated with them is high, or both. Policies designed to stimulate investment in traditional agriculture must be directed toward the cause(s) of low rates of investment.

The objective of this paper is to test the hypothesis that price and yield risks associated with investments in tradional agriculture are relatively high. That is,

the variability of income streams caused by price and yield risk is greater in LDCs than in DCs.

Method

The above hypothesis of relatively high levels of income risk in LDCs will be tested by comparing the average variability of simulated income streams from sample farm firms in two regions of Brazil and one region of the United States.

The variability of an income stream produced by a given enterprise is determined by the variability of price and yields for that enterprise, and by the covariance between price and yield. For a multi-enterprise firm, income risk depends on the variance of the income stream from each enterprise and the covariances between them all. Since the price and yield variates for each enterprise are multiplicative (rather than additive) it is not possible to compute the variance of their joint distribution directly. Therefore, simulated incomes are computed for a number of firms; the variability of which will be taken as a measure of risk.

Given the existing enterprise structure of the firm the income risk inherent in that structure may be simulated using historical price and yield data series. The income that would be earned by a firm in each year is:

$$(1) \quad I_n = \sum_{i=1}^{m} U_{in} P_{in} Y_{in}$$

where

I_n = gross income of the firm in year n.

U_{in} = production units of enterprise i in year n; taken from survey data.[2/]

[2/] Production units refer to hectares harvested for crops and animal unit equivalents for livestock enterprises. Prices and yields are expressed per production unit.

P_{in} = market price of the product i in year n; taken from historical price series.

Y_{in} = average yield of enterprise i in year n; taken from historical data series.

m = number of enterprises in the firm's enterprise structure.

Assume that the observed U vector for each firm is the same for all n, and that P and Y are taken from historical data series. Then vector I is the simulated historical income stream for each firm.

Numerous alternative interpretations of the entrepreneur perception of risk associated with a given income stream may be found in the literature; e.g., maximin, maximax, probability of loss, etc. [12]. For our purposes, risk will be defined as the variability of the firm's simulated income stream, I. In order to permit comparisons of variances about different means, risk will be expressed as the coefficient of variation of the I vector [3, p. 514; 11].

$$(2) \quad \text{risk index} = \frac{\sqrt{\text{variance of I}}}{\text{mean of I}} \times 100$$

It is important to note that the calculation of the I vector only identifies the risk inherent in agricultural production that results from price and yield variability. Since technical risk is not accounted for, (2) probably underestimates the total risk felt to exist in many investment situations--particularly with regard to investments in new technologies. Nonetheless, (2) probably corresponds closely to the firm manager's estimate of the anticipated risks associated with future investments after technical risk has been minimized by information gathering and is therefore the appropriate measure of risk for this analysis.

The Data

Farm data revealing enterprise patterns (the U vector) were obtained for two regions of Minas Gerais (Brazil) and in Indiana (USA).[3/] Historical price and yield data series were taken from secondary sources.

Brazilian Survey Data. The Brazilian data were collected in two regions of the state of Minas Gerais (south-central Brazil). The data from both regions were collected by the authors. The sampling procedure was essentially random, but differential response rates may have skewed the sample toward larger and better managed farms. Slightly more than one hundred farmers were interviewed in each region.

Muriae, one of the municipios surveyed, is located in the Zona da Mata. Once a major coffee producing area, the Zona da Mata now faces

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3/ Descriptive summaries of these surveys can be found in [1,pp. 41-67] and [9].

problems of depleted soils and high levels of rural under-employment as labor extensive activities (such as dairy) have replaced labor intensive coffee production. There is very little mechanization in the region.

The second municipio, Capinopolis, is favored by rich alluvial soils and gently sloping land. Long recognized as one of the most mechanized regions of Brazil [8, p. 43], corn and rice yields in Capinopolis have consistently been among the best in the country. Until recently Capinopolis was considered part of the agricultural frontier, but the rapid expansion of a national transport network and development of Brasilia to the north recently integrated Capinopolis with major urban markets.

While neither of the two municipios possess all the characteristics of traditional agriculture, Muriae is considerably more traditional than is Capinopolis. Thus the two municipios provide a basis for a comparison of two levels of modernization of agriculture within a single LDC.

Indiana Data. Indiana is one of the leading agricultural states in the United States. Located in the corn belt, the major enterprises are corn, soybeans, swine and cattle. Farming in the state is characterized by high average levels of mechanization and technology. Both the level and the rate of investment in Indiana agriculture are among the highest in the U.S.A.

The data for Indiana that were used in this study were taken from the 1970 Purdue University Farm Records. These data are collected annually from nearly 500 volunteer participants. Since participation in the program is voluntary, the sample is not based on a random selection procedure. The use of a non-random sample in the present study is not a serious limitation because there is no a priori reason to expect the average U vector of the Purdue sample to be different from that of the population being sampled.

Price and Yield Data. Historical data for prices and yields in Indiana and Brazil were taken from secondary sources [2; 13]. For Brazil it was necessary to use national, rather than state or regional data. Implicitly it was assumed that the variability found in the nation approximates that found in Capinopolis and Muriae. State level data were used for Indiana prices and yields. All prices in both regions were deflated to a base period and secular trends in yields were removed. All data cover the period 1947-1970.

Results

The hypothesis to be tested suggests that the risk of anticipated income streams from investments in agriculture is greater in two regions of Minas Gerais (Brazil) than in Indiana (USA) and greater in the more traditional of the two Brazilian regions. Risk indicies were computed

according to (2) for each firm surveyed. Mean risk indicies for each survey region are shown in Table 1. In each region, the standard deviation of income over the simulation period was approximately 15% of mean income. While Indiana's mean risk index is slightly higher than for either region of Brazil, the difference between the sample means is not statistically significant at the 5 percent level.

Table 1.
Sample Values of the Risk Index for Indiana and Minas Gerais, 1970.

Sample Region	Risk Index	
	Sample Mean	Sample Variance
Indiana (USA)	15.1553	10.7696
Minas Gerais (Brazil)		
Muriae	14.9869	15.2098
Capinopolis	13.1248	16.6250

The nature of the risk index distributions in each region is shown in Table 2. Again, there is little appreciable difference among the three samples. Therefore, the hypothesis is rejected. Based on the measure of risk adopted for this study, no significant difference was found between the income risk of farmers in one region of the USA and farmers in two regions of Brazil.

Table 2.
Distribution of Sample Risk Indicies for Indiana and Minas Gerais, 1970.

Point on Distribution	Value of Risk Index for -		
	Indiana (USA)	Minas Gerais (Brazil)	
		Muriae	Capinopolis
Maximum	25.3264	25,5203	24.8687
Upper Quartile	17.5544	17.8774	14.5785
Median	15.0453	14.0759	12.6359
Lower Quartile	12.1117	12.0728	10.4319
Minimum	8.4491	8.3086	6.7601

Discussion of the Results

The above results could conceivably be misleading, and open to erroneous interpretation. Often it is argued that farmers diversify their enterprise patterns as a risk avoidance strategy. By producing a few units of many enterprises it is usually possible to reduce risks relative to that inherent in monoculture or highly specialized enterprise structures [14]. If the income risk for individual enterprises is greater in Minas Gerais than in Indiana, then farmers in Minas Gerais could have developed enterprise structures that are diversified sufficiently to reduce total income risks to an acceptable level. The net result of such a strategy would be an apparent parity of income risks in the two countries caused by significant differences in the level of enterprise diversification adopted.

It is possible to test for differences in the level of diversification of enterprise structures using an index of diversification that was developed by the authors [1, p. 9-12]. The level of diversification for a given enterprise pattern is related to two factors: the number of enterprises; and, the relative importance of each enterprise in the overall structure. An index including both of these dimensions that is logically consistent with the usual connotation of diversification is defined by:

$$(3)\quad \text{diversification index} = \sum_{i=1}^{m} \frac{V_i}{2^{(i-1)}}\,,\ V_i > V_{i+1} \quad \text{for all } i$$

where V_i is the proportion of total output value generated by the i^{th} activity ($V_i = U_i P_i Y_i / \Sigma_i U_i P_i Y_i$). As the firm becomes more specialized, the value of the index increases toward its theoretical maximum of 1.0. For a multi-enterprise firm, the value of the index approaches this limit as the relative proportions among activities become more concentrated, and as the number of enterprises is reduced. While the absolute value of the index has no meaning, it is meaningful in a relative sense.

Diversification indicies were computed for each firm in the three samples based on the observed U vector and 1970 price and yield data. The mean values of the diversification indicies in each survey region are presented in Table 3. There is no statistically significant difference, at the 5 percent level, between the values of the indicies from the two regions of Brazil and that of Indiana.

Therefore, the level of risk avoidance that is implied by the firm's enterprise diversification is about the same in each of the regions. Unless there is a radical difference in the magnitude of the covariances between enterprise income streams in the regions, this result suggests that the level of enterprise diversification has a neutral effect on interregional difference in the magnitude of the risk index. In other words, no evidence of differences in the risk confronting farmers in Minas Gerais and Indiana has been identified. Consequently,

Table 3.
Sample Values of the Diversification Index for Indiana and Minas Gerais, 1970.

Sample Region	Diversification Index	
	Sample Mean	Sample Variance
Indiana (USA)	0.6981	0.0123
Minas Gerais (Brazil)		
Muriae	0.7494	0.0149
Capinopolis	0.7162	0.0169

the hypothesis of this paper is rejected, suggesting that relatively high levels of risk for expected returns to investments is not a sufficient explanation for low rates of investment in Minas Gerais relative to Indiana.

Summary and Conclusions

Low growth rates in traditional agriculture may be explained by relatively low rates of investment in that sector. If traditional farmers are rational in their investment behavior, then low rates of investment must be due to relatively low certainty equivalent returns from those investments. That is, either the expected returns from investments are low, or the risk associated with the income streams those investments will generate are high, or both. Using cross-country data, this paper has tested the hypothesis that the risks associated with the income streams from existing investments in agriculture are greater in two regions of Minas Gerais (Brazil) than in Indiana (USA).

An index of the income risk associated with existing enterprise structures was not found to be significantly different in the three areas. This result could imply that farm operators in Minas Gerais have diversified their enterprise structures (relative to those in Indiana) in an explicit effort to avoid high levels of risk extant in single enterprise. However, it was shown that the level of diversification in Indiana was not significantly different from that found in either survey region of Minas Gerais.

Therefore, the hypothesis of high income risks for investments in Minas Gerais agriculture relative to those in Indiana is rejected. Several implications flow from this finding. In the first place, it would appear that institutions largely responsible for mitigating income variability (price supports, etc.) are equally effective in the

two countries. This is particularly significant in light of the recent Brazilian experience with widely fluctuating rates of inflation.

With regard to the main theme of this paper, our results lead to the conclusion that low rates of investment in Brazilian agriculture relative to Indiana agriculture should be attributed to relatively low rates of expected return rather than to relatively high rates of risk. Policies aimed at stimulating investments in research and human capital are suggested as one means of increasing the rate of return that can be expected from all investments whether in traditional or non-traditional capital forms. Finally, policies designed to reduce or compensate the supposed risk associated with the adoption of new technologies (technical risk) must also be dealt with effectively if investments in research and human capital are to effectively enter into the production process.

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