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Impact and implications of price policy and land degradation on agricultural growth in developing countries

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ABSTRACT

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In many developing countries, a high proportion of the population resides and works in rural areas. Agriculture is the dominant sector in rural areas and has the greatest concentration of poverty: landless workers, small tenant farmers, and small farm owners. Thus, any development strategy that is directed towards increasing employment and alleviating a country's hunger must concentrate on sustainable agricultural growth.

Historically, economic development in most countries has been based on exploitation of natural resources, particularly land resources. Soil erosion and land degradation have been serious worldwide. Due to reasons such as high population pressure on land and limited fossil energy supplies, land degradation is generally more serious in the developing world. Empirical studies show that soil erosion and degradation of agricultural land not only decrease the land productivity but they can also result in major downstream or off-site damage which may be several times that of on-site damage.

In promoting industrialization, governments of many developing countries adopt a package of price and other policies that reduce agricultural production incentives and encourage a flow of resources out of agriculture. Increasing evidence shows that these policies cause a substantial efficiency or social welfare loss, and a great loss in foreign exchange earnings. In addition, a World Bank study on the effect of price distortions on economic growth rates concluded that neither rich resource endowments, nor a high stage of economic development, nor privatization are able to make up the adverse effects caused by high price distortions.

This analysis is primarily concerned with identifying the factors that determine the agricultural production growth rate and in testing the effects these factors have on agricultural growth in developing countries. Specifically, this study involves statistical estimation of an aggregate agricultural growth function based on cross-country data for 28 developing

countries. Special attention is devoted to land degradation and agricultural pricing policy, and to the policy implications resulting from the effects these variables have on agricultural and food production growth.

The overall results of this study show that price distortions in the economy and land degradation had statistically significant negative impacts while the change in arable and permanent land was positively related to the growth of agricultural production and food production in 28 developing countries from 1971 to 1980. These results emphasize the importance of 'getting prices right' and implementation of sustainable land and water management practices if future growth in food and agricultural output is to be realized and sustained in developing countries.

INTRODUCTION

In many developing countries, a high proportion of the population resides and works in rural areas. Agriculture is the dominant sector in rural areas and has the greatest concentration of poverty: landless workers, small tenant farmers, and small farm owners. Thus, any development strategy that is directed towards increasing employment and alleviating a country's hunger must concentrate on agricultural development. Sustainable agricultural growth is the key to the achievement of these goals.

Disparity in agricultural growth among developing countries has been attributed to many factors and a large body of literature exists on the interrelationships between agricultural growth and these factors. Many of these studies are mainly based on conceptual analysis, or general observations, with a few regression analyses. This has resulted in an overemphasis on a few factors and neglect of others. Although conceptual analysis and general observations have suggested that land degradation and price distortions greatly influence agricultural production, little effort has been made to evaluate statistically the effect of these factors.

Historically, economic development in most countries has been based on exploitation of natural resources, particularly on exploitation of land resources. Soil erosion and land degradation have been serious world wide. Due to reasons such as high population pressure on land, and limited fossil energy supplies, land degradation is generally more serious in the developing world. Empirical studies show that soil erosion and degradation of agricultural land not only decrease the land productivity but they can also result in major downstream off-farm or off-site damage (Clark et al., 1985; Crosson, 1985; Hauck, 1985; Warford, 1987). Furthermore, the off-site damage may be several times that of on-site damage (Clark et al., 1985; Crosson, 1985).

In promoting industrialization, governments of many developing countries adopt a package of policies that reduce agricultural production incentives and encourage a flow of resources out of agriculture. An increasing amount of evidence shows that these policies cause a substantial efficiency

and social welfare loss, and a great loss in foreign exchange earnings.¹ In addition, a World Bank study on the effect of price distortions on economic growth rates concluded that neither rich resource endowments, nor a high stage of economic development, nor privatization are able to make up the adverse effects caused by high price distortions (Argawala, 1983).

This study is primarily concerned with identifying the factors that determine the agricultural production growth rate and in testing the effects these factors have on agricultural growth in developing countries. Specifically, this study involves statistical estimation of an aggregate agricultural growth function based on cross-country data for 28 developing countries. Special attention is devoted to environmental degradation, and agricultural pricing policy and to the policy implications resulting from the effects these variables have on agricultural and food production growth.

MODEL SPECIFICATION AND DATA

The methodology used in this study is based on the concept of a metaproduction function hypothesized by Hayami and Ruttan (1985). Following Lau and Yotopoulos (1987), this metaproduction function can be written as:

$$Y_t = f(X_{1t}, \dots, X_{mt}, t) \quad (1)$$

where Y_t is the quantity of output, X_{it} is the quantity of i th input, $i = 1, \dots, m$, and t is time. This production function can be used to represent the input-output relationship of agriculture or food production. As defined by Lau and Yotopoulos, the embedded hypothesis for this metaproduction function is that all producers (or countries) have potential access to the same set of technology options but each may choose a particular one, depending upon its natural endowment and relative prices of inputs. In this study, a metaproduction function similar to equation (1) will be estimated. However, since our focus is not on the estimation of productivity changes, the time variable t is replaced by two variables, land degradation and price distortion. These two variables are hypothesized to have impacts on technology choices among different countries during the study period.²

¹ Estimation of these losses can be calculated by a set of formulas, which is based on the nominal protection coefficients (NPC). NPC is defined as P_d/rP_w , where P_d is domestic price, P_w is world price and r measures the degree of protection [see Bale and Lutz (1981) for details].

² Note that the price distortion level measure used in this study reflects all price distortions in the economy to be discussed later. It is not limited to price distortion in the agricultural sector. Therefore, it is appropriate to treat this variable as exogenous in the model.

Since in this study we are interested in estimating the relative changes in output rather than the absolute levels of output, the dependent variables are expressed in relative terms as a percent change or average level of output during the study period. Following Hayami and Ruttan (1971), the inputs may be categorized as: (1) internal resource accumulation, including an expansion of the arable and permanent crop land, and the growth of labor force; and (2) technical inputs supplied by the nonagricultural sector. Two industrial inputs, fertilizer and machinery, represent proxies for the whole range of inputs that include modern biological and mechanical technologies.

It is widely recognized that government policies may greatly affect agricultural production growth in developing countries (Krishna, 1982; Argawala, 1983; IBRD, 1986). Most of these studies conclude that the general economic policies pursued in developing countries have limited the growth of agricultural production and hampered efforts to reduce rural poverty.

Although price is not a complete measure of incentives in agricultural production, it is one of the most important policy devices. Agricultural price policy has been actively used by virtually all governments to pursue a wide variety of resource allocation and income distribution objectives. The fact that most developing countries discriminate against agriculture is reflected in price distortions.

The agricultural or food production growth function can be established by estimating the coefficients between agricultural/food production growth and the changes in the relevant independent variables. The growth of total agricultural production or food production is affected by changes in the same factors. Based upon discussions above, the aggregate agricultural or food production growth function can be expressed in the following form:

$$Y_g = f(A_g, L_g, Q, F_g, M_g, G)$$

where Y_g is growth rate of agricultural or food production, A_g is rate of change in labor input, L_g is rate of change in land cropped, F_g is rate of change in fertilizer consumption, M_g is rate of change in machinery power utilization, Q is quality of arable land or soil, and G is government policies, e.g., price, land use.

Those variables with subscript 'g' are flow variables, and they should be measured in growth rate. 'Q' and 'G' can be seen as stock variables and the average values are to be used in estimation.

The approach used in this study involves estimating a cross-country agricultural growth function based on a sample of 28 countries in the Third World. Variations in agricultural growth rate are accounted for by differences in the growth rate of agricultural inputs and related factors. All the data used in this study are from the period of 1971–1980. The data for flow

variables are the average of 1971–1980 and the data for stock variables are the 1975 actual figures.

Agricultural development is a multi-dimensional rather than a unidimensional economic phenomenon. The agricultural sector covers not only food production, but also non-food products and the food related activities such as post-harvest processing, food storage and distribution. Therefore, one of the measures should reflect the growth of all agricultural activities. However, in most of the developing countries, food production growth is the first and foremost goal in agricultural development. Thus, two measures of agricultural growth are developed in this study. One is the growth of total agricultural production – gross domestic product produced in agriculture and the other is the growth of total food production (mainly grain and livestock). The two dependent variables can be defined as: TFP, growth of total food production during the period of 1971–1980; and TAP, growth of total agricultural production during 1971–1980.

The independent variables used in this study include LAND, the change in arable and permanent land area during 1970–1980, and LD, land degradation level. In this study, land degradation level refers to erosion from water, wind, waterlogging, salinization, compaction, surface crusting and destruction of vegetative cover and it is used to reflect the average degradation level or quality of the agricultural land in the 1970s. It is based on categorical data, and the three categories of HIGH, MOD(erate) and LOW are based on Dregne's (1982) four-category classification: slight, moderate, severe and very severe.³ FERT is the change in fertilizer consumption per hectare of arable and permanent crop land during 1971–80. All fertilizers are adjusted to a standard unit in terms of plant nutrients. TRACT is the growth in number of tractors per 1000 ha of arable land and land under permanent crops between 1971 and 1980. PDL, the price distortion level, is derived from the so-called 'price distortion index' developed by Argawala (1983) which involved summation of high (3), medium (2) and low (1) 'scores' for seven subindices of distortion.⁴ The price distortion level rather than the price distortion index is used because the index is basically categorical not continuous and its estimated coefficients are not interpretable. Therefore, the price distortion level is categorized as low, moderate, and high based on the price distortion index.

³ There were no countries in this study with a very severe classification, e.g., land denuded of vegetation, severe gullies and blow out areas from erosion, and crop yields reduced more than 90%. Slight degradation involves less than 10% reduction in crop yields, excellent to good range condition and to slight erosion [see Dregne (1982) for further detail].

⁴ Distortion level in exchange rate, pricing in agriculture, interest rates, wages, overall price level and infrastructure pricing in power utilities as well as the protection level for manufacturing industries.

Two measures of growth are compared in this study. One is a percent measure for all flow variables. Under this approach, growth is measured as the average annual rate of increase (or decrease) during 1971–1980. The other measure is to compute the average index during 1971–1980, with 1969–1970 being 100. The latter measure was used in some FAO statistics (e.g. FAO, 1984) and this average index growth measure is especially appropriate when growth experiences great fluctuations.⁵

Every effort was made to include as many countries as possible in the analysis. However, problems of missing, incomplete and unreliable data required that guidelines be developed and applied systematically in the selection of individual countries for inclusion in the study. To have a data set which is representative of the Third World, the following three guidelines were applied in the country selection. (1) Only nations with population equal to or larger than one million people in 1970 were included. (2) The countries that had severe political turmoil, natural catastrophe, or were at war during the 1970s were excluded, such as Ethiopia, Egypt, Afghanistan and Cambodia. (3) Only countries with data available were included. Under these criteria, 28 countries are included in this study.⁶ One major restriction is the availability of data on the price distortion variable.

Because of the aggregate nature of the data used and the absence of resources for primary data collection, all data were from secondary sources. Information regarding land degradation and price distortions were derived from published research by the USDA and the World Bank, respectively. Other data were collected from various statistics published by FAO, and the World Bank.⁷

ANALYSIS AND RESULTS

Table 1 summarizes the main results of the estimation of the aggregate agricultural production and the food production growth function. Considering the aggregate nature of the secondary data, the levels of statistical significance of several of the estimated coefficients are quite good. The six independent variables in the model can explain as high as 82% of the

⁵ For example, when a growth pattern is: 100, 115, 110, 105, the average percentage growth is 2.4; but when the growth pattern is 100, 105, 110, 115, the average percentage growth rate is 4.8. The average index number will be the same for both patterns.

⁶ Countries included are: Argentina, Bangladesh, Bolivia, Brazil, Chile, Colombia, Ghana, India, Indonesia, Ivory Coast, Jamaica, Kenya, South Korea, Malawi, Malaysia, Mexico, Nigeria, Pakistan, Peru, Philippines, Senegal, Sri Lanka, Tanzania, Thailand, Tunisia, Turkey, Uruguay, Yugoslavia.

⁷ Data on TAP, TFP, TRACT, FERT are from FAO (1984). LAND is from FAO (1981b, 1985). PDL is derived from Argawala (1983), and LD is from Dregne (1982).

variation in total agricultural production, and about 78% of the variation of food production when growth is measured by the average index. However, the models based on percentage growth measure are less satisfactory, and the R^2 's for the TAP and TFP models are 0.66 and 0.68, respectively. The F tests show that one can be 95–99.99% confident of rejecting the hypothesis that all the estimated coefficients are zero for the four models. These models, as a whole, are quite well defined and the multicollinearity problem in the statistical analysis does not appear to be serious based on the SAS collinearity diagnostics procedure (Belsley et al., 1980).

Land degradation. Even though the data are categorical (three classifications) and thus gross measures, the statistical significance is relatively strong. Based on the percentage measure, the estimate of the moderate level of land degradation is significant at the 5% level in the total agricultural production growth model, and the estimate for food production growth is significant at the 2% level. If the growth is measured by the average index, the estimate for moderate land degradation is not significant in the total agricultural production growth model. It is, however, still significant at the 15% level in the food production growth model. When comparing the absolute values of the estimates and their corresponding significance levels, the land degradation variable has higher absolute coefficient values, and the estimates are more significant in the TFP than in the TAP models. This difference indicates that land degradation tends to affect food production more significantly than it affects non-food agricultural production. The result seems to confirm the belief that land degradation does threaten food production growth. It also impedes income increases in rural areas because of a direct relationship between farmers' income and food production growth. Notice that the estimated coefficients of the high degradation level have wrong signs and are insignificant at the 15% level. This may be due to the fact that there are only three countries with a high degradation level, which results in large standard errors of the coefficient estimates.

Price distortion level. Table 1 shows that the price distortion level is statistically a highly significant variable for explaining both total agricultural production growth and food production growth. The estimated coefficients for severe distortion in all three models are significant at the 2% level, i.e., one could be 98% confident in saying that high price distortions greatly reduce agricultural production growth and food production growth.

The estimated coefficients for moderate distortion are smaller in magnitude and less significant statistically than those for high price distortion. For example, the coefficient of moderate price distortion in the food production growth function (based on the average index measure) is -5.3 and it is

TABLE 1

Estimates of agricultural growth function on cross-country data, 1971–1980

Dependent variable	Independent variable	Coefficient estimations	
		Percent growth measure	Average index measure
TAP	(Intercept)	3.433 *** (4.14)	80.552 *** (5.28)
	LAND	0.114 (0.54) [0.046]	0.461 *** (3.73)
	LD		
	moderate	−1.135 ** (−2.07)	−0.871 (−0.34)
	high	0.180 (0.22)	7.049 (1.53)
	FERT	0.003 (0.12) [0.011]	0.001 (0.15)
	LABOR	0.229 (0.94) [0.061]	−0.033 (−0.22)
	TRACT	0.053 ** (1.89) [0.162]	0.009 (1.21)
	PDL		
	moderate	−0.246 (−0.41)	−9.637 ** (−3.17)
	high	−1.858 *** (−3.29)	−20.013 *** (−7.00)
		$R^2 = 0.655$	$R^2 = 0.821$
		PROB > $F = 0.0051$	PROB > $F = 0.0001$

significant at the 15% level, while the coefficient for severe price distortions is -19.2 and is significant at the 1% level. It is interesting to note that the estimates of moderate price distortions are significant at the 15% level when growth is measured as an average index, but not significant when growth is measured as an average percentage. However, the significant estimates of moderate distortions in the average index TAP and TFP growth models and the highly significant estimates of high distortions in all four models are consistent with several studies on individual countries or individual crops (e.g. Timmer and Falcon, 1975; Grigshy and Arnade, 1986). To measure

⁸ These regression results show that the price distortion level alone can explain more than 43% of the variation in percentage agricultural production growth, 40% of the variation in percentage food production growth, 64% of the variation in the index of agricultural production growth, and 60% of variation in the average index of food production growth.

TABLE 1 (continued)

Dependent variable	Independent variable	Coefficient estimations	
		Percent growth measure	Average index measure
TFP	(Intercept)	3.297 *** (4.28)	80.568 *** (4.55)
	LAND	0.136 (0.56) [0.056]	0.404 ** (2.82)
	LD		
	moderate	-1.628 ** (-2.65)	-4.795 * (-1.62)
	high	0.517 (0.56)	4.424 (0.83)
	FERT	0.004 (0.13) [0.015]	0.003 (0.31)
	LABOR	0.273 (0.97) [0.075]	0.040 (0.23)
	TRACT	0.064 ** (1.98) [0.203]	0.006 (0.68)
	PDL		
	moderate	0.600 (0.87)	-5.332 * (-1.51)
	high	-1.677 ** (-2.62)	-19.150 *** (-5.77)
		$R^2 = 0.682$	$R^2 = 0.778$
		PROB > F = 0.0017	PROB > F = 0.0001

Linear equations are estimated by the least squares method. *** indicates that the coefficient is significant at 1% level, ** at 10% level, and * at 15% level. Figures in parentheses are *t*-values and figures in brackets are mean value elasticities.

how much variation in agricultural or food production growth the price distortions can explain, simple linear models were estimated and reported elsewhere (Zhao, 1988).⁸

Other factors. The positive relationship between the land-area-change rate and agricultural production growth or food production growth are quite strong with both significant at the 1% level based on the index measure of growth. However, the estimates are insignificant in percentage measured growth models. In contrast to the negative influence of the land degradation factor (LD) discussed above, the amount of arable and permanent crop land is strongly related to agricultural and food production growth. Reduction in

severe land degradation should increase the future availability of arable and permanent land which may increase agricultural output.

The estimates for LABOR and FERT are not significant in any of the four growth functions. While the estimation results for FERT may be unexpected, the insignificant estimates of LABOR are believed to be due to an excess labor supply in the rural areas of many developing countries. Thus, increases in labor supply may have a negligible impact on agriculture and food production growth. The estimates for mechanical power are not significant when growth is measured in the average index, but they are significant at the 10% level in the percentage TAP and TFP growth models. The difference may be attributed to the measurement disparity.

SUMMARY AND CONCLUSIONS

The results of this study show that price distortion in the economy and land degradation had statistically significant negative impacts while the change in arable and permanent land was positively related to the growth of agricultural production and food production in 28 developing countries from 1971 to 1980. These results emphasize the importance of 'getting prices right' and implementation of sustainable land and water management practices if future growth in food and agricultural output is to be sustained in developing countries.

Among the six variables studied, the price distortion level is the most important variable in explaining the variation in total agricultural production growth and food production growth. These results suggest that price distortions impact not only food production growth, but also overall agricultural development. Countries with slight price distortions are found to have relatively high agricultural/food production growth, while countries with severe price distortions generally have low agricultural/food production growth. This evidence supports the conclusion in Argawala's study that neither the availability of resources (e.g., in Peru and Chile), nor the higher stage of development (e.g., in Argentina), nor privatization (e.g., in Chile) was adequate to prevent low agricultural or food production growth when price distortions were high. Comparing Argawala's simple regressions with those in this study shows that price distortion affects agricultural growth more significantly than it affects overall economic growth.

The next variable of great significance is the degree of land degradation. The reduction in overall agricultural (as opposed to food) production growth caused by land degradation is smaller in magnitude and less significant statistically. The regression results confirm the belief that land degradation in developing countries does constitute an immediate as well as long run threat to these countries' capacity to produce food. The estimation in this

study failed to capture the offsite damage from land degradation, e.g., water pollution and siltation of hydropower reservoirs and harbors. Thus, the actual negative effects are likely to be much larger and more significant than estimated, since off-site impacts of soil erosion are generally much greater than on-site impacts.

Two major policy implications can be summarized as (1) sustainable agricultural growth, and (2) 'getting prices right'.

Sustainable agricultural growth. Most developing countries are more dependent on their natural resources, notably land and water, and land degradation significantly threatens agricultural growth. Soil and water conservation is of great importance to sustainable economic development. Past development efforts have been based on the exploitation of natural resources in many developing countries. In the long run, land protection and agricultural growth are complementary rather than competitive, even though there might be some tradeoff between the two in the short run. Not only conservation projects but also policy reforms are needed to protect the soil base. Policy reforms require that soil conservation, proper drainage in irrigation projects, etc., be incorporated as an integral part of a development program.

The policy reforms should focus on increasing economic incentives for conservation. Since in the majority of developing countries, most agricultural activities are done by small operational units, such as households and small farms, appropriate economic incentives for millions of farmers are vital in the Third World to channel development activities into sustainable development patterns. Studies show that the serious degradation is primarily due to the cumulative effects of many small agricultural operations that are not affected by environmental regulations (IIED/WRI, 1986; Repetto, 1987). The appropriate economic incentives may include increasing agricultural prices to the competitive level, reducing taxation on agricultural production, establishing effective property rights, providing subsidies and assistance for conservation practices, and eliminating input subsidies.

Correcting farm level disincentive problems is inadequate because soil erosion causes major off-site impacts which are not borne by farmers. In addition, farmers' time horizons are much shorter and their discount rates much higher than the society at large. Therefore, public interventions and national actions are usually required to ameliorate the effects of soil erosion and degradation including better defined property rights, government regulations on land use and the traditional approach to environmental problems—public authorities investing in reforestation and pollution control projects.

'Getting prices right'. Price distortions result in great losses of agricultural production in the Third World. The statistical results in this study confirm

the conclusions that many theoretical analyses and empirical observations have reached. Schultz's perspective that the economic potential for agricultural development has been largely unexploited because of the low incentives caused by the low prices of agricultural products is borne out, but development must also be sustainable from an environmental perspective. To promote industrialization by means of lowering agricultural prices is, at least, not efficient. The costs are too high, and evidence shows that the costs are borne not only by agriculture, but the whole economy. To have a high economic growth and at the same time have a high agricultural growth, 'getting prices right' is a necessary condition.

Many countries have emphasized the importance of agricultural development, but they also often have complex policies that consistently tax agriculture, mainly by keeping agricultural prices low. To offset the detrimental consequences of price distortions, many governments try to promote agricultural growth by providing farmers with cheap credit and/or cheap inputs, such as fertilizers and machinery. These methods cause an inefficient allocation of resources. For example, subsidies on fertilizers in some areas result in a shortage in other areas. Since credit is highly fungible, cheap credit may not go to the targeted agricultural activities, or it may go to some non-agricultural activities, which are more profitable than agricultural activities. Thus, cheap credit is not effective in promoting agricultural development.

In some sense, 'getting prices right' also applies to the argument for a sustainable pattern of growth. One of the most important causes of environmental degradation is that environmental services are undervalued. Activities that exploit land resources and cause land degradation are not priced or taxed, or, at least, not priced at their marginal social valuation. The problem of inadequate land and water management or exploitation of land and water resources is similar to the undervaluation of commodities or credit – the natural resources are overused and they are undervalued. Thus, the arguments for well defined property rights, pollution taxes and implementation of conservation measures is 'getting prices right on environmental services'.

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