SUPPLY RESPONSE BY TRADITIONAL AND COMMERCIAL PRODUCERS OF BASIC GRAINS IN LDCs*

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Traditional farms can play an important role in the agricultural development process [4, 6, 7, 8]. Less developed countries (LDCs) emphasize production and productivity increases for basic grains by relying on modern yield-increasing technology [2]. Technological advance, however, may produce diverging results; productivity may increase while production stagnates or declines. Due to both major seasonal and cyclical price fluctuations in basic grains and income limitations, traditional farmers in LDCs choose, quite rationally, to grow only enough of some food crops for home consumption. Yet policy makers often seek to increase the marketed supply of food crops and to determine possible changes in land utilization to meet that objective.

Knowledge of total supply and market supply responses by traditional farmers to changes in production, income and prices under varied regional conditions is lacking. Nearly forty authors have estimated the sign and magnitude of price elasticity of marketable surplus.[1] Many encounter an inverse relationship between surplus and price attributed primarily to: (1) the relatively fixed demand for money by subsistence farmers calling for sales only to the level of money needed, and (2) increasing subsistence crop prices which stimulate an increase in the farmer's income such that the income effect on his demand for consumption of the crop outweighs the substitution effect in production and consumption. For either cause, marketable surplus may be inversely related to price [5]. Why the two causal phenomena happen in some but not all regions of a country, and how one can predict and measure effects of this behavior, remain unanswered.

MODEL DESCRIPTION

The environment in which a traditional farmer lives determines his consumption and selling decisions. Many grow basic grains mainly for home consumption. At harvest time they dispose of their production in several ways. A large share is kept for family consumption and other noncash purposes such as feed, seed and payments in kind. Part may be sold at harvest time or throughout the year as cash is needed and/or high prices stimulate sales.

The hypothetical price-income-consumption (PIC) path developed in Figure 1 (A) illustrates the traditional farmer's consumption and selling decisions and is used to develop his market supply curve for a product. Due to his subsistence needs, a traditional farmer's demand and supply situation is somewhat unique as depicted by the PIC path for a commodity produced and consumed at the farm level. Assume the farmer is at point Z, where price is P_a and increases to P_b. His income will increase. The income effect created by this price increase causes him to move up and along the PIC path. Most food crops produced on the farm can be considered inferior goods; since the traditional farmer usually has so little income, a small price increase may produce significant change in his income position such that he is willing to consume less of the product. Since he is his own supplier, the farmer can reduce his consumption. As the process is repeated, a PIC path is developed. Total output is fixed at OB and the amount OC is the minimum necessary for family subsistence and seed for the coming season. If quantity OB is desired for home consumption and other noncash purposes, the

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[1] For a complete discussion of the literature reviewed on this subject see [1].

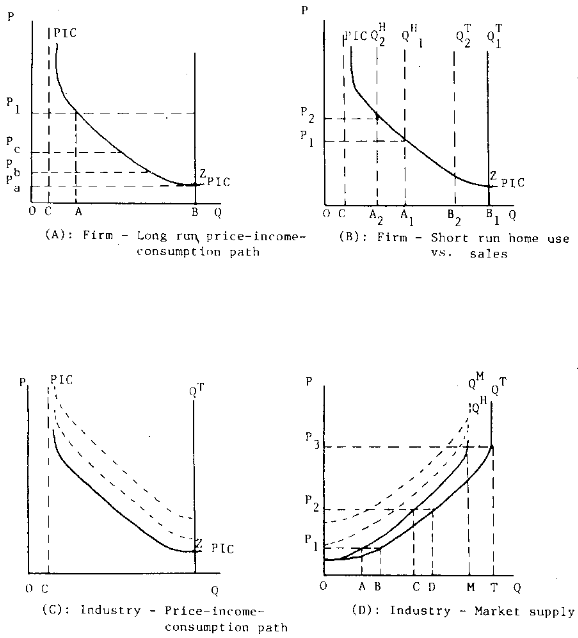

FIGURE 1. LDCs TRADITIONAL FARMER CONSUMPTION AND SELLING DECISIONS

farmer will not sell any output. However, cash needs or higher prices throughout the year might induce him to sell some of his product and forego some consumption. For example, if the price is P_1, with other products' prices being constant, the farmer keeps OA and sells AB.

The decision process at harvest time and for the short-run, depicted in Figure 1 (B), depends primarily on product price, home consumption needs, and cash needs to purchase other goods. At harvest, total supply is Q^T_1. If the price is P_1, the farmer expects to consume OA_1 (Q^H_1 = quantity used at home) and to sell A_1B_1 (Q^M = quantity marketed). This decision at harvest time establishes OA_1 and A_1B_1 as supply and demand proportions for the year if price stays at P_1. When all the output is sold at harvest, no further decisions are possible. If the farmer did not sell everything at harvest, Q^T_2 becomes the new fixed total supply curve, since B_2B_1 was sold or consumed. At P_1 expected home use would remain at Q^H_1. However, as price rises to P_2, home use declines to Q^H_2 or OA_2 and sales are A_2B_2 thus re-establishing demand and supply proportions. The process, when induced by increasing prices, may continue until Q^T reaches the amount where the PIC path becomes asymptotic to the Y axis at OC, the minimum needed for family subsistence and seed. It may happen that, as Q^T shifts left during the marketing period, prices above P_2 result in decreasing quantities marketed. Little or no surplus available when prices keep rising may stimulate inverse relationships between prices and quantities marketed. For price declines, the process is also operative and illustrates greater home use relative to sales for the short run or one season.

From the PIC path for each traditional farmer, as illustrated in Figure 1 (A), a community of price-income-consumption paths can be developed as in Figure 1 (C). Effects of price and income changes, (e.g., constrained variables) result in movements along the path. Other variables influence the position of the PIC path. While increases in farm size and in level of education, other things remaining equal, make the path shift downward, the opposite occurs as distance to market and quantity demanded on the farm increases. If the profitability of other grains rises, the PIC path also shifts upward. As the path approaches the total production constraint (Q^T), it becomes more elastic. At point Z, elasticity of the PIC path is infinite; price is so low at this point that farmers decide to consume everything they produce since there is no incentive to forego consumption through sales in the market.

The hypothetical PIC paths, when aggregated, are used to derive market supply (Q^M) shown in Figure 1 (D). By starting at point Z and moving up and along the PIC path, quantities marketed at different prices can be read to establish Q^M. If quantities used on the farm (Q^H) are added to Q^M, the total quantity produced (Q^T) is identified[2]. At this point, Q^T does not present the completely vertical shape that the fixed total supply curve shows in sections (A), (B) and (C) of Figure 1. Although Q^T is fixed until the next harvest, it decreases during the marketing period as the farmer alters his consumption and selling decisions due to changes in income created by price changes. For that reason, when Q^H (OC or MT) is added to Q^M, Q^T slopes upward. At P_3, however, both annual supply functions (Q^T and Q^M) are perfectly inelastic and will not be affected by further price increases. Here the basic identity $Q^M + Q^T - Q^H$ will not be subjected to further alterations until the following harvest. There is an infinite number of PIC paths, representing numerous farm families. There is also an infinite number of combinations that can be made between Q^H and Q^M. Therefore, since Q^T shifts over the marketing period, there is an infinite number of possible Q^M curves as shown by

[2]Income level and farm area devoted to the crop in question provide offsetting influences on Q^H which are not measured in this research. As income rises with an income inelastic demand for a basic grain, consumption per capita at the farm level may decline while demand for seed may expand until the income supply response function Q^M becomes perfectly inelastic. For this reason a fixed Q^H is assumed.

Q_1^M to Q_n^M in Figure 1 (D). Since Figure 1 (D) is derived from Figure 1 (C), the starting points of all industry supply functions are completely elastic; such a low price does not induce farmers to market any output.

Assuming Q^M and Q^T in Figure 1 (D) are two observable supply functions, traditional farm market behavior can be further investigated. At price P_1, OT is total quantity produced (Q^T), AB is the quantity kept at home (Q^H) and OT minus AB is the quantity marketed (Q^M). As price rises, Q^H will fall until it reaches the minimum amount MT. At P_2, for example, OT is again total quantity produced (Q^T), CD is the quantity kept at home (Q^H), and OT minus CD is the quantity sold in the market (Q^M). Q^M is therefore not a fixed amount but because a function of price throughout the marketing period. Thus, knowledge of those conditions that induce changes in Q^T and Q^M are necessary to identify both curves and the implications of their relative locations and shapes.

Since the levels of Q^H observed are not actually purchased in the market at different prices, we can not obtain farm family demand functions, final equilibrium points and demand elasticities. Interest, however, is in determining supply responsiveness to changes in farm size and level of income.

SUPPLY RESPONSE TO CHANGES IN INCOME AND FARM SIZE

The impact of income changes on the crop mix use patterns by traditional farmers follows demand and supply theory. Varied levels of risk aversion are sought as relative incomes change. With few small and divided plots of land at his disposal, the traditional farmer grows primarily subsistence crops though he may also produce some cash crops where risk is minimal relative to that of other high value crops. Low risk cash crops, where adversity does not extend beyond normal weather fluctuations, are a source of income. These cash crops may receive government price protection.

The traditional farmer's behavior within his basic economic system is one of carefully balanced risk aversion, income maintenance and risk taking. As depicted in Figure 2, at very low levels of income or farm size, the farmer grows basic grains for subsistence though he may also sell part of his production. The difference between total quantity produced (Q_i^T) and quantity marketed (Q_i^M) of a traditional crop depicts home use requirements for consumption, seed and other purposes (Q_i^H). Since crop *i* is mainly intended for subsistence, the curves show some income responsiveness at very low levels of income and almost none at high income levels. As income

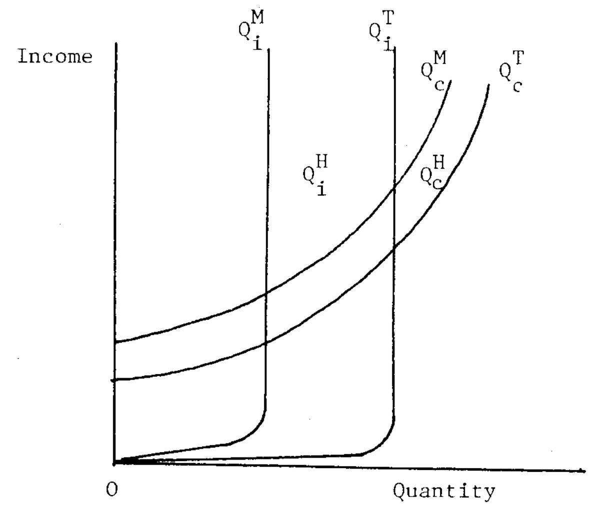

FIGURE 2. INCOME — QUANTITY RELATIONSHIPS FOR THE TRADITIONAL FARMER IN LDCs, GIVEN HIS LAND CONSTRAINTS

rises due to productivity and/or price reasons, the farmer will divert some of his land into other commercial crops (Q_c) while maintaining his self-sufficiency production on less land. In this case, the response will increase with income up to the point where he has no more land available for crop production or it is feasible to introduce another commercial crop.

Thus, as income rises, traditional farmers with their self-sufficiency guarnateed will tend to diversify production by growing high value crops until the land constraint is reached. Q_c in Figure 2 is not produced until a certain minimum consumption and income level is attained with basic and low risk crops. Income responsiveness of the higher value and higher risk crops is greater than for the traditional crops. Figure 2 is also operative to determine land use patterns when the vertical axis is labeled with different levels of farm size.

METHOD OF ESTIMATION

Based on the traditional farm decision process just described, the following market supply function can be estimated:

$$Q_i^M / Q_i^T = \beta_0 + \beta_1 \frac{1}{P_i} + \beta_2 E + \beta_3 \frac{1}{A_i} + \beta_4 D_i + \beta_5 I_i + \beta_6 W_i + \beta_7 \frac{1}{Y_i} + \epsilon_i \quad (1)$$

where

Q_i^M / Q_i^T = percent of grain production that is marketed (kg)

P_i = farm price of basic grain i (quetzales/kg) and estimated in reciprocal form

E_i = education of household head (number of years of formal education)

A_i = total farm size (ha) and estimated in reciprocal form

D_i = distance to the nearest market (km)

I_i = quantity of basic grain i demanded at the farm level for all purposes (kg)

W_i = return per hectare in all basic grains except basic grain i divided by return per hectare in basic grain i, and

Y_i = total family income (quetzales/kg) and estimated in reciprocal form.

The reciprocal is chosen for P_i, Y_i and A_i because in the theoretical presentation the function is hypothesized to slope upward to a point and then become vertical. Complete inelasticity occurs in the case of price, when the farmer will not sell any part of the quantity saved for home consumption and seed; in the case of income, when the subsistence level has been achieved; and in the case of total farm size, when other crops enter the production system. The rest of the variables are estimated in direct form.

The ratio of marketed output to total output (Q_i^M / Q_i^T) is estimated instead of Q_i^M alone because Q_i^T becomes a different constraint, based on farm size, for each farmer. The quantity retained for home use varies considerably among farmers and crops, and only a certain maximum percentage of total supply can be marketed. For a totally commercialized farm, the ratio equals one, while for a totally traditional farm it equals zero. A positive sign indicates that the crop becomes more commercial as independent variables increase while a negative sign indicates a tendency to more traditional, or less commercial crops for the direct variables (E_i, D_i, I_i, W_i) and the opposite for the reciprocal variables (P_i, A_i, Y_i). The ratio also becomes smaller or larger at different price levels due to the total production constraint.

Total farm size (A_i) is included instead of area producing each crop to account for differences in farm size and to illustrate variations in quantities marketed at different levels of farm size. Therefore, the same observation (A_i) per farm is used in the equations for each basic grain regardless of the amount of land devoted to production of that grain. Weight (W_i) should account for different basic grains grown by a farmer and, therefore, any possible substitution among them. For example, when commercial crops appear in the numerator, and the estimated crop is a traditional one, a negative sign may imply a shift to production of the more commercial crop. The remaining variables are self-explanatory.

Price (P_i), income (Y_i) and total farm size (A_i) carry negative signs if the function behaves as postulated. Quantity demanded at the farm level (I_i) is also expected to carry a negative sign. Distance to the nearest market (D_i) and education (E_i) are expected to have negative and positive signs, respectively; the greater the distance, the less output is expected to be marketed, and, as the level of education increases, farmers become more involved in activities of the monetary economy. The relative profitability ratio (W_i) will be positive or negative according to the traditional or commercial nature of crops in the region.[3]

RESEARCH RESULTS

Market supply equations for basic grains grown in the Central Highlands region of Guatemala are shown in Table 1. Cross-section data used came from the Small Farm Credit Survey conducted by the Government of Guatemala and the Agency for International Development (AID) in 1974 for agricultural activities during the 1973 calendar year.

In general the coefficients behave as hypothesized. Total income, quantity demanded on the farm and farm size (except for equation (3)) present expected signs and high levels of statistical significance. The distance coefficient in general is not significant and displays an unexpected sign, possibly because trucker-middlemen tend to move through many Central Highland communities several times a month. Positive signs for price coefficient reciprocals and statistical significance may express an inverse relationship between surplus and price; based on the conceptual model, farmers move up and along the PIC path during the year as prices rise and the marketing period draws to a close, leaving lower quantities available for sale. R^2's are low but characteristic of results from cross-section data.[4]

Income, farm size and price elasticities of market supply were computed (Table 2). At very low levels of income, farm size and price, the supply of basic

[3]Once Q_i^M / Q_i^T is estimated, both Q_i^M and Q_i^T can be obtained. From the theoretical presentation $Q_i^T \equiv Q_i^M + I_i$ is known.

[4]The low R^2's may be the result of some independent variables not considered. Examples would include family nutritional levels as related to nutritional needs; market intervention policies towards realizing consumption needs (food for work, input subsidies, etc.); extent of female participation in the farm labor force, and other related cultural conditions.

TABLE 1. REGRESSION COEFFICIENTS OBTAINED FOR EACH BASIC GRAIN OR ASSOCIATION IN THE CENTRAL HIGHLANDS OF GUATEMALA[a]

Crop[b] \ Coefficients	Constant	$\frac{1}{P_i}$	E_i	$\frac{1}{A_i}$	D_i	I_i	W_i	$\frac{1}{Y_i}$	d.f.	R^2
(1) W	0.92030	-0.00893	0.01989*	-0.03073**	0.00019	-0.00020*	0.01076**	-3.37986*	196	.37
		(0.00871)	(0.00509)	(0.01631)	(0.00049)	(0.00002)	(0.00648)	(0.96901)		
(2) C	0.44802	0.02884**	0.01116	-0.14456**	0.00176***	-0.00011*	0.00129	-20.41058*	78	.28
		(0.01312)	(0.01686)	(0.07254)	(0.00113)	(0.00003)	(0.00148)	(7.41719)		
(3) B	0.33231	0.07544**	-0.02071	0.31937*	0.00010	-0.00004	-0.00071	-16.94399*	13	.48
		(0.02915)	(0.02981)	(0.11896)	(0.00139)	(0.00006)	(0.00367)	(5.60921)		
(4) C-B	0.27392	-0.00524	0.00482	-0.08943*	0.00024	-0.00001*	0.00144***	-10.61613*	55	.33
		(0.00419)	(0.00541)	(0.01974)	(0.00040)	(0)	(0.00099)	(4.25824)		

[a]Figures in parentheses are standard errors.
[b]W, C and B, represent wheat, corn and beans, respectively.
*Significant at the 99 percent level; **the 95 percent level; ***the 90 percent level.

TABLE 2. INCOME, FARM SIZE AND PRICE ELASTICITIES OF MARKET SUPPLY FOR EACH BASIC GRAIN OR ASSOCIATION IN THE CENTRAL HIGHLANDS OF GUATEMALA

	CROP[a]			
	W	C	B	C-B
Income[b]				
100	0.02820	1.52148	0.72133	3.14180
200	0.00705	0.38037	0.18033	0.78545
400	0.00176	0.09509	0.04508	0.19636
600	0.00078	0.04226	0.02004	0.08727
1000	0.00028	0.01522	0.00721	0.03142
Farm size[c]				
0.50	0.2681	2.9461	-5.2697	6.6595
1.00	0.0670	0.7365	-1.3174	1.6649
1.50	0.0298	0.3274	-0.5855	0.7399
2.00	0.0168	0.1841	-0.3294	0.4162
4.00	0.0042	0.0460	-0.0823	0.1041
Price[d]				
0.06	0.4849	-2.0057	-9.5506	1.0364
0.12	0.1212	-0.5014	-2.3877	0.2591
0.18	0.0539	-0.2229	-1.0612	0.1152
0.24	0.0303	-0.1254	-0.5969	0.0648
0.30	0.0194	-0.0802	-0.3820	0.0415

[a]W, C and B represent wheat, corn and beans, respectively.
[b]In quetzales (1 quetzal = $1 U.S.A.) per year.
[c]In hectares.
[d]In quetzales/kg.

grains shows some responsiveness. Once farmers pass the subsistence level, however, responsiveness tends to decrease because: (1) other crops provide better income alternatives, (2) the land constraint is reached or (3) the available surplus has been marketed. Lower responsiveness for wheat may be the result of the price support program, which simultaneously places a floor and a ceiling on earnings beyond which higher value crops may provide greater income opportunities.

Potential Policy Implications and Limitations

Income and farm size elasticities of market supply are important signals of traditional farmer behavior concerning production and marketing decisions and land utilization. These elasticities provide a basis for estimating market supply effects of future increases in income, productivity and production. As income and farm size increase or new land becomes available resulting from new technology, traditional farmers will cultivate basic grains on less land, devoting the newly available land to other crops. Price elasticities are often less meaningful due to the nature of the data and to the heavy emphasis given by small farmers to farm income and land utilization. Price observations from cross-section data usually do not capture seasonal price variations and thereby create price elasticity situations without easy interpretation and application. This limitation is less relevant, though, since emphasis is given to income and farm size elasticities as indicators of supply responsiveness by farmers to factors that change their income positions. Another limitation is lack of site-specific data on agronomic options as well as data on nutrition, cultural conditions, labor force participation, consumption, planning and government intervention, and other similar conditions that impact on farmer decisions.

One of the most important values of regionally and locally testing the theory presented in this paper is an understanding of the basic economic system of traditional farmers and the relationships between this system and green revolution agriculture. The theory suggests that the natural reaction of traditional farmers to basic subsistence needs is a built-in supply control mechanism for basic grains or low-value low-risk crops in the traditional farm system. This mechanism, explaining why productivity increases yet production is stagnant, is a natural reaction to basic subsistence needs and avoids some of the second and third generation problems of the green revolution [3]. Over production might not usually result, so prices would not decline sharply to create major income disparities. The usually disoriented market system itself would not be so forcefully challenged.

Should these hypotheses prove reasonably accurate, our research and development programs might carefully consider the total traditional or small farm system. Research on basic grains alone will not serve the small developing farmer's needs entirely as he moves into higher value and higher risk crops. Meeting the risk element squarely in both agronomic and economic research programs could be most productive.

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