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Price and Tax Policy for Semi-Subsistence Agriculture in Ethiopia

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Tax and food price policies are important mechanisms for affecting smallholder food supply.

In the case of semi-subsistence agriculture where wage employment is not available, the role played by prices and taxes in determining production and consumption decisions is not clearly established by economic theories of household choice. This study demonstrates that where choices in production, consumption, and leisure can be made independently, farmers will decide what to grow on the basis of their preferences for marketed goods, and will also be affected by the level and type of taxation.

The model shows the impact of four taxes — agricultural revenue, land (either a head tax or a tax based on land area), production, and marketed goods consumption — on crop production and tax revenues. The results demonstrated that a production tax curtailed output while a lump-sum land tax expanded production. The impact of a tax on agricultural revenue or on products sold in the market depends on the farmers' preferences for marketed goods.

For Ethiopia, a model of production was estimated for eight food crops for semi-subsistence households. In general, production responded to changes in relative expected prices, land availability, level of household demand, and sowing period rainfall. Production of teff, wheat, chick peas, and sorghum was found to increase with higher prices, and production of field peas was found to fall. Evidence suggests that expanding the amount of arable land will raise farmers' output of wheat, chick peas, maize, and sorghum.

These results give strong evidence of the role of producer and consumer prices in semi-subsistence agriculture. In addition, the results show the importance of production capacity, household demand, and climatic factors, supporting a balanced approach to agricultural development that recognizes the joint roles of prices, production capacity, and demand.

This paper is a product of the International Commodity Markets Division, International Economics Department. Copies are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Dawn Gustafson, room S7-044, extension 33714.

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I. INTRODUCTION

The potential role of prices and taxes in agricultural development strategies has been recognized in an emerging literature focused on various cash crops. However, less is known about the semi-subsistence case where agriculture represents the sole source of income and food crops can be either held for home consumption or sold for income that can be used for purchase of consumer goods. In the presence of a wage market, the role of prices or taxes in determining crop production is simplified by the well-known independence of production and consumption decisions. Where wage markets do not exist, the production and consumption decisions are simultaneous and their response to prices has been recognized to be indeterminant in sign. The objectives of this paper are to (1) reconsider this general case of semi-subsistence agriculture and identify the determinants of the qualitative nature of choice response; (2) establish the impacts of alternative agricultural taxes on production levels and responsiveness; and (3) for the case of Ethiopia (1961-78) present results concerning price responsiveness of food crop production and the likely effects of alternative taxes.

II. THE SEMI-SUBSISTENCE HOUSEHOLD

The Choice Problem

The semi-subsistence household is characterized by a choice problem in which household preferences exist over leisure (S), the level of home consumption of farm output (Q), and the level of consumption of market purchased goods (C). Preferences are conditional on a vector of household characteristics α and are represented by a monotonic, twice-continuously differentiable, strictly concave utility function:

(1) $U = U(S, Q, C; \alpha)$ where $U'(\cdot) > 0$, $U'' < 0$.

Food production (Y) results from combination of household labor (L) with a vector θ of fixed levels of services of such inputs as land or draft power. The technology is represented by a monotonic, twice-continuously differentiable, strictly convex production function:

(2) $G(Y, L, \theta) = 0$ where $G_Y > 0$, $G_L < 0$

$$G_{YY} < 0,\ G_{LL} > 0,\ G_{YL} \lesseqgtr 0$$

The household is assumed to control L, Q, and C in order to maximize utility subject to a full income constraint:

(3) $P_C C + PQ + T = PY$

and a time constraint:

(4) $L + S \leq H$

where H represents total available household time,

P_C and P represent market prices, and

T represents taxes paid.

This representation of the choice problem differs from Nakajima's (1969) semi-subsistence model where preferences were assumed over leisure and income. Here, we focus on commodities, not income as the source of utility. Although we employ scalar interpretations of Y, L, C, and Q, their interpretation as vectors would not change our results. Rosenzweig (1980) considered a household model in which a vector interpretation of L was used to analyze male versus female roles. The inclusion of taxes will allow consideration of the impact of alternative taxes on choices as well as choice response.

Summarizing the choice problem in Lagrangean form, we have maximized:

$$U(S, Q, C; \alpha) + \lambda_1(PY-P_CC-PQ-T) + \lambda_2G\ (Y, H-S, \Theta)$$

Assuming an interior solution exists for all choices, the first-order conditions necessary for solution of the choice problem are:

$$U_S + \lambda_2G_S = 0$$

$$U_Q - \lambda_1\ P = 0$$

$$U_C - \lambda_1P_C = 0$$

$$\lambda_1P + \lambda_2G_Y = 0$$

(5) $$PY - P_CC - PQ - T = 0$$

$$G\ (Y, H-S; \Theta) = 0$$

Comparative-Statics

This system of implicit choice functions presents the basis for analyzing the responsiveness of semi-subsistence agrarian households to changes in policy controls such as prices, taxes, and size of landholding. Total differentiation of the system results in:

$$(6)\quad \begin{bmatrix} U_{SS} + \lambda_2 G_{SS} & U_{SQ} & U_{SC} & \lambda_2 G_{SY} & 0 & G_S \\ U_{QS} & U_{QQ} & U_{QC} & 0 & -P & 0 \\ U_{CS} & U_{CQ} & U_{CC} & 0 & -P_C & 0 \\ \lambda_2 G_{YS} & 0 & 0 & \lambda_2 G_{YY} & P & G_Y \\ 0 & -P & -P_C & P & 0 & 0 \\ G_S & 0 & 0 & G_Y & 0 & 0 \end{bmatrix} \begin{bmatrix} dS \\ dQ \\ dC \\ dY \\ d\lambda_1 \\ d\lambda_2 \end{bmatrix}$$

$$= \begin{bmatrix} 0 & 0 & 0 \\ \lambda_1 & 0 & 0 \\ 0 & \lambda_1 & 0 \\ -\lambda_1 & 0 & 0 \\ Q-Y & C & 1 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} dP \\ dP_C \\ dT \end{bmatrix}$$

Solutions of (6) for the comparative-static changes in choice consistent with (5) will be considered individually.

Solution of (6) results in the following prediction of agricultural output supply response to a change in its price:

$$(7) \qquad \frac{\partial Y}{\partial P} = (\frac{U_C}{P_C} |H|_{24} - \frac{U_C}{P_C} |H|_{44} + (Y-Q) |H|_{54})/|H|$$

where H is the bordered Hessian matrix on the left-hand side of (6), $|H|_{ij}$ is its i,j_{th} cofactor, and $|H|$ is its determinant. By assumption of strict concavity of U(·) and strict convexity of G(·), we have $|H| > 0$. However, inspection of the cofactors involved in (7) suggests that the sign of the numerator is ambiguous. This type of result was also suggested by analysis by Nakajima as well as Rosenzweig, and follows a long tradition of recognition of the possibility of backward bending supply. However, it is possible to obtain sharper insight than offered by these earlier papers into the factors which determine the sign of comparative-statics such as (7).

The complexity of the general case can be seen from the cofactors involved in (7), e.g.,

$$(8) \qquad |H|_{24} = P^2 G_S^2 U_{CC} - P\, P_C G_S G_Y U_{SC} - P\, P_C G_S^2 U_{CQ} + P_C^2 G_S G_Y U_{SQ}$$

while $U_{CC} < 0$ as a result of strict concavity, the signs of U_{SC}, U_{CQ}, and U_{SQ} depend on whether S, C and Q are substitutes or complements. Suppose C is a substitute for Q, i.e., $U_{CQ} < 0$ and leisure (S) is a complement to consumption of either C or Q, then $U_{SC} > 0$ and $U_{SQ} > 0$. The sign of $|H|_{24}$ would remain ambiguous. Only in the case in which C and Q are complements, and U_{SC} and U_{SQ} differ in sign with $U_{SC} > 0$ would the sign of $|H_{24}|$ be determinant. The same type of conclusions follow from consideration of $|H|_{44}$ and $|H|_{54}$, rendering the determination of the sign of (7) an empirical issue.

Greater insight into the sign of supply response can be gained without unreasonable loss of consistency with observed systems by simplifying the total differential system (6) using the assumption of group-wise weakly separable preferences across S, C, and Q. In the vector case, this implies that preferences over S, C, and Q satisfy the condition that marginal rates of substitution for within group elements are independent of levels of elements of other groups, see Greene (1974). In fact, these conditions are sufficient for equivalent representation of $U(\cdot)$ as a function of vectors S, C, and Q by an alternative representation where S, C, and Q are interpreted as index numbers or aggregates of the elements in their respective vector forms. Most important for simplification of comparative-statics such as (7), the separability assumption implies $U_{CQ} = U_{SC} = U_{SQ} = 0$. Under this assumption, (7) becomes

$$(9) \qquad \frac{\partial Y}{\partial P} = -[U_C P_C G_S^2 U_{QQ} + (Y-Q)\, P G_S^2 U_{QQ} U_{CC}]/|H|$$

While this assumption turns our focus to a more specialized case, the assumption has been accepted as sufficiently consistent with observed systems to justify its adoption in empirical studies by Barnum and Squire (1979), Ahn Singh, and Squire (1980). While the presence of a labor market establishes independence of production from consumption decisions, the present assumption preserves the simultaneity of choice among S, C, and Q aggregates, and implies only that within-group choices (i.e., within elements of the vectors S, C, and Q) be independent.

Although the sign of (9) remains ambiguous, insight to its variation can now be obtained. Given $|H| > 0$, by strict concavity of U and strict convexity of $G(\cdot)$, the sign of the comparative-static depends on whether

$$(10) \quad -\frac{U_C}{U_{CC}} \gtrless (Y-Q)\,\frac{P}{P_C}$$

This result suggests the following intuitively useful rule:

$$(11) \quad \frac{\partial Y}{\partial P} \gtrless 0 \quad \text{as} \quad -\varepsilon_C \gtrless \mu$$

where

$\varepsilon_C = \dfrac{\partial \log U_C}{\partial \log C}$ is the elasticity of U_C or marginal subjective value of C to changes in C, and

$\mu = P_C C/P(Y-Q)$ is the market expenditure share of market, or cash income.

The rule in (11) suggests that production response is dependent upon characteristics of preferences for market-originating consumption goods, and is independent of the characteristics of production technology. If we interpret ε_C as the elasticity of subjective marginal value of C, the μ as the real market exchange rate between C and marketed surplus (Y-Q), then the rule establishes that production response is positive if at current levels of L, Q, and C, the elasticity of subjective marginal value of C resulting from a change in the level of C is less than the market's valuation of amount of C obtainable for additional marketed surplus.

In addition to technology and preferences which determine the left-hand side of (11), the existence and nature of taxes influence the nature of supply response by their effect on the right-hand side of (11). By use of the budget constraint where T is a consumption tax, i.e., $T = \gamma P_C C$, (11) can be further simplified in order to highlight the dependence of the sign of $\partial Y/\partial P$ on the functional properties of $U(\cdot)$, and the nature of taxation, i.e.,

$$(12)\quad \frac{\partial Y}{\partial P} \gtrless 0 \quad \text{as} \quad -\varepsilon_C \gtrless 1/1 + \gamma$$

When $\gamma = 0$, the condition relies on $-\varepsilon_C \gtrless 1$. In this form the effect of a tax can be isolated as an expansion of the range of elasticity $-\varepsilon_C$ over which positive supply response could be found. Before proceeding to consider other comparative-static results, it is of interest to consider the sign of $\partial Y/\partial P$ over the range of C and for different characteristics of utility. In general, ε_C is a function of C and for a particular form of $U(\cdot)$, the consumption level C^s at which $\partial Y/\partial P$ changes sign is determined as the solution of $-\varepsilon_C = \mu$. For example, for the quadratic form:

$$U(C) = A\,C + BC^2$$

we have

$$(13)\quad C^s = -A/(4B + 2B\gamma)$$

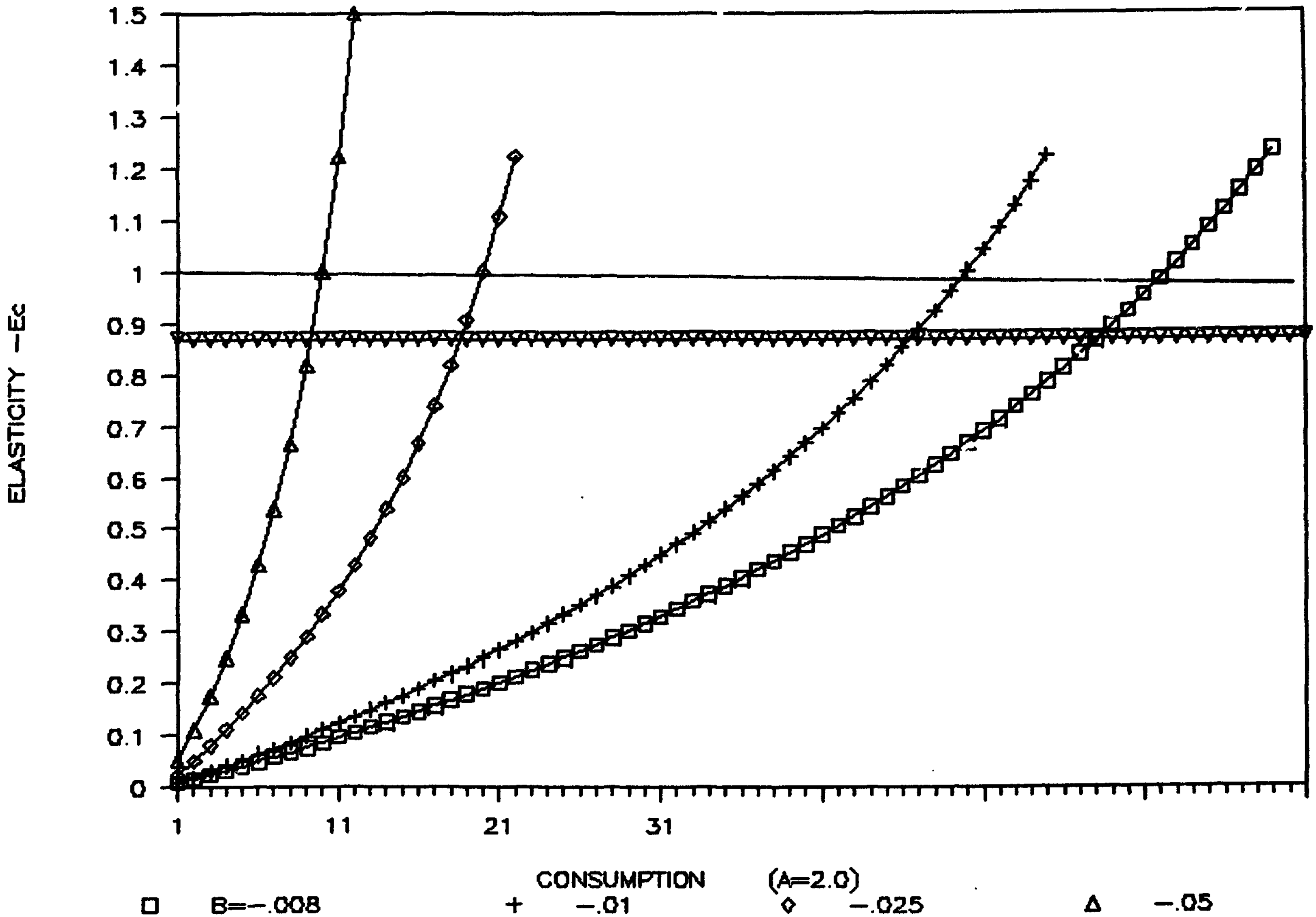
As also noted from (12), the switch point C^s depends on the level of taxation, $U''(C)$ and $U'(C)$. From Figure 1 it is clear that for a given utility function, as γ increases, the range $[0, C^s]$ over which $\partial Y/\partial P < 0$ is reduced. For $\gamma = 0$, C^s is indicated by the consumption level corresponding to $-\varepsilon_C = 1$. The lower horizontal line in Figure 1 is consistent with $\gamma = 0.15$. Further, as indicated in Figure 1, C^s increases as $-U_{CC}/U_C$ and B/A decreases. Recalling that C^s indicates the level of consumption above which positive supply response can be expected, Figure 1 illustrates that increases in a consumption tax such as γ decreases C^s, increasing the range over which a positive supply response would be expected. Empirically, the magnitude of this shift in C^s depends upon the shape of preferences.

Where preferences are characterized by rapidly diminishing marginal utility, increases in T (increases in γ) can be expected to be less effective in leading to a switch to positive price responsiveness. However, where U_{CC} is small, a more significant shift in C^s can be expected. In general, for a given T, Figure 1 illustrates that where preferences have relatively more rapidly declining marginal utility, i.e., larger U_{CC}, the range $[0, C^s]$ is reduced, making it more likely that $\partial Y/\partial P > 0$ could be expected. Similar results occur in the general nonlinear case.

Alternative forms of tax T have effect on these general results only through their effect on μ. For a consumption tax, $\mu = 1/(1 + \gamma)$ and μ is horizontal in (ε_C, C) space. In the case of a lump-sum tax, $\mu = P_C C/(P_C C + T)$ and μ varies nonlinearly with C with a positive slope. In general, a lump-sum tax can be shown to result in a smaller range of consumption over which supply response will be negative. This property of μ is illustrated in Figure 1 with $\mu(C)$. The extent of this reduction in C^s is an empirical issue; however, it can be shown that if C^s is to be reduced significantly the tax would have to claim a significant percentage of the household budget. In the case illustrated, the tax T initially accounts for 25 percent of the budget. Finally, in this simple illustrative case the effect of changes in Q and S can be conceptualized as vertical shifts in the graph of $-\varepsilon_C$. Suppose Q and C are substitutes, then increases in Q could be expected to reduce U_{CC} and U_C, leaving the net effect on $-\varepsilon_C$ uncertain. Where Q and C are complements, an increase in Q might be expected to increase both U_{CC} and U_C, leaving the effect on $-\varepsilon_C$ uncertain.

FIGURE 1: DEPENDENCE OF SUPPLY RESPONSE

ON LEVEL OF CONSUMPTION AND PREFERENCES



Further comparative-statics may be derived from (6) and in all cases their signs are indeterminant. Nonetheless, a similar strategy of examination of the variation of their signs can be taken. Since labor is the only input and is assumed to have positive marginal productivity, the signs of $\partial Y/\partial P$ and $\partial L/\partial P$ are jointly determined and are the same. However, the production response to changes in consumption goods is more complicated and worth consideration. From (6),

$$\frac{\partial Y}{\partial P_C} = \left(\frac{U_C}{P_C} \; PP_C G_L^2 U_{QQ} + CPU_{CC} G_L^2 U_{QQ} \right) / \; |H| \gtrless 0$$

(14)

$$\text{as} \quad (U_C + CU_{CC}) \lessgtr 0$$

$$\text{or} \quad U_C \lessgtr - CU_{CC}$$

From the budget constraint, and assuming a consumption tax where $T = \gamma P_C C$, we have $C = P(Y-Q)/P_C(1 + \gamma)$ allowing

$$(15) \quad \frac{\partial Y}{\partial P_C} \gtrless 0 \quad \text{as} \quad - \frac{U_C}{U_{CC}} \gtrless + \frac{P(Y-Q)}{P_C(1 + \gamma)}$$

For any nonnegative γ, it follows from (10) that

$$(16) \quad \partial Y/\partial P_C \gtrless 0 \quad \text{as} \quad \partial Y/\partial P \lessgtr 0.$$

Before proceeding, it is of interest to note that the household theory leaves indeterminant the implications of changes in α, the demographic characteristics of the household and Θ, fixed production factors. For example, by allowing these factors to vary exogenously, solution of a generalized version of the total differential (6) would indicate that the sign of $\partial Y/\partial\alpha$ would depend on (1) $U_{S\alpha}$, $U_{Q\alpha}$, $U_{C\alpha}$, the change induced in the marginal utilities of alternative choices, (2) U_{CC}, and (3) G_Y and G_S. In a more generalized problem this result suggests that $\partial Y/\partial\alpha$ would be determined through the interplay of marginal productivities of labor across crops and changes in marginal utilities induced. If α is interpreted as the scale of household demand, then the indeterminacy of an increase in α on production of alternative crops would be reflected by a change in the mix of crops produced that would be consistent with the differing labor intensities of the crops, and preferences for home consumption of the crops.

III. THE ECONOMICS OF TAXATION OF SEMI-SUBSISTENCE HOUSEHOLDS

The above results provide a solid foundation for analysis of the impacts of alternative taxes on the semi-subsistence household. The focus here will be on the impact of alternative taxes on the level of production (Y) and tax revenue (T). The following taxes are considered:

1.	Agricultural Revenue Tax:	$T = \delta P(Y-Q)$
2.	Lump-sum Land Tax:	$T = t\theta$
3.	Transportation Tax:	$T = \tau Y$
4.	Consumption Tax:	$T = \gamma P_C C$

Before proceeding, alternative interpretations of these taxes should be noted. The lump-sum tax could be generated by a tax on any asset fixed in the production period, e.g., land area occupied or family size as in a head tax. The transportation tax, perhaps generated by a tax on fuel or road tolls, will be seen to separate the unit revenue price of production from that of home consumption. In this sense, such taxes represent production taxes rather than marketing taxes as in the case of agricultural revenue taxes. The consumption tax considered focuses on marketed products only. An alternative would be to tax all consumption, e.g., $\gamma(P_C C + PQ)$. The operational difficulties of such a tax suggest it is of little interest.

The following comparative-statics are derived from the alternative taxes:

$$\frac{\partial Y}{\partial \delta} = -\frac{\partial Y}{\partial P} P \lesseqgtr 0 \quad \text{as} \quad -\varepsilon_C \gtreqless \mu$$

$$\frac{\partial Y}{\partial t} = \frac{\partial Y}{\partial T}\,\theta = \frac{P\,U_{CC}G_s^2\,U_{QQ}}{|H|}\,\theta > 0$$

$$\frac{\partial Y}{\partial \gamma} = \frac{\partial Y}{\partial P_C}\,P_C \gtreqless 0 \quad \text{as} \quad \frac{\partial Y}{\partial P_C} \gtreqless 0, \text{ or}$$

$$\text{as} \quad -\varepsilon_C \lesseqgtr 1/(1+\gamma)$$

The effect of the transportation tax requires generalization of the model to separate the market revenue value of production from its farmgate value (P). We define P_y as the market price. The effect of a transport or production tax is to reduce the market price to $(1 - \tau)\,P_y$. The comparative-statics of choice for the generalized problem are as follows:

$$\frac{\partial Y}{\partial P_y} = (U_C U_{CC} P^2 G_s^2\,/P_C) + U_{QQ} P_C G_s^2 - U_{QQ} U_{CC} YPG_s^2 > 0$$

$$\frac{\partial Y}{\partial P} = (U_C U_{CC} P^2 G_s / P_C) + U_{QQ} U_{CC} QPG_s^2 \gtreqless 0$$

$$\text{as} \quad -\varepsilon_C \lesseqgtr -P_C Q/P$$

It follows, $\partial Y/\partial \tau = -\left[(U_C U_{CC} P^2 G_s^2/P_C) + U_{QQ} P_C G_s^2 - U_{QQ} U_{CC} YPG_s^2\right] P < 0$

These results illustrate the differing impacts of alternative taxes. The impacts on production vary in sign. In the case of the revenue tax and the consumption tax the sign depends on preferences as summarized in ε_C. A transportation tax, or equivalently a production tax, unequivocally reduces production while the lump-sum tax expands production.

In the small country case considered, tax revenues are defined in the absence of price changes. The question of optimality of a tax arises only from production response to the tax. Taxes which optimize revenue are defined by the following rules:

$$\delta: \quad \frac{PQ}{P(Y - Q)} \frac{\partial Q}{\partial \delta} \frac{\delta}{Q} - \frac{PY}{P(Y - Q)} \frac{\partial Y}{\partial \delta} \frac{\delta}{Y} = 1$$

$$\tau: \quad \frac{\partial Y}{\partial \tau} \frac{\tau}{Y} = -1$$

$$\gamma: \quad \frac{\partial C}{\partial \gamma} \frac{\gamma}{C} = -1$$

In each case, choices respond to changes in the tax rate and the optimum occurs depending on the sign and curvature of choice response. The monotonic response of production to a lump-sum, or asset-based tax such as land tax t, implies an optimum does not exist.

IV. EMPIRICAL IMPLICATIONS AND EVIDENCE FROM ETHIOPIA

The above theoretical model of smallholder choices suggests that the magnitude of response is an empirical question. Further, the theory clearly establishes the roles of farm prices, transportation costs, consumption goods prices, and exogenous factors affecting agricultural productivity and conditioning household preferences. The impacts of alternative taxes were illustrated to depend on choice response to market prices, suggesting that inferences concerning tax policy could be derived from empirical evidence concerning choice response. The implications of the theory developed above are evaluated using the experience of Ethiopia from 1961 to 1978. Before 1961 very little data are available, while after 1978, publication of price data was discontinued, but more importantly, parastatal marketing dominated agriculture.

General Background

The production of food crops in Ethiopia increased by 29 percent between 1960 and 1980 or at an average annual rate of only 1.4 percent, while the population increased by 58 percent—equivalent to an average annual growth rate of 2.5 percent (see Table 1). Yields remained stagnant but imports increased dramatically though not enough to offset declines in the per capita food production (18 percent), per capita caloric intake (17 percent) and protein (18 percent).

Unfavorable weather conditions contributed to the poor performance of crop production, particularly during the mid-seventies; however, poor weather and other limitations imposed by the natural environment cannot explain entirely the slow growth over the whole period. Part of the poor

Table 1: SOME INDICATORS OF THE ETHIOPIAN AGRICULTURAL SECTOR PERFORMANCE

	1960	1970	1980
Food Production Index (1969/71 = 100)	82	101	106
Yield (cereals) kg/ha		835	868
Population ('000)	20,000	25,400	31,464
Index of Food Production Per Capita (1969/71 = 100)	103	101	84
Imports (cereals) ('000)	6	77	397
Per Capita Supplies of Calories (% of Requirement)	91	83	76
Per Capita Supplies of Proteins (grams/day)	72	69	59

Source: Central Statistical Office, Statistical Abstracts.

production record has been due to transition from a feudalistic tenure system, inadequate production technology, poor infrastructure, inefficient markets, inappropriate marketing policies and internal turmoil.

Smallholders dominate Ethiopian agriculture as well as the entire economy [FAO (1984)]. They provide a living for 7 million families which make up over 80 percent of the population. They utilize 94 percent of the cultivated land and produce 90 percent of the agricultural output--including most food crops and coffee. The principal food crops are: teff, barley, wheat, horse beans, chick peas and field peas.

The sector comprises several production systems, but the highland mixed farming system is the dominant one [Getahun (1978)]. The average farm family operates a farm of 1.5 ha which is highly fragmented [Gryseels and Anderson (1981)]. At planting time the seedbed is generally prepared with indigenous ox-drawn plows. Weeding is done with hoes or bare hands while crops are harvested with sickle and threshed by oxen which trample on the ears and legumes until the grains and beans drop out. The farm work is almost entirely done with family labor. Farm machinery, improved seeds and herbicides are seldom used and the application of fertilizers is limited. Soil fertility is maintained with the occasional application of livestock manure and crop rotation in which generally three or four years of cereals is followed by a year of legumes.

Although these production systems have not changed dramatically, the tenure and the market systems were restructured by the new government in 1975. Before that date most of the land was worked by peasants either as owner-farmers or farmed by tenants; and the commerce was in the hands of merchants. According to a survey undertaken just before the reform, 36 percent of the farm holdings was operated by tenants, 38 percent by private owners, 15 percent was partly owned and rented, while the remaining 11 percent of the holdings was under communal ownership [FAO (1984)]. After the land reform of 1975, all land was nationalized, land was redistributed from the limited number of large commercial farms to state farms and peasant associations (OPAs), usufructuary rights were awarded to the farmers, and in order to enforce the redistribution of land and mobilize resources, incentives were established to encourage the organization of OPAs.

Crop marketing during the 1960s and 1970s was handled by private traders in central village markets, but the role of the government in the market was significantly increased in 1976 when a marketing state agency--The

Agricultural Marketing Corporation (AMC)--was created. This corporation has broad powers to buy and sell cereals, pulses and oilseeds, and to import and export agricultural commodities. Another state agency, the Agricultural Input Marketing Corporation (AIMCO) was empowered with the procurement and distribution of fertilizers and chemicals. Before the land reform, credit was provided to the peasants mostly by landlords and money lenders. Following the reform, credit is offered by the Agricultural Industrial Development Bank (AIDB) and AMC through the state commercial banks to OPAs.

Despite the profound transformations in the tenure and the market structure, the basic characteristics of the subsector have by and large remained unchanged: the average size of the smallholdings is very close to that of the pre-revolutionary period. Production technology remains traditional, the farming family still provides all the farm work, consumes about 70 percent of its produce and makes production choices with limited resources in a capricious natural environment.

The bulk of the food crops is produced by peasants with small and fragmented holdings, using simple hand implements and ox-drawn plows, and growing mainly unimproved low-yield varieties. The basic physical infrastructure is poorly developed. Beyond the vicinity of the major urban centers, the road network is either nonexistent or inadequate, rendering the transportation of agricultural produce and inputs over even short distances uneconomical. Such high transportation costs have inhibited the development of regionally and nationally integrated markets and led to uncompetitive, small, isolated markets with the consequence of reduced incentives to farmers.

Changes in policy designed to improve the performance of the smallholder sector depend upon knowledge of the sign and magnitude of production responses to policy and exogenous changes in the economic environment. Of particular interest are (1) the own- and cross-price elasticities of subsistence food crops, and cash crops; and (2) the relative importance of prices versus fixed factors, of production or determinants of subsistence food demand. The period prior to 1978 offers a case for study of the potential response of smallholders to changes in prices and fixed factors, and therefore data for the period 1961-78 are employed in the empirical model.

Empirical Evidence

The empirical analysis focuses on five cereals--teff, wheat, barley, sorghum, and maize--and three pulse crops--chick peas, field peas, and horse beans--which accounted for over 90% of cereal and pulse production in 1974. Further, available data indicate that production of these crops was dominated by smallholders. The crops were grown principally in the central highlands; over 50 percent of maize and sorghum, and about 80 percent of the other crops were grown there.

The empirical implications of the theory developed above are limited to the identification of: (1) relative expected crop prices; (2) measures of scale of fixed production factor flows; and (3) measures of fixed determinants of the scale of household subsistence food demand as determinants of planned production levels of smallholder crops. Significantly, theory does not suggest a partial adjustment model. In the absence of any prior theory or evidence concerning the functional form of the smallholder choice functions derivable from (5), we adopt linear forms:

$$(17)\quad Y^*_{it} = \beta_o + P^e_t\beta_i + L_t\gamma_i + P^e_tA\alpha_i + H_t\lambda_i + R_{ti}\delta_i$$

where Y^*_{it} is the planned output of crop i in year t;

P^e_t is a (1 x m) vector of relative (CPI deflated) expected crop prices;

L_t is arable land;

H_t is agricultural population;

R_{ti} is average sowing period rainfall for crop i; and

A is binary equal to zero prior to land reform in 1975.

We define estimated production:

$$(18)\quad Y_{it} = Y^*_{it} + D_t\alpha_i + \varepsilon_{it}$$

where D_t is a vector of two binary variables indicating charges in estimation method by the CSO in 1963 and 1972 (prior to these dates $D_k = 0$), and

ε_{it} is an i.i.d. random variable with $E(\varepsilon_{it}) = 0$, $E(\varepsilon_{it}\varepsilon_{jt}) = \sigma^2_{ij}$ for all i,j and $E(\varepsilon_{it}\varepsilon_{jt'}) = 0$ for all $t \neq t'$.

Arable land (L) is employed as a measure of agricultural production capacity which is fixed within the production period. The scale of household subsistence demand is measured by agricultural population. It is important to note the theoretical motivation for this factor lies in its microeconomic origin as a measure of household food demand. Given this definition, it is distinguished from population density considered by the Boserup hypothesis.

Data are described in more detail in an appendix available from the authors. However, in brief, production levels were collected from the Central Statistical Offices (CSO) Statistical Abstracts which report estimates based on a synthesis of small surveys and estimates of exports and local consumption. Wholesale prices for products in selected towns of the major producing areas, as reported in Statistical Abstracts, were employed. Average annual and average crop-specific growing season rainfall estimates were computed using monthly average data for eight weather stations in the central highlands. Agricultural population estimates and arable land size estimates were taken from the FAO Production Yearbook.

In order to proceed, price expectations must be modeled. Although a naive or adaptive model might be assumed, we adopt the hypothesis that past prices will be used efficiently to construct expectations, see Weaver (1977, 1981). The adoption of this hypothesis supports the use of identified and estimated ARIMA models as summarized in Table 2. In general, the ARIMA results support very simple models of price expectations and do not support the adaptive expectation form. Instead, results indicate the adaptive expectation model would provide systematically biased forecasts that do not minimize forecast error. If we assume $P^e_{it} = E(P_{it}) - V_{it}$ and that the measurement error V_{it} is independent of the determinants of production, then unbiased, efficient estimates of the parameters in the model (17) can be estimated with the Zellner (1962) efficient estimator.

Table 3 presents parameter estimates of the eight equations in (17), while Table 4 reports the own- and cross-price elasticities for pre- and post-land reform periods. The coefficient of determination (R^2) ranges from 0.70 for field peas to 0.87 for teff, which indicates that the independent variables have good explanatory power. This is supported by the high value of the F-statistic which is a measure of the extent to which the explanatory variables are related with the independent variable.

Table 2: ESTIMATED ARIMA MODELS FOR THE PRICE SERIES OF CROPS AND CONSUMER PRICE INDEX

Price Series	Model	χ^2 [a]	Prob>χ^2 [b]	Std[c]
Teff	$\dot{P}_t=1.0+u_t$	3.89	0.69	4.41
Wheat	$\dot{P}_t=1.5+u_t$	5.43	0.49	3.27
Barley	$\dot{P}_t=2.2+u_t$	4.86	0.56	2.51
Sorghum	$\dot{P}_t=u_t$	17.69	0.01	3.86
Maize	$\dot{P}_t+u_t$	11.21	0.08	3.49
Chick peas	$\dot{P}_t=u_t$	7.84	0.25	4.12
Field peas	$\dot{P}_t=1.59+.5u_{t-1}+u_t$ (3.67)[e] (2.36)	4.98	0.44	3.45
Horse beans	$\dot{P}_t=1.10+.7u_{t-1}+u_t$ (0.67) (3.12)	6.82	0.15	3.45
CPI[f]	$\dot{P}_t=9.44-.7u_{t-1}+u_t$ (2.0) (-3.79)	3.19	0.52	12.07

[a] Estimated Chi-squared for a Q-statistic with six lags.

[b] Probability that χ^2 is greater than the estimated value.

[c] Standard error.

[d] $\dot{P}_t = P_t - P_{t-1}$.

[e] The figures in parenthesis are t-ratios.

[f] Consumer price index.

Table 3: SEEMINGLY UNRELATED REGRESSION (SUR) ESTIMATES OF THE OUTPUT CHOICE EQUATIONS

Independent Variable	Choice Equation		
	Teff	Wheat	Barley
Constant	3866.60 (3.90)[a]	-2788.72 (-3.27)	-1693.40 (-0.87)
Price of:			
Teff	59.90 (4.43)	-23.14 (-2.48)	-22.81 (-1.17)
Wheat	-64.15 (-3.25)	31.46 (2.47)	
Barley			2.08 (0.06)
Arable land	0.01 (0.07)	0.27 (2.20)	0.09 (0.32)
Agricultural population	-0.14 (-2.02)	-0.01 (-0.24)	0.04 (0.31)
Sowing period rainfall[a]	0.25 (0.35)	0.97 (1.74)	2.93 (2.22)
D_1	-27.86 (0.20)	-14.10 (-0.14)	162.87 (0.74)
D_2	-74.82 (-0.75)	-166.36 (-1.85)	-670.00 (-3.22)
D_3	15.45 (2.24)	-6.69 (-0.92)	-2.65 (-0.11)
Post-reform own price	75.35 (4.83)	24.77 (2.01)	-0.57 (-0.02)
R^2	0.87	0.86	0.80
F	10.02	9.35	7.00
Prob>F	0.0001	0.0001	0.0001

....Continued

Table 3 continued...

Independent Variable	Choice Equation		
	Chick peas	Field peas	Horse beans
Constant	-181.76 (-1.31)	3.50 (-0.03)	-272.23 (-1.56)
Price of:			
Wheat	-11.31 (-2.09)		6.22 (1.18)
Chick peas	4.92 (1.84)	0.39 (0.29)	
Field peas		-3.40 (-1.31)	
Horse beans			7.29 (1.39)
Agricultural population	-0.03 (-2.37)	0.004 (0.51)	0.03 (1.93)
Sowing period rainfall	0.15 (1.21)	0.14 (1.85)	0.13 (1.47)
Arable land	0.08 (3.37)	0.001 (0.05)	-0.04 (-1.16)
D_2	-7.12 (-0.34)	-40.75 (-2.76)	
D_3	-4.67 (-2.86)	0.22 (0.20)	7.17 (2.49)
Post-reform own price	0.25 (0.09)	-3.18 (-1.20)	14.46 (2.41)
R^2	0.82	0.70	0.86
F	7.18	5.09	5.70
Prob>F	0.0001	0.0001	0.0001

...Continued

Table 3 continued...

Independent Variable	Choice Equation	
	Maize	Sorghum
Constant	-657.22 (-1.31)	-397.49 (-0.52)
Price of:		
Maize	-7.50 (-0.43)	-41.75 (-2.63)
Sorghum	8.58 (0.59)	31.64 (2.34)
Arable land	0.31 (3.57)	0.22 (1.93)
Agricultural population	-0.12 (-2.87)	-0.06 (-1.27)
Sowing period rainfall	1.40 (0.34)	0.63 (1.31)
D_1		-142.00 (-1.57)
D_2		-205.53 (-2.51)
D_3	36.10 (3.88)	1.29 (0.15)
Post-reform own price	28.60 (1.51)	32.93 (2.25)
R^2	0.77	0.76
F	5.38	7.60
Prob>F	0.0001	0.0001

[a] The figures in parentheses are t-ratios.
[b] This is the total rainfall in the months of July-August for teff, wheat, and barley; August-September for chick peas; July-August for field peas; May-July for horse beans; May-June for maize; and March for sorghum.

Table 4: PRICE ELASTICITY OF SUPPLY BASED ON PRICE COEFFICIENTS FROM (SUR) ESTIMATES

	Price Elasticity of							
Prices	Teff	Wheat	Barley	Chick peas	Field peas	Horse beans	Maize	Sorghum
Teff	1.01 (1.2[illegible])[a]	-0.84	-0.47					
Wheat	-0.84	0.88 (0.68)		-1.19		0.59		
Barley			0.02 (-0.01)					
Chick peas				0.42 (0.02)	0.06			
Field peas					-0.48 (-0.45)			
Horse beans						0.64 (1.16)		
Maize							-0.10 (0.38)	-0.54
Sorghum							0.13	0.48 (0.50)

[a] The figures in parentheses refer to the elasticities after the land reform.

The estimates of own-price coefficients have positive signs except for field peas and maize which are not statistically significant. Significant cross-commodity price effects are also found, suggesting substitutability and complementarity of crops. These cross-commodity effects are statistically significant and suggest substitution between wheat and teff, wheat and chick peas, and sorghum and maize. The estimates of the coefficient for the post-land reform era (binary A) have positive signs except for barley and field peas where the coefficient is statistically insignificant. For other crops, the estimates indicate that the land reform and associated institutional reforms lead to increases in the responsiveness of crop production to own-price. In the cases of teff, wheat, horse beans, and sorghum, the estimated positive changes in responsiveness were statistically significant. Given the observed declines in crop production combined with declines in real crop prices after 1975, the conclusion can be drawn that reductions in real crop prices played a significant role in reduction of crop production. The coefficient of the sowing season rainfall is positive for all crops indicating the significant role of preseason precipitation in determining supply. The estimate of the arable land coefficient has a positive coefficient for all crops except horse beans where it is statistically insignificant. The positive coefficients are statistically significant for wheat, chick peas, maize, and sorghum. Agricultural population is interpreted as a measure of the scale of household demand for food. The estimated coefficients were statistically significant and negative for teff, chick peas, and maize, and positive for horse beans. Given population growth in excess of 33% during the sample period, these results could be interpreted as indicating a strong biased effect of rapid growth in subsistence household demand which shifts production from crops such as teff, chick peas, maize, and sorghum to field peas and horse beans. Such a change in the mix of crops is consistent with the theory of the semi-subsistence household, as indicated above.

The coefficient estimates and elasticities associated with crop prices appear correlated with the degree of commercialization of crops. Data on the proportion of each crop that is marketed is lacking, but the literature reviewed seems to indicate the following ranking of crops by commercialization:

Table 5: PRICE ELASTICITIES AND LEVEL OF COMMERCIALIZATION

Crop	Extent of Commercialization	β	t	η_y
Teff	high	31.46	2.47	1.01
Wheat	high	59.90	4.43	0.88
Barley	high	2.08	0.06	0.22
Sorghum	high	31.64	2.34	0.48
Horse beans	medium	7.29	1.39	0.64
Chick peas	medium	4.92	1.84	0.42
Maize	medium	-7.50	-0.43	-0.10
Field peas	low	-3.40	-1.31	-0.48

where β is the coefficient estimate, t refers to t-ratio and η_y is the own-price elasticity of supply.

Tables 3 and 4 indicate that own-price response of crops was robust with respect to the land reform. In the cases of teff, wheat, horse beans and sorghum, the reform effect on price response was statistically significant; however, only small quantitative changes in the elasticity of supply were implied. For other crops, the reform effect was statistically insignificant.

Empirical results reported for Ethiopia suggest significant and positive own-price response as well as significant cross-price response indicating substitution and complementarity among crops. These results are robust to post-revolutionary changes and suggest how smallholders could be expected to respond to prices in any movement toward a more open market economy.

The implications of these results for tax policy can now be drawn using theoretical results reported above. First, recognizing that the elasticity of production of the numeraire price (CPI) is the negative of the sum of the price elasticities of production, and that the CPI may be interpreted as the price of marketed consumer goods, the production elasticity with respect to the consumer price may be estimated from results in Table 1 and is reported in Table 6. With these results the implications of alternative taxes can be empirically considered.

Table 6: ESTIMATED ELASTICITIES OF CROP PRODUCTION TO CONSUMER GOODS PRICES

Crop	Production Elasticity with Respect to Consumer Goods Prices
Teff	-0.17 (-0.45)[a]
Wheat	-0.04
Barley	+0.45
Chick peas	+0.77
Field peas	+0.42
Horse beans	-0.05
Maize	-0.03
Sorghum	+0.06

[a] Post-reform elasticity, omitted for other crops due to insignificance.

Results of the household theory established that a land tax would unambiguously increase production while a transport or production tax would reduce production. However, the signs of an agricultural revenue tax (δ) and a consumption tax (γ) were seen as dependent upon the production elasticities with respect to own-price and the consumption goods price, respectively. Results in Table 6 suggest a consumption tax would reduce production of teff, wheat, horse beans, and maize, and increase production of barley, chick peas, field peas, and sorghum. From Table 4, positive own-price response of production suggests an agricultural revenue tax would reduce agricultural production of all crops except field peas and maize.

The relative magnitudes of elasticities reported provide a basis for predicting the magnitudes of production response to changes in these taxes. Table 4 suggests teff and wheat production would be reduced by roughly twice the amount of chick peas, horse beans, or sorghum in response to an agricultural revenue tax. By comparing Tables 4 and 6, the output effect of agricultural revenue and consumption taxes are seen to vary across crops and in some cases, e.g., chick peas, to be of similar orders of magnitude. These results highlight the importance of considering the heterogeneous effects of price and tax policy across output (Y) with respect to the agricultural revenue tax and the consumption tax.

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