FARM HOUSEHOLD DECISIONS UNDER VARIOUS TAX POLICIES: COMPARATIVE STATIC RESULTS AND EVIDENCE FROM HOUSEHOLD DATA

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ABSTRACT

The study is devoted to the comparative static analysis and econometric estimation of farm household decisions under both standard and agricultural taxes. Accounting for labor market constraints a non-separable model is constructed implying increasing per-unit costs of accessing labor markets. To control for tax-induced adjustments related to labor market imperfections we compare the results to those derived from a separable approach, assuming perfect labor markets. Theoretical results suggest that most tax-induced responses are ambivalent mainly caused by shadow prices effects. Further, tax-induced effects differ between the two model versions. In particular standard taxes may imply production adjustments in the case of non-separability. Thus, income and value-added taxes are no more necessarily superior to agricultural taxes. Econometric analysis using individual household data from Mid-West Poland indicates remarkable responses to market surplus and input taxes. In contrast, standard and land taxes imply only negligible production adjustments. Thus, they seem to be superior, at least in the Polish case.

INTRODUCTION

There are at least two good reasons why taxation of agricultural households deserves special study and cannot simply be treated as a standard taxation problem of non-peasant economies. First, in many countries, especially in developing and transition economies, the use of both standard tax tools, value added and income taxes, is limited. It is often costly to tax transactions between producers and consumers by a value added tax, especially within the farm household or in informal markets. Furthermore, difficulties in observing a household's annual income restrict the implementation of a well-defined income tax scheme (Ahmad and Stern; Newbery). Second, tax-induced farm household decisions may be reflected inadequately by conventional household and firm approaches, dichotomizing consumption and production decisions. In particular, when related markets are imperfectly competitive, production organization and consumption choice are jointly determined (Strauss).

Extensive literature refers to the identification of feasible taxation tools for peasants' households ('agricultural taxes'). In this context, agricultural taxes are surrogates for standard taxes, in particular for income taxes. Prominent representatives include land taxes, output or input taxes, and poll taxes (Bird; Rao; Burgess and Stern). In addition, some papers investigate the analysis of tax-induced allocation and distribution effects within partial equilibrium frameworks (Atkinson) and dual-economy approaches (Sah and Stiglitz), as well as the application of optimal taxation models to peasant economies (Heady and Mitra; Stiglitz and Dasgupta; Munk). In contrast, studies focusing on the rigorous derivation of farm household decisions to tax policies are rare. Ahmad and Stern examine the farm household effects of several agricultural tax tools (marked surplus, gross output, and input taxes) within a simplified theoretical farm household approach. Chambers and Lopez analyze the implications of standard taxes (income, profit, and consumption taxes) on financially constrained farm households within a dynamic approach. Lopez considers several income tax brackets by the estimation of farm household decisions, but does not explicitly examine their implications on consumption and production decisions.

This study is devoted to the theoretical analysis and empirical estimation of farm household decisions under both standard and agricultural taxes, assuming labor markets are imperfect. Binding hours constraints in off-farm employment may prevent a complete adjustment in agricultural labor markets (Benjamin). Family and hired labor may be imperfect substitutes in agricultural production (Deolalikar and Vijverberg; Jacoby). Also, farmers may have preferences towards working on or off the farm (Lopez). In addition, costs associated with labor market transaction, can explain why households have different relationships to the labor markets (Sadoulet, de Janvry and Benjamin).

To account for imperfect labor markets, a non-separable farm household model is constructed. The model implies increasing per-unit costs in accessing both the market for hired on-farm labor and the market for off-farm family labor (Carter and Yao). Thus, the relevant wage rate is endogenously determined. The advantage of this methodology is twofold. First, the model accounts for several kinds of labor market imperfections, notably institutional restrictions (e.g. binding hours settled by collective agreements), variable transaction costs in accessing labor markets, or heterogeneity between hired and family labor on-farm and also between family labor on and off the farm (Low 1982, 1986). In particular, it differs from former approaches, which usually assume either a completely absent labor market or an exogenously fixed rationing of off-farm employment. Second, the approach is applicable for various labor market regimes, including the cases in which farms simultaneously hire on-farm labor and sell off-farm labor.

We investigate the comparative static to compare production, consumption, and labor market effects caused by alternative tax policies. In detail, we analyze an income and value-added tax, the main standard tax tools, as well as an off-farm income tax (‘wage tax’) and several agricultural taxes (market surplus, input and land taxes). To control for tax-induced adjustments related to labor market imperfections, we compare the results to those derived from a separable approach assuming perfect labor markets. These comparisons allow us to examine basic rules regarding the optimality of the tax tools under consideration, at least from the efficiency point of view.[1] Since in a world of perfect markets standard taxes are superior to agricultural taxes and land taxes are superior to the other agricultural taxes, it seems to be interesting whether this ranking holds when labor markets are constrained.

The econometric analysis is based on a full-specified non-separable farm household model and relies on individual household data from several regions in Mid-West Poland (1991-1994). Based on the estimated parameters we derive ‘tax elasticities’ quantitatively capturing tax-induced consumption, production, and labor market reactions. We compare the results with tax elasticities assuming separability.

THE MODEL

To concentrate on the role of tax policies and labor market constraints, we construct a static model that ignores some aspects of farmers’ decisions, notably (price) risk (Finkelshtain and Chalfant; Fafchamps) and credit constraints (Chambers and Lopez). The model framework can cover both the case of imperfect and, with few rearrangements, perfect labor markets. The farm household is assumed to maximize utility derived from consumption and leisure subject to a technology constraint (2), a time constraint (3), and a ‘tax-corrected’ budget constraint (4). Therefore, farm households solve the following maximization problem:

$$\max_{x,c} U(c) \tag{1}$$

subject to

$$G(x,r) = 0 \tag{2}$$

$$T_l - |X_l| + X_l^h - X_l^s - C_l \geq 0 \tag{3}$$

$$\begin{aligned}(1+\tau_{vat})P_m C_m + P_a C_a \leq (1-\tau_y)\Big\{(1-\tau_{ms})\left[P_c X_c + P_a(X_a - C_a)\right] + P_a C_a - (1+\tau_v)P_v|X_v| \\ - g(X_l^h) + (1-\tau_w)f(X_l^s) + E\Big\} - \tau_G R_G\end{aligned} \tag{4}$$

Here $U(c)$ is the farm household's utility function, which is assumed to be monotonically increasing and strictly concave. c is a vector of consumption goods consisting of market commodities (C_m), self-produced agricultural goods (C_a), and leisure (C_l).

Production technology (2) is represented by a multi-output, multi-input production function $\left(G\left(x,r\right)=0\right)$, which is assumed to be well behaved in the usual sense (Lau). Here $x \in PG$ is a vector of production goods, expressed as netputs, and r is a vector of quasi-fixed factors. The farm household is assumed to produce market (X_c>0) and home-consumed (X_a>0) agricultural goods using variable inputs (X_v<0), labor (X_l<0), and the quasi-fixed factors land and capital.

The farm household faces a time constraint (3) where T_l denotes the total time available. $\left|X_l\right| = X_l^f + X_l^h$ is the total of on-farm labor time subdivided into family labor (X_l^f) and hired labor (X_l^h). Furthermore, X_l^s indicates off-farm family labor and C_l the leisure of the family members. In general, four regimes of labor market participation are possible. First, the farm household sells family labor and hires labor at the same time. Second, farmers neither sell nor hire labor (autarky). Third and fourth, they either sell or hire labor.

Farm household budget constraint (4) states that a household's ('tax-corrected') expenditures (left-hand side of (4)) must not exceed its ('tax-corrected') total income (right-hand side). Households may receive income from farming and from off-farm employment. In addition, it receives (E>0) or pays (E<0) transfers, which are determined exogenously. Here, $P_i; i = m, a, c, v$ denote the exogenous consumer and producer prices before tax, and τ_j are the parameters of tax policies to be analyzed. Note, to analyze the impact of the market surplus (τ_{ms}) and value-added taxes (τ_{vat}), it becomes necessary to differentiate between net sellers and net buyers of the self-produced agricultural goods. In particular, due to the empirical evidence in our data base, we suppose that the household is a net supplier $(X_a - C_a > 0)$.

In detail, τ_{vat} denotes the value-added tax. Legally and in non-peasant households, total monetary expenditures are subject to value-added taxes. For farm households, however, internal transfer of self-produced agricultural goods cannot be observed by tax authorities. Thus, only the expenditures for market commodities $(P_m C_m)$ are subject to the value-added tax. The basis of the income tax (τ_y) is the household's monetary income, including profits from farming $\left(P_c X_c + P_a X_a - P_v\left|X_v\right| - g\left(X_l^h\right)\right)$, where $g\left(X_l^h\right)$ denotes hired labor costs (see below), and also off-farm labor income $\left(f\left(X_l^s\right)\right)$, and transfers $\left(E\right)$. Due to the virtual absence of record keeping, farm income is often not taxable and thus only incomes from off-farm employment can be taxed by a wage tax (τ_w). Similarly, market surplus, input, or land taxes are applied as surrogates for an income tax. The base of the market surplus tax (τ_{ms}) are revenues from sales of agricultural goods $\left(P_c X_c + P_a\left(X_a - C_a\right)\right)$, assuming internal transfers are not taxable. Expenditures for commercial inputs $(P_v X_v)$ such as fertilizer and chemicals are subject to the input tax (τ_v) and the market value of land $\left(R_G\right)$ is taxed by a land tax $\left(\tau_G\right)$.

To consider labor market imperfections, revenues from off-farm employment and hired labor costs are conceptualized as functions of supplied $f\left(X_l^s\right)$ and hired $g\left(X_l^h\right)$ labor time. If perfectly competitive labor markets are to be assumed, then the functions are both linear, with $f\left(.\right) = P_l X_l^s$ or $g(.) = P_l X_l^h$. Hence, marginal off-farm income or marginal costs for hired labor are equal to the exogenously given wage rate (P_l). In this case, the farm household model is separable (between production and household decisions).

In contrast, when labor markets are assumed to be imperfectly competitive both functions become nonlinear with the following properties: $\partial f(.)/\partial X_l^s > 0$; $\partial^2 f(.)/\partial X_l^{s^2} < 0$ and $\partial g(.)/\partial X_l^h > 0$; $\partial^2 g(.)/\partial X_l^{h^2} > 0$, respectively. Now, off-farm income is an increasing and strictly concave function of supplied labor time. Analogously, the costs of hired labor are an increasing and strictly convex function of hired labor time. In this case, the price of labor and leisure (P_l) is endogenously determined and thus the farm household model is non-separable. The production and consumption decisions are simultaneously determined by the stationary solution of the equation system (1) to (4).

As mentioned above (see 'Introduction'), this framework is applicable for several kinds of labor market imperfections. In particular, it accounts for labor market imperfections which lead to a decreasing price effectively received for each further unit of off-farm employment and to an increasing price effectively paid for each further unit of hired labor time. Hence, such conditions can be interpreted as increasing per-units costs of accessing labor markets, or in other words as increasing transaction costs.

Increasing transaction costs associated with working off the farm may be caused by an increasing heterogeneity between on- and off-farm family labor. With a growing migration household members are first transferring to the 'best jobs' followed by the 'next best jobs' and so on (Low 1982, 1986). Similarly, increasing search and transportation costs may lead to a decreasing net wage rate. Increasing per-unit costs of hired labor may result from increasing search, supervision, and monitoring activities. It seems to become more and more difficult to find the 'right' staff for the different and often farm-specific areas of production. Moreover, with increasing staff and hired labor time, respectively, the supervision and monitoring per-unit of hired labor may become more costly. Similarly, the existence of land-specific experience may lead to a decreasing substitutionality between family and hired labor. Hired labor becomes less productive and the costs for a standardized hired labor unit increase.

Note that the approach could additionally incorporate fixed costs of transactions that are invariant to the traded quantity, but also could affect the farm household's decision to participate in markets (Sadoulet, de Janvry and Benjamin for the labor markets; Goetz as well as Key, Sadoulet and de Janvry for food markets; Skoufias, and Carter and Yao for the land market). Fixed transaction costs may include bargaining and negotiation efforts and transportation costs, often taking place once per transaction, and are invariant to the level of transaction.

Taking fixed costs of accessing labor markets into account might mainly contribute to the explanation of the different labor market participation regimes. This paper does not investigate the analysis of different market participation regimes and thus we do not explicitly model fixed transaction costs within the theoretical framework. We assume that the farm household hires on-farm and supplies off-farm labor simultaneously. Without any problems, the model is applicable for all other market participation schemes. In contrast, within the empirical analysis the possible occurrence of fixed cost in accessing the labor market is taken into account, in particular to identify the 'true' labor market conditions.

The stationary solutions to the maximization problem (1)-(4) determine the optimal quantities of consumption and production goods, and the allocation of time, assuming there exists an interior solution ($\lambda,\phi,\mu > 0; C_m, C_a, C_l, X_c, X_a, X_l^h, X_l^s > 0$, and $X_l, X_v < 0$).

$$U_i\left(.\right) - \lambda P_i^* = 0 \qquad i \in \{m,a,l\} \qquad (5)$$

$$\phi G_i\left(.\right) + \lambda P_i^* = 0 \qquad i \in \{c,a,v,l\} \qquad (6)$$

$$f_l^*(.) = P_l^* = g_l^*(.) \qquad (7)$$

$$\sum_{i\in\{c,a,v\}} P_i^* X_i - g^*\left(X_l^h\right) + f^*\left(X_l^s\right) - R_G^* + E - \sum_{i\in\{m,a\}} P_l^* C_i = 0 \qquad (8)$$

$$G(x,r) = 0 \qquad (9)$$

$$T_l + X_l + X_l^h - X_l^s - C_l = 0 \quad (10)$$

Here $\lambda, \phi > 0$ are Lagrangian multipliers associated with the budget and the technology constraints, respectively. U_i, G_i, f_l and g_l represent the first derivatives of the corresponding utility, production, and labor market functions. $P_l^* = \mu/\lambda$ denotes the unobservable internal wage in the case of non-separability, where μ is the Lagrangian multiplier associated with the time constraint. In the separable version, P_l^* indicates the exogenous 'tax corrected' wage rate. Furthermore, $P_{Cm}^* = (1+\tau_{vat})P_m$ and $P_{Ca}^* = (1-\tau_{ms})P_a$ represent the ('tax-corrected') decision prices for consumption goods. The decision prices for production goods are indicated by $P_{Pc}^* = (1-\tau_y)(1-\tau_{ms})P_c$, $P_{Pa}^* = (1-\tau_y)(1-\tau_{ms})P_a$ and $P_{Pv}^* = (1-\tau_y)(1+\tau_v)P_v$. In addition, the following definitions hold: $R_G^* = \tau_G R_G$, $f^*(.) = (1-\tau_y)(1-\tau_w)f(.)$, and $g^*(.) = (1-\tau_y)g(.)$.

COMPARATIVE STATIC

To facilitate the comparative static analysis we transform the primal decision problem (1)-(4) into a dual representation (Diewert). First we define a dual restricted profit function

$$\Pi(p^*, r) \equiv \max_x \left\{ p^* x \mid G(x,r) = 0 \right\},$$

where p^* is the (decision) price vector of the production goods and $\Pi(p^*, r)$ is the maximal profit. Following Hotelling's lemma, the optimal quantities of production goods are defined by $\partial\Pi(.)/\partial P_i^* = X_i(p^*, r); \forall i \in \{c, a, v, l\}$.

Further, we can define a dual expenditure function $e(p^*, U^\circ) \equiv \min_c \left\{ p^* c \mid U(c) \geq U^\circ \right\}$. Here p^* is the (decision) price vector of the consumption goods and U° is the obtainable utility level. According to Shepard's lemma, we can derive the Hicksian compensated demand function, with $\partial e(.)/\partial P_i = C_i^H(p^*, U^\circ); \forall i \in \{m, a, l\}$. Substituting the indirect utility function $V(p^*, Y)$ for U°, it holds that $C_i^H(p^*, V(p^*, Y)) \equiv C_i(p^*, Y)$. Thus, the Hicksian demand at utility $V(p^*, Y)$ is the same as the Marshallian demand at income *Y*.

For the non-separable model version, condition (7) defines the off-farm labor supply $X_l^s = X_l^s(P_l^*, \tau_j)$ and the demand for hired labor $X_l^h = X_l^h(P_l^*, \tau_j)$ as implicit functions of the endogenous labor price (P_l^*) and of those tax parameters (τ_y, τ_w) that (directly) affect the general wage level and hence the position of the labor market functions[2].

Substituting the defined dual and implicit functions into the time constraint (10) results in:

$$T_l + X_l(p_P^*, r) + X_l^h(P_l^*, \tau_j) - X_l^s(P_l^*, \tau_j) - C_l(p_C^*, Y) = 0, \quad (11)$$

where $Y = \Pi(.) - g^*\left[X_l^h(.)\right] + f^*\left[X_l^s(.)\right] + P_l^*\left[T_l + X_l^h(.) - X_l^s(.)\right] - R_G^* + E = \sum_{i \in CG} P_{Ci}^* C_i$.

Equation (11) implicitly defines the shadow wage (P_l^*) around the optimal solution of the non-separable model.

Hence, $P_l^* = \chi\left(p^*, r, T_l, E, R_G^*, \tau_j\right)$ is an implicit function of exogenous decision prices for consumption and production goods (p^*), fixed resources (r), total time available (T_l), land tax payments (R_G^*), and those tax parameters $\left(\tau_j \mid j = y, w\right)$, which directly affect the wage level. Note that the impact of the other tax policies to the shadow price is already reflected by 'tax-corrected' exogenous prices.

Based on the above defined functions, we can derive farm households' consumption, production and labor market responses $\left(Z = C_i, X_i, X_l^s, X_l^h\right)$ to changes in any of the designed tax parameters $\left(\tau_j \mid j = y, w, ms, v, r, vat\right)$. In the case of non-separablility, we can decompose the tax-induced farm household reactions for any arbitrary tax policy into the following two components (de Janvry, Fafchamps, and Sadoulet; Sonoda and Maruyama):

$$\frac{\partial Z}{\partial \tau_j} = \left.\frac{\partial Z}{\partial \tau_j}\right|_{P_l^* = const.} + \frac{\partial Z}{\partial P_l^*}\frac{\partial P_l^*}{\partial \tau_j} \quad . \tag{12}$$

The first term (direct component) on the right-hand side represents the supply or demand reactions to changes in the designed tax parameters assuming a constant endogenous labor price (P_l^*). The second term (indirect component) represents the adjustments to the changes in the internal wage rate caused by changes in the same tax parameter.

In order to determine the indirect component of the non-separable version, we have to derive the tax-induced shadow price adjustment from equation (11), applying the implicit function theorem (de Janvry, Fafchamps, and Sadoulet):

$$P_{l\tau_j}^* = \frac{\partial P_l^*}{\partial \tau_j} = -\frac{\left(X_{l\tau_j} + X_{l\tau_j}^h - X_{l\tau_j}^s - C_{l\tau_j}^H\right) - \left(C_{lY}\Psi\right)}{\left(X_{ll} + X_{ll}^h - X_{ll}^s - C_{ll}^H\right)} \tag{13}$$

The numerator on the right-hand side represents the change in the time allocation due to increasing tax rates. Here, $X_{l\tau_j} = \sum_{i\in\{c,a,v\}} \frac{\partial X_l}{\partial P_i^*}\frac{\partial P_i^*}{\partial \tau_j}$ denotes tax-induced on-farm labor adjustment, and

$X_{l\tau_j}^h = \left.\left(\partial X_l^h / \partial \tau_j\right)\right|_{P_l^* = const.}$ and $X_{l\tau_j}^s = \left.\left(\partial X_l^s / \partial \tau_j\right)\right|_{P_l^* = const.}$, respectively are the direct labor market reactions to increasing income or wage taxes[3]. Furthermore, $C_{l\tau_j}^H = \sum_{i\in\{m,a\}} \frac{\partial C_l^H}{\partial P_i^*}\frac{\partial P_i^*}{\partial \tau_j}$ and $C_{lY}\Psi = \left(\partial C_l / \partial Y\right)\Psi$ are the tax-induced substitution and income effects with regard to the demand of leisure. Here, $\Psi = \left.\left(\frac{\partial Y}{\partial \tau_j} - \sum_{i\in\{m,a\}} C_i \frac{\partial P_i^*}{\partial \tau_j}\right)\right|_{P_l^* = const.}$ reflects the budget effects.

The denominator indicates the change in the time allocation caused by changes in the internal wage rate. Here, $X_{ll} = \partial X_l / \partial P_l^* > 0$, $X_{ll}^h = \partial X_l^h / \partial P_l^* = 1 \Big/ \left(\partial^2 g^*(.) / \partial X_l^{h2}\right) > 0$, $X_{ll}^s = \partial X_l^s / \partial P_l^* = 1 \Big/ \left(\partial^2 f^*(.) / \partial X_l^{s2}\right) < 0$ and $C_{ll}^H = \partial C_l / \partial P_l^* < 0$[4]. Note that the denominator is always positive given convexity of Π(.) and the concavity of *e*(.) in prices, and given the convexity of $g^*(.)$ and the concavity of $f^*(.)$ in traded labor.

Substituting equation (13) into expression (12) yields farm household tax-induced economic adjustments:

$$\partial X_i \big/ \partial \tau_j = X_{i\tau_j} + X_{il} P^*_{l\tau_j} \qquad i = \{c, a, v, l\} \tag{14}$$

$$\partial C_i \big/ \partial \tau_j = C^H_{i\tau_j} + C_{iY}\Psi + C^H_{il} P^*_{l\tau_j} \qquad i = \{m, a, l\} \tag{15}$$

$$\partial X^s_l \big/ \partial \tau_j = X^s_{l\tau_j} + X^s_{ll} P^*_{l\tau_j} \tag{16}$$

$$\partial X^h_l \big/ \partial \tau_j = X^h_{l\tau_j} + X^h_{ll} P^*_{l\tau_j} . \tag{17}$$

Equation (14) indicates the tax-induced production adjustments, where $X_{i\tau_j} = \sum_{k\in\{c,a,v\}} \frac{\partial X_i}{\partial P^*_k} \frac{\partial P^*_k}{\partial \tau_j}; i = \{c, a, v, l\}$ denotes the respective direct component and

$X_{il} P^*_{l\tau_j} = \frac{\partial X_i}{\partial P^*_l} \frac{\partial P^*_l}{\partial \tau_j}, i = \{c, a, v, l\}$ is the indirect component. Equation (15) represents households' consumption responses, where $C^H_{i\tau_j} = \sum_{k\in\{m,a\}} \frac{\partial C^H_i}{\partial P^*_k} \frac{\partial P^*_k}{\partial \tau_j}$ and $C_{iY}\Psi = \frac{\partial C_i}{\partial Y} \frac{\partial Y}{\partial \tau_j}; i = \{m, a, l\}$, respectively are the tax-induced direct substitution and income effects. $C^H_{il} P^*_{l\tau_j} = \frac{\partial C_i}{\partial P^*_l} \frac{\partial P^*_l}{\partial \tau_j}; i = \{m, a, l\}$ denotes the corresponding indirect component. The last two equations (16) and (17) represent farm households adjustments regarding the supply of family labor off-farm and the demand for hired labor, respectively. Here, the respective first terms (right-hand side) are direct tax-induced adjustments, whereby the second terms indicate the respective indirect components (see above).

Assuming separability, in most cases farm households' economical adjustments coincide with the direct components of the non-separable version. This is particularly true for all production and consumption adjustments to changes in tax parameters which do not affect the general wage level $\left(\tau_j \mid j = ms, v, r, vat\right)$. In contrast, they do not coincide with the direct components of the separable version in the case of an income tax or a wage tax $\left(\tau_j \mid j = y, w\right)$ since both directly affect the general wage level and hence shift the labor market functions. Regarding the labor markets, the comparative static of the separable version differs from the direct component of the non-separable version for all tax policies under consideration. In the case of separability, labor market adjustments residually result from the time constraint, after production and consumption decisions are made: $\partial(T_l + X_l - C_l) \big/ \partial \tau_j$.

In accordance with the equations (13) to (17), we derive the complete comparative static for all tax instruments mentioned above,[5] summarized in the following two tables[6]. In particular, we compare the tax-induced adjustments within the non-separable version with those of the separable framework.

Table 1. Theoretical tax effects – non-separable model version.

Tax	Farm				Household			Labor Market			Internal Wage
	X_c	X_a	X_l	X_v	C_m	C_a	C_l	X_l^h	X_l^s	X_l^s - X_l^h	P_l^*
τ_y	?	?	?	?	(-)	(-)	?	?	?	?	-
τ_w	+	+	+	(+)	(-)	(-)	?	-	?	?	-
τ_{ms}	?	?	?	?	?	?	?	?	?	?	?
τ_v	?	?	?	?	?	?	?	?	?	?	?
τ_G	+	+	+	(+)	(-)	(-)	?	-	+	+	-
τ_{vat}	?	?	?	?	?	?	?	?	?	?	?

Notes: It is assumed that goods are not inferior and technologies are not regressive.
+/- = clear, increase/decrease; (+)/(-)
= unclear, but most likely an increase/decrease (assuming labor
and variable inputs are complements, and consumption goods are net-substitutes);
? = unclear.

Table 2. Theoretical tax effects – separable model version.

Tax	Farm				Household			Labor market
	X_c	X_a	X_l	X_v	C_m	C_a	C_l	X_l^s - X_l^h
τ_y	/	/	/	/	(-)	(-)	?	?
τ_w	+	+	+	(+)	(-)	(-)	?	?
τ_{ms}	-	-	-	-	(-)	?	(-)	(+)
τ_v	-	-	(-)	-	-	-	-	(+)
τ_G	/	/	/	/	-	-	-	+
τ_{vat}	/	/	/	/	-	?	?	?

Notes: It is assumed that goods are not inferior, technologies are not regressive, and farmers are net supplier of labor.
/ = clear, no effect
+/- = clear, increase/decrease;
(+)/(-) = unclear, but most likely an increase/decrease
(assuming labor and variable inputs are complements, and consumption goods are net-substitutes);
? = unclear.

Comparative static results suggest that when labor market imperfections occur (table 1) most tax-induced allocation effects are theoretically unclear, mainly caused by undetermined or partly counteracting shadow price components. Only a wage tax (τ_w) and surprisingly a land tax (τ_G) might clearly lead to an expansion of production. Also, tax-induced consumption effects are strictly speaking theoretically unclear. However, assuming consumption goods are net-substitutes, a decreasing demand for market and self-produced consumption goods seems probable in some cases. In addition, nearly all tax induced labor market adjustments are theoretically undetermined.

In particular, the analysis reveals some unexpected results in case of non-separability (table 1). In contrast to several other studies, we find that standard taxes, that is income (τ_y) and value added taxes (τ_{vat}), as well as land taxes (τ_G) thoroughly could imply production adjustments. Analogously, increasing agricultural taxes, as market surplus (τ_{ms}) and input (τ_v) taxes, may lead to a higher demand of some consumption goods. Increasing agricultural taxes might imply a higher internal valuation of labor, and thus lets the household members to substitute leisure for other consumption goods. Similarly, a value added tax (τ_{vat}) theoretically might lead to a higher consumption of commercial goods, which are themselves subject to the tax. Also the reduction of hired labor as a result of an increased wage tax (τ_w) appears to be surprising. However, a lower internal wage rate implies that family labor becomes less expensive compared to hired on-farm labor. Therefore hired labor will be substituted as long as their marginal cost equals the (reduced) shadow wage.

Furthermore, the analysis indicates that tax-induced farm household effects may differ between the non-separable (table 1) and the separable (table 2) model version. That is, labor market imperfections may have an impact on tax effects. In particular, production and consumption adjustments might differ for all agricultural taxes (τ_{ms}, τ_v, τ_G) and the value-added tax (τ_{vat}), while an income tax (τ_y) may imply different production, but similar consumption adjustments. The wage tax (τ_w), however, probably induces similar production and consumption responses within the two model versions. Labor market adjustments might theoretically differ between the two model versions for market surplus (τ_{ms}) and input (τ_v) taxes.

Finally, comparative static analysis reveals that basic results of optimal taxation and agricultural taxation literature have to be modified in part. In particular, since income and value-added taxes could imply production effects, they are no more necessarily superior to agricultural taxes in the sense of the optimal taxation theory. One of the basic results of the optimal taxation literature is that theoretically optimal taxation policies usually consist of a well-defined combination of consumption (value added) and income taxes, assuming those taxes imply no production effects. Diamond and Mirrless point out in their fundamental work, that production efficiency is desirable within an optimal taxation system, although a full Pareto optimum is not achieved, since commodity taxes imply that marginal rates of substitution are not equal the marginal rates of transformation. Analogously, since the presence of labor market imperfections implies that a land tax can lead to production adjustments and efficiency losses, it is no more clearly superior to market surplus or input taxes.

EMPIRICAL SPECIFICATION

To clarify the direction and quantify the extent of the tax-induced farm household reactions, we estimate a fully-specified non-separable farm household model. The data rely on a farm accounting survey undertaken in various regions in Mid-West Poland. Based on the estimated parameters we derive tax elasticities which capture tax-induced production, consumption and labor market reactions.

The farm household model is specified as follows. The production decisions are represented by a multi-output, multi-input profit function from the symmetric normalized quadratic[7] (SNQ) form (Diewert and Wales 1987, 1992; Kohli). The SNQ profit function is flexible. To ensure global convexity, we apply the method proposed by Koebel, Falk and Laisney (2000, 2003) (see below). The consumption decisions of the farm households are specified by an AIDS consumer demand system (Deaton and Muellbauer). The AIDS is flexible, but not necessarily concave. Therefore, we have to check concavity. Imperfectly competitive labor markets are represented by a convex cost function for hired labor and by a concave income function for off-farm family labor.

The econometric estimation of the proposed model is carried out in three steps. First, we estimate the cost function for hired labor $\left(g^*\left(X_l^h\right)\right)$ and the off-farm income function $\left(f^*\left(X_l^s\right)\right)$ as two nonlinear regression equations:

$$g_n^* = \beta_h \left(X_{ln}^h\right)^{\alpha_h} + \kappa_h + \upsilon_n \tag{18}$$

$$f_n^* = \beta_s \left(X_{ln}^s\right)^{\alpha_s} - \kappa_s + \omega_n, \tag{19}$$

Here n indicates the observation and X_l^h and X_l^s indicate the farm-specific quantities of traded labor. β, α and κ are the parameters to be estimated, where κ accounts for fixed costs of assessing labor markets, and υ and ω represent the random error terms. Based on the estimated parameters, we can calculate the 'basic' internal wage (P_l^*) for each individual farm household, with: $P_{ln}^{h*} = \alpha_h \beta_h \left(X_{ln}^h \right)^{\alpha_h - 1}$ for hired labor and $P_{ln}^{s*} = \alpha_s \beta_s \left(X_{ln}^s \right)^{\alpha_s - 1}$ for supplied off-farm labor, respectively.

Unfortunately, the estimation results show remarkable price differences between hired and supplied labor for those households that both hire and sell labor, neglecting the fact that in equilibrium marginal cost of hired on-farm labor has to be equal to marginal off-farm income. In all cases, the prices for supplied labor $\left(P_{ln}^{s*} \right)$ are higher than those for hired labor $\left(P_{ln}^{h*} \right)$. This might be the result of unobservable transaction costs (e.g. search, supervision, or transportation costs), which increase the internal value of hired labor, and decrease the internal value of supplied labor. Thus, the occurrence of unobservable transaction costs might offset the 'observed' differences between the internal prices of hired on-farm and supplied off-farm labor. Hence, $P_{ln}^* = P_{ln}^{h*} + \Lambda_n^h = P_{ln}^{s*} - \Lambda_n^s$, where Λ_n^h and Λ_n^s denote the unobserved per unit costs of accessing labor markets.

Since there is no further information available, it is assumed that the unobserved per unit cost of hiring on-farm and of selling off-farm labor are equal, with: $\Lambda_n^h = \Lambda_n^s = \frac{1}{2}\left(P_{ln}^{s*} - P_{ln}^{h*} \right)$. Thus, the 'adjusted' shadow prices are simply defined as the mean of the prices for hired and supplied labor, with

$$P_{ln}^* = \frac{1}{2}\left(P_{ln}^{h*} + P_{ln}^{s*} \right).$$

For farm households that either (only) sell or (only) hire labor, it seems reasonable to assume that the relations between the unobservable transaction costs and the 'observed' internal wages are similar to those households that both supply and hire labor.[8]

Considering the ratios of the average unobserved transaction costs and 'observed' labor prices of households that sell and hire labor at the same time with $\overline{\Lambda}^s / \overline{P}_l^{s*}$ and $\overline{\Lambda}^h / \overline{P}_l^{h*}$, the 'adjusted' internal prices for purely selling households are defined as $P_{ln}^{s*} = P_{ln}^{s*} - P_{ln}^{s*} \frac{\overline{\Lambda}^s}{\overline{P}_l^{s*}}$ and for purely hiring farms as $P_{ln}^{h*} = P_{ln}^{h*} + P_{ln}^{h*} \frac{\overline{\Lambda}^h}{\overline{P}_l^{h*}}$. Here, $P_{ln}^{s*} \frac{\overline{\Lambda}^s}{\overline{P}_l^{s*}} = \Lambda_n^s$ and $P_{ln}^{h*} \frac{\overline{\Lambda}^h}{\overline{P}_l^{h*}} = \Lambda_n^h$, respectively, indicate the calculated unobserved transaction costs. Finally, for farms that neither sell nor hire labor (autarky) the internal wage rate is defined as the average 'adjusted' shadow wage of the other households in the sample.

Considering the calculated 'adjusted' wage rates, in the second step we estimate the four netput equations $\left(X_i; i = \{c, a, v, l\} \right)$ from the SNQ profit function[9]:

$$X_{in} = \alpha_i + w_n^{-1} \sum_{j \in PG} \beta_{ij} P_{jn}^* - \frac{1}{2} \theta_i w_n^{-2} \sum_{j \in PG} \sum_{k \in PG} \beta_{jk} P_{jn}^* P_{kn}^* + \sum_{j \in R} \delta_{ij} R_{jn} + \frac{1}{2} \theta_i \sum_{j \in R} \sum_{k \in R} \gamma_{jk} R_{jn} R_{kn} + \xi_{in}, \quad (20)$$

where $w_n = \sum_{i \in PG} \theta_i P_{in}^*$ and $\theta_i = \frac{\sum_n P_{in}^* \left| X_{in} \right|}{\sum_n \sum_{j \in PG} P_{jn}^* \left| X_{jn} \right|}$. Further, P_i^* indicates the producer price indices and X_i; $i = \{c, a, v, l\} \in PG$ denotes the aggregated net outputs and net inputs. R represents the quasi fixed factors land (G) and capital (K). α, β, δ, γ are the parameters to be estimated, and ξ represents the error terms. To identify all β coefficients, we impose the following restrictions: $\sum_{j \in PG} \bar{P}_j^* \beta_{ij} = 0; \forall_i$, where $\bar{P}_J^*$ are the mean prices (Diewert and Wales 1987, p. 54).

In the last step we estimate the household's consumption decisions via an AIDS consumer demand system consisting of three commodity groups: purchased commodities (C_m), self-produced consumption goods (C_a), and leisure (C_l). The following specification is used (Deaton and Muellbauer):

$$W_{in} = \alpha_i + \sum_{j \in CG} \gamma_{ij} \ln P_{jn}^* + \beta_i \ln \frac{Y_n}{\wp_n} + \omega_{in} \quad (21)$$

$$\ln \wp_n = \alpha_0 + \sum_{i \in CG} \alpha_i \ln P_{in}^* + \frac{1}{2} \sum_{i \in CG} \sum_{j \in CG} \gamma_{ij} \ln P_{in}^* \ln P_{jn}^* . \quad (22)$$

Here, $W_i = P_i^* C_i / Y \; ; i = \{m, a, l\}$ are the budget shares, where Y indicates the full income. $\wp$ is the translog consumer price index, and P_I^* indicates the consumer price indices of the aggregated commodity groups (C_i; $i=\{m, a, l\} \in CG$). α, β, and γ are the parameters to be estimated[10], and ω represents the error terms.

DATA AND EMPIRICAL RESULTS

Data used for the estimations are based on an accounting survey of a four year-panel (1991-1994) of agricultural households in several regions around Poznan (Mid-West Poland). The data were collected and published by the Institute for Agriculture and Food Industries (IERiGZ) in Warsaw. Initially, the data consists of an unbalanced panel of about 650 farms over the observation period. For this study, a balanced panel of 76 farms per annum is selected, i.e. we considered only those farms that were in the sample each year.

On the production side, pure market goods (X_c) consist of cereals, sugar beets, rape, and potatoes, while milk, beef, pork, poultry, and eggs were considered as home-consumed production goods (X_a). Variable inputs (X_v) comprises fertilizer, chemicals, seed and feed. Labor (X_l) includes both family and hired labor. Land (G)[11] and Capital (K) are considered as a quasi-fixed factors. On the consumption side, C_m includes all purchased consumption goods, in particular nonfood including housing. C_a corresponds conceptually to the self-produced livestock products (X_a). The amount of leisure (C_l) is determined by calculating the yearly available time (T_l) of households (household members older then 15 years × 16 hours × 365 days) minus on-farm (X_l^f) and off-farm (X_l^s) family labor. Appendix table A1 gives an overview of main sample characteristics.

Before beginning to present and interpret the main results, namely the tax elasticities, we use appendix tables A2 to A4 to give an overview of the estimated parameters, the goodness of fit, and the theoretical consistency of the estimated model. All estimations and calculations are carried out by the (free) software "R" (Ihaka and Gentleman, see also http://www.r-project.org).

Parameter Estimates, Goodness of Fit, and Consistency

We found most parameters of the labor market function ((18) and (19)) and nearly all parameters of the demand system ((21) and (22)) of statistical significance. In particular, the estimated α_h is significantly greater than 1, indicating convexity of the cost function for hired labor. The estimated α_s lies between 0 and 1, revealing concavity of the off-farm income function, but is not significantly different from one.[12] Since at the production side (20) the estimated coefficients of the netput equations did not satisfy convexity of the profit function, we restrict the model retaining convexity (see below). However, this procedure does not provide standard errors.[13] When evaluating the goodness of fit of the estimated farm household approach, we found R^2 values between 0.04 and 0.86. While the 'fit' appears to be satisfactory for the labor market equations with a R^2 of 0.73 and 0.85, and the (restricted) netput equations (R^2 values ranging from 0.50 to 0.83), the calculated coefficients of determination of the budget share equations are relatively low (0.04, 0.38 and 0.15). However, we find R^2 values explaining quantities to be consumed between 0.25 and 0.92.

Theoretically consistent estimations require, that the regularity conditions (adding-up, symmetry, homogeneity, monotony, and convexity and concavity, respectively) have to be fulfilled. The symmetry and the homogeneity (AIDS) condition are enforced by parameter restrictions, but we have to check monotony as well as convexity and concavity. Monotony of the profit and expenditure function can be easily checked via the signs of the netput quantities and budget shares, respectively. We found that the monotony conditions are fulfilled in nearly all cases (100 % at the consumption side and 98% at the production side).

Finally, we check convexity and concavity via the semi-definiteness of the Hessian's of the profit and expenditure function, respectively. The expenditure function is at almost all data points (91%) concave. In contrast, the estimated coefficients of the netput equations did not satisfy convexity of the profit function. Thus, we enforce convexity with a new procedure proposed by Koebel, Falk, and Laisney (2000, 2003). In a first step, we tried to impose convexity by the Cholesky decomposition (Lau). Since the estimation of the restricted non-linear netput equations did not converge, we chose the method suggested by Koebel, Falk, and Laisney. It is based on the minimum distance and asymptotic least squares estimation (Gourieroux, Monfort, and Trognon; Kodde, Palm, and Pfann), and is asymptotic equivalent to a (successful) direct estimation with convexity imposed. First, the unrestricted (linear) netput equations are estimated as SUR system, and the resulting coefficients are used to calculate the unrestricted Hessian matrix. Second, the weighted difference between this unrestricted and a restricted Hessian is minimized by a nonlinear Newton-type optimization algorithm. Finally, restricted coefficients are identified by an asymptotic least squares (ALS) framework.[14]

Tax Elasticities

Tax elasticities presented here reflect the relative change of the respective economic variables with respect to the change of the analyzed taxes. In order to separate the impact of labor market imperfections, we derive tax elasticities assuming non-separability as well as separablility. We compute the tax elasticities as a function of the relevant price and income elasticities (see annex tables A5 and A6), which are based on the underlying estimated parameters and calculated using the sample mean values of the relevant variables. Strictly speaking, 'tax elasticities' indicate the percentage change of the economic variables (*Z*) when the tax increases by one percentage *point*.

The tax elasticities correspond to the differentials in the comparative static analysis.[15] Analogously to equation (12), tax elasticities within the non-separable framework compound a direct and an indirect component

$$\frac{\partial \ln Z}{\partial \tau_j} = \left.\frac{\partial \ln Z}{\partial \tau_j}\right|_{P_l^*=const.} + \frac{\partial \ln Z}{\partial \ln P_l^*}\frac{\partial \ln P_l^*}{\partial \tau_j} \tag{23}$$

Here $Z = \left(C_i, X_i, X_l^s, X_l^h\right)$ indicates the consumption and production goods, as well as supplied off-farm and hired on-farm labor, and $\tau_j \,(j = y, w, ms, v, r, vat)$ are the tax parameters under investigation.

Table 3 gives an overview of the tax elasticities and shadow price elasticities within the non-separable framework. We find unexpected low production effects and a mediocre reduction in consumption as a result of an increasing income tax (τ_y). Only the adjustments regarding the labor markets are relatively large: Farmers will increase their supply of off-farm labor (2.19) and hire less on-farm labor (-1.27). The low tax-induced production response can be explained by both the fact that the tax induced shadow price elasticity (1.32) is not very different from one and, in addition, the very low labor price elasticities of output supply and input demand. The first argument needs to be further explored (see also section 'comparative static'). An income tax *directly* affects all prices apart from the labor price of the output supply and the input demand functions with 'tax-price elasticities' of one. With a tax induced shadow price elasticity close to one, all production prices approximately change in the same proportion. Thus, given the homogeneity condition of output supply and input demand functions, the income tax does not affect the production plan to a remarkable extent.

Table 3. Tax elasticities – non-separable model version.

Tax	Farm				Household			Labor Market			Internal Wage
	X_c	X_a	X_l	X_v	C_m	C_a	C_l	X_l^h	X_l^s	X_l^s - X_l^h	P_l^*
τ_y	0.00	0.01	0.01	0.01	-0.76	-0.46	-0.10	-1.27	2.19	3.07	-1.32
τ_w	0.01	0.03	0.02	0.03	-0.34	-0.22	0.05	-2.84	-2.04	-1.84	-0.71
τ_{ms}	-0.14	-0.26	-0.06	-0.35	-1.22	0.18	-0.42	-5.71	9.83	13.78	-1.42
τ_v	-0.14	-0.24	-0.05	-0.33	-0.58	-0.32	-0.24	-3.26	5.62	7.88	-0.81
τ_G	0.00	0.00	0.00	0.00	-0.06	-0.03	-0.02	-0.32	0.56	0.78	-0.08
τ_{vat}	0.00	0.01	0.01	0.01	-0.87	0.33	-0.06	-0.75	1.29	1.81	-0.19

Notes: Tax elasticities are calculated at τ_j=0 using the sample mean values of the relevant variables.

An increasing taxation of off-farm labor (τ_w) leads to an increasing subsistence character of the farm households. Labor market transactions both for hired (-2.84) and supplied (-2.04) labor will be reduced to a great extent. Further, the consumption of self-produced food and market commodities decreases while the demand for leisure slightly increases. On the production side, we find a slight increase in the output supply and input demand, which seems to be the result of very low labor price elasticities of output supply and input demand. Note, that the exclusive taxation of off-farm labor corresponds to the tax policy that has existed in Poland's agricultural sector during the observation period (1991-1994).

The most important and relative homogenous allocation effects will be induced by a market surplus and an input tax (τ_{ms} and τ_v). We find the general reduction of production activities with elasticities ranging from -0.05 up to -0.35, a sharp decreasing consumption of purchased commodities (-1.22 and -0.58), and moderate consumption adjustments of self-produced food and leisure. Furthermore, farmers will hire less labor (-5.71 and -3.26) and sell more off-farm labor (9.83 and 5.62) to a great extent, particularly in the case of a market surplus tax. Although, the tax induced shadow price reactions are relatively large (-1.42 and -0.81), the production decisions seem to be determined by the respective direct components.

On the consumption side, the very elastic adjustment of market goods caused by an increasing market surplus tax can be explained by an additional direct Hicksian substitution effect. In contrast to the input tax, the market surplus tax induces a lower (decision) price for the self-produced good enforcing the household members to substitute self-produced goods for market commodities.

Except for the labor market responses, the land tax (τ_G) elasticities are around zero, especially due to very low shares of land assets, which leads to a adjustment of the internal wage (-0.08). A value-added tax (τ_{vat}) leads via the indirect (shadow wage) component to a slight increase in the supply and demand of production goods, and to a relatively large decrease of the household's market consumption (-0.87). However, the consumption of self-produced goods does increase (0.33). Since the value of self-produced food cannot be observed and taxed (see above) the Hicksian cross price effect 'works' against the (tax-induced) negative income effect, and lets households substitute self-produced consumption goods for market goods.

In the case of perfectly competitive labor markets (table 4), the income tax (τ_y) induces (as expected) no production adjustments. While the adjustments of the consumption pattern are similar to the non-separable model version, net off-farm labor supply increases to a greater extent (4.32) as in the case of non-separability (3.07). Likewise, farm household adjustments of an increasing wage tax (τ_w) are very similar to the non-separable version. We only find remarkable differences regarding the net off-farm labor supply.

Table 4. Tax elasticities – separable model version.

Tax	Farm				Household			Labor Market
	X_c	X_a	X_l	X_v	C_m	C_a	C_l	$X_l^s - X_l^h$
τ_y	/	/	/	/	-0.62	-0.36	-0.13	4.32
τ_w	0.01	0.04	0.03	0.04	-0.47	-0.31	0.09	-3.09
τ_{ms}	-0.16	-0.32	-0.10	-0.40	-0.58	0.61	-0.58	19.41
τ_v	-0.15	-0.27	-0.07	-0.36	-0.14	-0.05	-0.21	7.23
τ_G	/	/	/	/	-0.02	-0.01	-0.03	1.10
τ_{vat}	/	/	/	/	-0.78	0.39	-0.08	2.55

Notes: Tax elasticities are calculated at τ_j=0 using the sample mean values of the relevant variables.

As expected, most important differences between the two model versions are found regarding the market surplus and input taxes (τ_{ms} and τ_v). We only find slightly larger production and labor market responses within the separable framework, but the consumption effects differ to a remarkable extent in most cases. This is particularly true for the demand of market and self-produced commodities. Farm household responses of land (τ_G) and value-added taxes (τ_{vat}) are very similar to the non-separable version. This seems to be mainly caused by the low shadow price elasticities.

To conclude, the designed tax instruments partly induce different allocation effects within both the non-separable and the separable model version. In both model versions, the production effects of the standard tax instruments (income, wage and value added taxes) are ignorable or non-existing, but their consumption and labor market effects are remarkable. In addition, tax induced labor market adjustments differ between the two model versions. Regarding the agricultural taxes, we find considerable production, consumption and labor market responses to increasing market surplus and input taxes, but only slight adjustments to an increasing land tax. Furthermore, the farm household's adjustments differ between the non-separable and separable model in regard the consumption and labor market decisions.

The overall small differences in tax induced production responses between the two model versions are mainly caused by the very low labor price elasticities of output supply and input demand[16], ranging between -0.01 and -0.04. That is, the low labor price elasticities limit the impact of the shadow wage effects on farmers production plans to a great extent. Hence, labor market imperfections do not influence tax induced production adjustments in Poland's farming sector to a considerable extent. Obviously, the surprisingly low production responses to changing tax policies seems to be technological determined.

Considering these empirical results, we have to somewhat weaken our conclusions drawing from the theoretical analysis (see section 'Comparative Static') – at least for the Polish case. Since, the income, wage, and value-added taxes obviously imply ignorable production effects, even in the case of imperfectly competitive labor markets, when compared with both market surplus and input tax, they seem to be superior to these specific agricultural taxes from the efficiency point of view. Analogously, since a land tax does not induce remarkable production effects, even in the case of non-separability, it seems to be superior to market surplus and input taxes.

CONCLUDING REMARKS

This paper provides a comparative static analysis and econometric estimation of farm households' production, consumption, and labor market decisions under alternative tax policies. A non-separable farm household model is constructed implying increasing per-unit costs of accessing labor markets and thus accounting for labor market constraints. To explicitly control for tax-induced adjustments related to labor market imperfections we compare the results to those derived from a separable approach assuming perfect labor markets. In detail, we analyze an income and a value-added tax, which are the usual tax tools of non-peasant households but often difficult to implement in agricultural households. Thus, we also examine an off-farm income tax as well as typical agricultural taxes (market surplus, input, and land taxes), which are treated as surrogates for standard taxes.

Theoretical results suggest that when labor market imperfections occur most tax-induced responses are ambivalent mainly due to shadow price effects. This is especially true for the labor market reactions and for the production responses to most tax tools under study, while a decreasing demand for consumption goods seems to be probable in several cases. Furthermore, tax-induced allocation effects may differ between the non-separable and the separable model version indicating the potential impact of labor market constraints on farm household responses to tax policies. In particular, standard taxes as well as a land tax may imply production adjustments in the case of non-separability. Econometric analysis using individual household data from Mid-West Poland (1991-1994) indicates remarkable allocation effects induced by market surplus and input taxes, which differ between the two model versions. In contrast, production responses to standard and land taxes are negligible or non-existing in both imperfect and perfect labor markets, while labor market adjustments slightly differ between the two models.

Methodologically, the analysis shows that using partial equilibrium or separable household models to analyze tax policies might be inappropriate when market failures create non-separabilities, as will be expected when labor markets are imperfect. Further, the model accounts for several kinds of labor market imperfections (e.g. institutional restrictions or fixed and variable transaction costs in accessing labor markets), and is applicable for different labor market regimes, including the case that households both hire on-farm and sell off-farm labor. Finally, all empirical results presented here are based on a theoretical consistent estimation of farm household behavior. In particular, applying a new method proposed by Koebel, Falk and Laisney allows us to ensure global convexity, which is always a problem when estimating flexible profit functions.

From a policy perspective, the work contributes to the on-going debate over agricultural tax reforms and the implementation of well-defined tax systems, respectively in less-developed and transition economies. In contrast to most studies, our theoretical results advise that income and value-added taxes are not necessarily superior to agricultural taxes in the sense of optimal taxation theory (Diamond and Mirrless). Analogously, since a land tax might imply production adjustments and thus efficiency losses, it is not clearly superior to market surplus or input taxes as most studies suggest. However, the empirical results show that in case of Poland standard and land taxes imply remarkably lower production effects compared to market surplus and input taxes. Thus, the superiority of standard and land taxes seems to be sustained.

REFERENCES

Ahmad, E., and N. Stern. *The Theory and practice of tax reform in developing countries.* Cambridge Univ. Press, Cambridge, 1991.

Atkinson, A.B. “The Theory of Tax Design for Developing Countries.” *The Theory of Taxation for Developing Countries,* Eds. Newbery, D. and Stern, N., Oxford Univ. Press, New York (1987): 387-404.

Benjamin, D. “Household Composition, Labor Market, and Labor Demand: Testing for Separation in Agricultural Household Models.” *Econometrica* 60 (1992): 287-322.

Bird, R.M. *Taxing Agricultural Land in Developing Countries,* Cambridge, 1974.

Brümmer, B., T. Glauben, and G. Thijssen. “Decomposition of Productivity Growth Using Distance Functions: The Case of Dairy Farms in Three European Countries.” *American Journal of Agricultural Economics* 84 (2002): 628-644.

Burgess, R., and N. Stern. “Taxation and development.” *The Journal of Economic Literature* 31 (1993) No. 2: 762-830.

Carter, M.R., and Y. Yao. “Local versus Global Separability in Agricultural Household Models: The Factor Price Equalization Effect of Land Transfer Rights.” *American Journal of Agricultural Economics* 84 (2002): 702-715.

Chambers, R.G., and R.E. Lopez. “Tax Policies and the Financially Constrained Farm Household.” *American Journal of Agricultural Economics* 69 (1987): 369-377.

Deaton, A., and J. Muellbauer. “An Almost Ideal Demand System.” *The American Economic Review* 70 (1980): 312-326.

De Janvry, A., M. Fafchamps, and E. Sadoulet. "Peasant Household Behaviour with Missing Markets: Some Parodoxes Explained." *The Economic Journal* 101 (1991): 1400-1417.
Deolalikar, A.B., and W.P.M Vijverberg. "A Test of Heterogeneity of Family and Hired Labour in Asian Agriculture." *Oxford Bulletin of Economics and Statistics* 49 (1987) No. 3: 291-305.
Diamond, P.A., and J. Mirrless. "Optimal Taxation and Public Production, Part I: Production Efficiency." *American Economic Review* 61 (1971) No. 1: 8-27.
Diewert, W.E. "Duality Approaches to Microeconomic Theory." *Handbook of Mathematical Economics, Vol. II*. Eds. Arrow, K.J. and Intriligator, M.D., Amsterdam, New York, Oxford (1982): 536-599.
Diewert, W.E., and T.J. Wales. "Flexible functional forms and global curvature conditions." *Econometrica* 55 (1987): 43-68.
Diewert, W.E., and Wales, T.J. "Quadratic spline models for producer's supply and demand functions." *International Economic Review* 33 (1992): 705-722.
Fafchamps, M. "Cash Crop Production, Food Price Volatility, and Rural Market Integration in the Third World" *American Journal of Agricultural Economics* 74 (1992): 90-99.
Finkelshtain, I., and J.A. Chalfant. "Marketed Surplus Under Risk: Do Peasants Agree with Sandmo?" *American Journal of Agricultural Economics* 73 (1991): 557-567.
Goetz, S.J. "A Selectivity Model of Household Food Marketing behavior in Sub-Sahara Africa." *American Journal of Agricultural Economics* 74 (1992): 444-52.
Gourieroux, C., A. Monfort, and A. Trognon. "Moindres carres asymptotoques." *Annales de I'INSEE* 58 (1985): 91-122.
Heady, C.J., and P.K. Mitra. "Optimal Taxation and Shadow Pricing in a Developing Economy." *The Theory of Taxation for Developing Countries,* Eds. Newberry, D. and Stern, N., Oxford Univ. Press, New York (1987): 407-425.
Ihaka, R., and R. Gentleman. "R: A language for data analysis and graphics." *Journal of Computational and Graphical Statistics* 5 (1996), No. 3: 299-314.
Jacoby, H. "Shadow Wages and Peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra" *Review of Economic Studies* 60 (1993): 903-921.
Key, N., E. Sadoulet, and A. de Janvry. "Transaction Costs and Agricultural Household Supply Response." *American Journal of Agricultural Economics* 82 (2000) No. 2: 245-259.
Klein, L.R. *A Textbook of Econometrics.* Row, Peterson and Co, New York, 1953.
Kodde, D.A., F.C. Palm, and G.A. Pfann. "Asymptotic least-squares estimation efficiency considerations and applications." *Journal of Applied Econometrics* 5 (1990): 229-243.
Koebel, B. "Tests of representative firm models: Results of German manufacturing industries." *Journal of Productivity Analysis* 10 (1998): 251-270.
Koebel, B., M. Falk, and F. Laisney. *Imposing and testing curvature conditions on a Box-Cox cost function*. Discussion Paper No.00-70, ZEW, Mannheim (2000), via: ftp://ftp.zew.de/pub/zew-docs/dp/dp0070.pdf.
Koebel, B., M. Falk, and F. Laisney. "Imposing and testing curvature conditions on a Box-Cox cost function." *Journal of Business and Economic Statistics* 21 (2003): forthcoming.
Kohli, U.R. "A symmetric normalized quadratic GNP function and the US demand for imports and supply of exports." *International Economic Review* 34, (1993), No.1: 243-255.
Lau, L.J. "Applications of Profit Functions." *Production Economics: A Dual Approach to Theory and Applications.* Eds. Fuss, M., and D. McFadden, North-Holland, Amsterdam (1978a): 133-216.
Lau, L.J. "Testing and Imposing Monotonicity, Convexity and Quasi-Convexity Constraints." *Production Economics: A Dual Approach to Theory and Applications.* Eds. Fuss, M., and D. McFadden, North-Holland, Amsterdam (1978b): 409-453.
Lopez, R.E. "Estimating Labor Supply and Production Decisions of Self-Employed Farm Producers." *European Economic Review* 24 (1994): 61-82.
Low, A. "Farm-Household Theory and Rural Development in Swaziland." *Development Study* 23 (1982), University of Reading.
Low, A. *Agricultural Development in Southern Africa: Farm-Household Economics and the Food Crisis.* London, 1986.
Michalek, J., and M.A. Keyzer. "Estimation of a Two Stage LES-AIDS Consumer Demand System for Eight EC-Countries." *European Review of Agricultural Economics* 19 (1992) No. 2: 137-163.
Munk, K.J. "Optimal Taxation with some Non-Taxable Commodities." *Review of Economic Studies* 47 (1980) No. 149: 755-766.
Newbery, D. "Structural Issues and Taxation." *The Theory of Taxation for Developing Countries,* Eds. Newbery, D., and N. Stern, Oxford Univ. Press, New York (1987): 163-204.

Ostrowski, L. “Ceny ziemi rolniczej w obrocie sasiedzkim w 1999 roku.” *Standardy, metody*, Nr.3, 35 (2000), via: http://www.srm.com.pl/kwartalnik/standardy/35_LO.shtml.

Rao, J.M. “Taxing Agriculture: Instruments and Incidence.” *World Development* 17 (1989) No. 6: 809-823.

Sadoulet, E., A. de Janvry, and C. Benjamin. “Labor Market Imperfections and Selective Separability in Household Models: A Predictive Typology of Mexican Ejidatarios.” *Working Paper* No. 786 (1996). University of California at Berkeley.

Sah, R.K., and J.E. Stiglitz. “The Taxation and Pricing of Agricultural and Industrial Goods in Developing Economies.” *The Theory of Taxation for Developing Countries.* Eds. Newbery, D., and N. Stern, Oxford Univ. Press, New York (1987): 426-452.

Skoufias, E. “Labor Market Opportunities and Intrafamily time Allocation in rural Households in South Asia.” *Journal of Developing economics* 40 (1993): 277-310.

Sonoda, T., and Y. Maruyama. ”Effects of the Internal Wage on Output Supply: A Structural Estimation of Japanese Rice Farmers” *American Journal of Agricultural Economics* 81 (1999): 131-143.

Stiglitz, J.E., and P.S. Dasgupta. “Differential Taxation, Public Goods, and Economic Efficiency” *Review of Economic Studies* 38 (1971), 114, 151-178.

Strauss, J. “The Theory and Comparative Statics of Agricultural Household Models: A General Approach” *Agricultural Household Models,* Eds. Singh, I., Squire, L. and Strauss, J., Baltimore (1986): 71-91.

ANNEX

Table A1. Characteristics of the sample.

Variable	Unit	Mean	Minimum	Maximum	Standard-deviation
P_aX_a	1000 PLZ	96878	825	1077813	120790
P_cX_c	1000 PLZ	53959	1275	843590	85470
P_vX_v	1000 PLZ	49545	5291	285904	38660
X_l	hours	3569	550	9587	1814
X_l^h	hours	124	0	1742	263
X_l^s	hours	612	0	4050	1027
X_l^f	hours	3445	492	9476	1799
P_aC_a	1000 PLZ	17567	3267	71479	10358
P_mC_m	1000 PLZ	36953	3833	264270	29649
C_l	hours	15615	3515	40124	7023
Land	hectare	9.9	1.1	94.6	9.9
Capital	1000 PLZ	329090	21590	2727076	393807

Notes: Calculations are based on IERiGZ (1995). PLZ= Zloty.

Table A2. Parameter estimates and R^2 - labor market functions.

Parameters and R^2	$g(X_l^h)$	$f(X_l^s)$
β_I	1049 (1.70)	32161 (1.00)
α_i	1.25 (15.15)	0.86 (7.02)
κ_i	177883 (1.96)	6855112 (0.46)
R^2	0.854	0.733

Notes: t-values in parentheses.

Table A3. Parameter estimates and R^2 - netput equations (restricted model).

Parameters and R^2	X_a	X_c	X_l	X_v
α_i	48493108	-498681	-19700495	-6100683
β_{ia}	23849540		symmetric	
β_{ic}	6461318	1910093		
β_{il}	-4118725	-762363	1494200	
β_{iv}	-26192133	-7609051	3386888	30414296
δ_{iG}	-3829442	4267996	-3067833	-6184582
δ_{iK}	230517311	13561871	-5128966	-64778534
γ_{GG}		313159		
$\gamma_{GK}=\gamma_{KG}$		439521		
γ_{KK}		-59634912		
R^2	0.501	0.824	0.610	0.828

Notes: The McElroy R^2 value of the system is 0.721.

Table A3*. Parameter estimates and R^2 - netput equations (unrestricted model).

Parameters and R^2	X_a	X_c	X_l	X_v
α_i	48616210 (8.06)	-1099787 (0.42)	-19777850 (12.94)	-6301388 (2.24)
β_{ia}	12301102 (1.62)		symmetric	
β_{ic}	21335732 (4.72)	-19909719 (4.03)		
β_{il}	-6829212 (2.24)	4395793 (1.66)	-320156 (0.11)	
β_{iv}	-26807623 (5.38)	-5821805 (1.83)	2753575 (1.34)	29875853 (6.55)
δ_{iG}	-3917879 (5.34)	4355447 (13.09)	-3095062 (13.68)	-6207536 (15.79)
δ_{iK}	232006284 (11.78)	12039050 (1.31)	-4553301 (0.68)	-64306427 (5.66)
γ_{GG}		316061 (4.42)		
$\gamma_{GK}=\gamma_{KG}$		408512 (0.23)		
γ_{KK}		-59936306 (1.19)		
R^2	0.513	0.829	0.605	0.828

Notes: t-values in parentheses. The standard errors of the coefficients that have not been directly estimated are calculated with the formula of Klein (p. 258). The McElroy R^2 value of the system is 0.721.

Table A4. Parameter estimates and R^2 - budget share equations.

Parameters and R^2	W_a	W_m	W_l
α_i	-0.351 (4.57)	0.002 (0.01)	1.349 (6.08)
β_i	-0.057 (12.13)	-0.040 (5.01)	0.097 (8.94)
γ_{ia}	0.147 (11.39)		symmetric
γ_{im}	0.115 (9.75)	0.092 (3.07)	
γ_{il}	-0.261 (13.48)	-2.07 (5.74)	0.486 (9.74)
R^2	0.377	0.035	0.152

Notes: t-values in parentheses. The standard errors of the coefficients that have not been directly estimated are calculated with the formula of Klein (p. 258). The McElroy R^2 value of the system is 0.234. We use for for the α_0 value 35, since it 'produces' the highest likelihood value of the AIDS Model.

Table A5. Price elasticities – SNQ (restricted) Model.

	Price elasticities			
	P_a^*	P_c^*	P_l^*	P_v^*
X_a	0.249	0.067	-0.043	-0.274
X_c	0.127	0.037	-0.014	-0.149
X_l	0.086	0.016	-0.031	-0.070
X_v	0.313	0.090	-0.040	-0.363

Table A. Price and Income elasticities – AIDS Model.

		Price elasticities	
	P_a^*	P_m^*	P_l^*
		Hicksian Elasticities	
C_a	-0.735	0.427	0.308
C_m	0.218	-0.673	0.455
C_l	0.030	0.086	-0.116
		Marshallian Elasticities	
C_a	-0.754	0.390	0.116
C_m	0.163	-0.781	-0.111
C_l	-0.055	-0.079	-0.990
		Income elasticities	
	C_a	C_m	C_l
Income	0.248	0.729	1.125

Notes:

[1] In their fundamental work, Diamond and Mirrless argue that production efficiency is desirable within an optimal taxation system, even if a full Pareto optimum is not achieved. Thus, tax tools that do not violate production efficiency should to be preferred unless there are administrative limitations or special distributional reasons restricting their use.

[2] Here, the income tax affects the position of both functions, with $f^*(.) = (1-\tau_y) f(.)$ and $g^*(.) = (1-\tau_y) g(.)$, while the wage tax affects only the position of the first, with $f^*(.) = (1-\tau_w) f(.)$.

[3] As noted before, direct labor market reactions result only for an income and a wage tax, since only these taxes directly affect the general wage level. Thus, the following direct tax-induced labor market reactions result:

$$\left.\frac{\partial X_l^s}{\partial \tau_j}\right|_{P_l^*=const.} = -\frac{P_l^*}{(1-\tau_j)} \Bigg/ \frac{\partial^2 f^*(.)}{\partial {X_l^s}^2} < 0; \ (\tau_j \mid j = y, w), \text{ and } \left.\frac{\partial X_l^h}{\partial \tau_y}\right|_{P_l^*=const.} = -\frac{P_l^*}{(1-\tau_y)} \Bigg/ \frac{\partial^2 g^*(.)}{\partial {X_l^h}^2} > 0 \ .$$

[4] Note that the full income effect of a changed internal wage strictly equals zero. This follows from partial differentiation of the full income constraint with regard to the internal wage.

[5] Note, because all designed tax policies have to be interpreted as *alternative* tax instruments, it is assumed that the respective tax under consideration is the only tax policy applied to the farm household.

[6] On request, a detailed documentation of the comparative static is available from the authors.

[7] This functional form is also traded under the name of “symmetric generalized McFadden function”.

[8] For the households either sell or hire labor, we can not observe price differences that could indicate the occurrence of unobservable transaction costs. Thus, we use the information from the sub-sample of households that both sell and hire labor.

[9] The SNQ profit function is defined as follows (Kohli):

$$\Pi(p^*, r) = \sum_{i\in PG} \alpha_i P_i^* + \frac{1}{2} w^{-1} \sum_{i\in PG}\sum_{j\in PG} \beta_{ij} P_i^* P_j^* + \sum_{i\in PG}\sum_{j\in R} \delta_{ij} P_i^* R_j + \frac{1}{2} w \sum_{j\in R}\sum_{k\in R} \gamma_{jk} R_j R_k \ .$$

[10] The simultaneous nonlinear estimation of the translog total price index together with the demand system, which share the same set of coefficients, usually results in estimation problems (Michalek and Keyzer). In order to avoid these problems, as well as to avoid difficulties of approximating the translog price index by, say, a Stone index (Deaton and Muellbauer), we chose an iterative estimation procedure proposed by Michalek and Keyzer (p.145).

[11] Land prices used to calculate the values of land stem from Ostrowski.

[12] Note the parameters of the fixed transaction costs reveal the “right” sign, but one of them only is statistically significant at 10% level.

[13] However, we found 56% of the parameters in the unrestricted model of statistical significance (see annex table A3*). Most of these parameters are similar to those of the restricted model.

[14] The weighting matrix is the inverse of the variance-covariance matrix of the Hessian, which can be derived from the variance-covariance matrix of the estimated coefficients. We use the Cholesky factorization to restrict the Hessian to be positive semi-definite. Note, to retain convexity of the SNQ profit function, it is sufficient to minimize the difference between the estimated (unrestricted) β-coefficients and the (linearly independent) values of a restricted β-coefficient matrix (Koebel 1998). This procedure only allows to adjust the β-coefficients, while the approach mentioned above (Koebel, Falk, and Laisney 2000, 2003) adjusts *all* coefficients. Thus, the fit of the constrained model is much better, due to the flexibility of the other coefficients. Both approaches ‘produce’ the same β’s.

[15] On request the detailed derivation of the tax elasticities is available from the authors.
[16] A reason for this might be the very low output elasticity with respect to labor as reported in Brümmer, Glauben and Thijssen (p. 636) for Polish dairy farms.