Modeling price response of farm households under imperfect labor markets:

A farm household approach to family farms in Poland

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Abstract

In the paper a flexible FHM approach is estimated to model price responses of farm households under imperfect labor markets. In contrast to former studies the model explicitly incorporates simultaneously fixed and variable transaction costs as well as heterogeneity. Main results are: (i) In the general approach non-separability not only occurs if households are autarkic, but also when households participate in labor markets. (ii) Under imperfect labor markets, price responses are ambiguous and differ for the non-separable and separable model. However, econometric analysis indicates only moderate differences between the two models except for crop production for which an inverse supply response is estimated.

Key words: farm household model, labor market, market imperfection

1 INTRODUCTION

There is a long-standing recognition in agricultural development literature that conventional microeconomic models are inappropriate to explain farm household behavior when markets are underdeveloped or absent. This recognition has stimulated the development of farm-household-models (FHM) that explicitly incorporate the interdependency of production and consumption decisions on the allocation of household resources (Strauss, 1986; de Janvry et al., 1991). The early work of the FHM literature focuses on the ability of interdependent FHM to explain sometimes paradox - and even perverse - microeconomic responses of peasants to changes in relative prices underlining the potential of the FHM approach as an adequate analytical tool to assess the effects of price and market policy (Strauss, 1986; Lopez, 1984; de Janvry et al., 1991; de Janvry, 1992). In essence, these early FHM approaches argue that market imperfection translates into transaction costs and if transaction costs are sufficiently high households find it unprofitable to either buy or sell a good on the market, i.e. stay in autarky. Assuming autarky for some markets implies a non-separable FHM and comparative static results no more coincide with conventional microeconomic models. Several theoretical and empirical studies have used the FHM approach to analyze farm household responses under imperfect labor (Lopez, 1986; Thijssen, 1988; Benjamin, 1992; Jacoby, 1993; Sadoulet et al., 1998), capital (de Janvry, 1992) or food markets (de Janvry et al., 1991; Goetz, 1992; Omamo, 1998; Skoufias, 1994; Abdulai and Delgado, 1999). But, non-separability makes theoretical and in particular empirical analyses more difficult. Therefore, most empirical analyses apply separable FHM or use reduced forms of a non-separable FHM. Thus, even nowadays it is still fair to say that comprehensive empirical analyses of price response of farm households under imperfect markets are still relatively rare in the literature. This is especially regrettable, since empirical analyses would be especially desirable to assess the question to what extent or under what conditions economic responses of the farm household theoretically identified for imperfect markets also translate into significant quantitative effects that are relevant for assessing agricultural policy (Chambers and Lopez, 1987).

In contrast to the early FHM work, more recent studies focus on the role of transaction costs and institutions determining households' decision on market participation (Goetz, 1992; Key et al., 2000; Vakis et al., 2003; Vance and Geoghegan, 2004). Carter and Yao (2002) and Carter and Olinto (2003) analyze the role of institutions, e.g. property rights, as determinants of transaction costs and participation in the capital market. Based on the work of Key et al. (2000), Vance and Geoghegan (2004) analyze empirically determinants of semi-subsistent and commercial land use estimating a switching regression model derived from a reduced form of a non-separable FHM (Vance and Geoghegan, 2004). More generally, Key et al. (2000) in an interesting paper theoretically analyze the impact of fixed (FTC) and proportional (PTC) transaction costs on households' decision to participate in the market and empirically test the importance of these transaction costs for aggregate supply response. Fixed transaction costs are invariant to the quantity of the good traded, while proportional transaction costs increase proportionally with the quantity. Key et al. (2000) consider search, bargaining and labor supervision costs as FTCs, while they consider transportation and information costs as PTC.

However, since PTCs simply correspond to constant marginal transaction costs, the question arises if variable marginal transaction costs are also conceivable and if or how the impact of transaction costs changes if variable transaction costs are included. For example, in contrast to Key et al. (2000) one might argue that bargaining, screening and enforcement costs are not fixed, but vary with the quantity traded, e.g. farmers who sell their product, land or labor on credit may have to use increasing resources to control for opportunistic behavior of buyers with an increasing quantity sold. Vice versa a farmer buying a product, land or labor on credit might observe increasing transaction costs for the same reason. Analogously, marginal costs to supervise hired labor may increase with the units of hired labor, because the larger the number of hired workers the higher is the probability of free-riding, the importance of coordination of work inputs and the effort to control for social conflicts among hired workers. Analogously, selling off-farm labor might involve increasing marginal transaction costs, e.g. some part-time job might be available nearby the farm, while full-time jobs are only available in larger settlements farther away from the farm. Analogously, it might be more difficult for an additional family member to find an adequate job implying higher search and bargaining costs. Thus, constant marginal transaction costs, i.e. PTCs, seem to be only a special case, while in general variable increasing or decreasing marginal transaction costs should be expected. However, the role of variable marginal transaction costs (VTC) regarding production and consumption decisions or market participation, respectively, has not been analyzed within a FHM approach, yet.

Moreover, beyond transaction costs imperfect markets might also correspond to heterogeneity of products (Strauss, 1986). For example, family and hired labor may be imperfect substitutes in agricultural production (Deolalikar and Vijverberg, 1987; Jacoby, 1993). In many cases the skill of farm family members to work off-farm varies significantly, although these variances often cannot be observed in empirical surveys (Low, 1982, 1986; Sadoulet et al., 1998). Assuming that the order of supplied off-farm work by family members corresponds to their relative skills, e.g. the most skilled family members will first work off-farm, implies that off-farm wage is a decreasing function of supplied off-farm work. Analogously, the skills of hired on-farm labor are often heterogeneous, too, i.e. assuming a constant labor wage the most skilled labor is hired first, which implies that the effective wage rate is increasing in the amount of hired labor (Benjamin, 1992). Therefore, analogous to increasing VTC, heterogeneity of the quality of traded goods implies that effective market prices decrease or increase with the supplied or demanded quantity resulting in a non-separable FHM.

In this paper we provide a theoretical and empirical analysis of the price response of farm-households facing imperfect labor markets allowing for variable marginal transaction costs and heterogeneity. Technically, transaction costs and heterogeneity of labor are taken into account by assuming a non-linear labor income function for off-farm labor supply and a non-linear labor cost function for hired on-farm labor. Theoretically, the curvature properties of the labor cost and income function are ambiguous. However, our empirical estimation implies a concave labor income and a convex labor costs function. Moreover, non-concave or non-convex labor supply or demand functions, respectively, make the FHM approach analytically less traceable. As regards content, the observed curvature properties imply increasing VTC's or heterogeneity that overcompensates decreasing VTCs. Our modeling strategy has the following advantages when compared to former approaches:

(1) The approach allows to analyze simultaneously fixed, proportional and variable marginal transaction costs as well as heterogeneity. Compared to existing approaches taking only FTC and PTC into account, in our approach non-separability not only occurs if households are autarkic, but can also occur when households actually participate in labor markets. (2) In contrast to most empirical analyses of interdependent FHMs using reduced forms of a non-separable FHM we estimate a full non-separable FHM based on flexible functional forms on the production and consumption side. (3) Our model is applicable for several kinds of labor market imperfections, e.g. institutional restrictions like binding hours settled by collective agreements, transaction costs due to search, monitoring or commuting costs or heterogeneity of family and non-family or heterogeneity of on-farm and off-farm labor (Low, 1982, 1986). (4) Our approach allows an analysis of farm household decisions under various labor market regimes including the case that farms simultaneously hire on-farm labor and sell off-farm labor, a case which is theoretically excluded if only FTCs and PTCs are analyzed and labor is treated as homogeneous

(Sadoulet et al., 1998). (5) We provide a simple empirical test for separability of the FHM approach.

The rest of the paper is structured as follows. In chapter 2 the theoretical model is described, while chapter 3 presents the comparative static of the model. The empirical specification is illustrated in chapter 4 and the estimation results using individual household data from several regions in Mid-West Poland are presented in chapter 5. Tests show that the model is significantly non-separable due to increasing VTC and heterogeneity of off-farm family labor and hired on-farm labor. Based on the estimated parameters we derive price elasticities capturing quantitatively consumption, production, and labor market reactions for the separable and non-separable FHM. Except for labor supply and crop production, price elasticities differ only slightly for the non-separable and separable FHM. However, for crop production we derive an inverse supply response.

2 THE MODEL

To concentrate on the role of labor market constraints, we construct a static model that ignores some aspects of farmers' decisions, notably (price) risk (Finkelshtain and Chalfant, 1991; Fafchamps, 1992) and credit constraints (Chambers and Lopez, 1987). 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 budget constraint (4). Therefore, farm households solve the following maximization problem:

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

subject to

$$(2) \qquad G(x,r) = 0$$

$$(3) \qquad T_L - |X_L| + X_L^h - X_L^s - C_L \geq 0$$

$$(4) \qquad P_m C_m \leq P_c X_c + P_a (X_a - C_a) - P_v |X_v| - g\left(X_L^h\right) + f(X_L^s) + E$$

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 is represented by a multi-output, multi-input production function (2), which is assumed to be well behaved in the usual sense (Lau, 1978a). 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 (R_g) and capital (R_k).

The farm household faces a time constraint (3), where T_L denotes the total time available. $|X_L| = X_L^f + X_L^h$ is the total of on-farm labor time subdivided into family labor $\left(X_L^f\right)$ and hired labor $\left(X_L^h\right)$. 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.

The budget constraint (4) states that a household's consumption expenditures (left-hand side) must not exceed its monetary income (right-hand side). The household 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. Due to the empirical evidence in our data, we suppose that the (average) household is a net supplier of the self-produced agricultural goods $(X_a - C_a > 0)$.

A key component of our model corresponds to the labor income and labor cost functions, $g\left(X_L^h\right)$ and $f\left(X_L^s\right)$, respectively. In particular, we assume that supply of off-farm labor and demand for on-farm labor involve marginal transaction costs, $TC^s\left(X_L^s, z_t^s\right)$, $TC^h\left(X_L^h, z_t^h\right)$, respectively, where marginal transaction costs can be constant, e.g. proportional transportation and marketing costs, or variable, e.g. bargaining, controlling and enforcement costs that vary with the quantity of traded labor. Note that proportional transaction costs imply that $TC^s\left(X_L^s, z_t^s\right)$ and $TC^h\left(X_L^h, z_t^h\right)$ are linear in X_L^s and X_L^h, respectively. In general marginal transaction costs are not observable (see Key et al., 2000), however, some factors that explain these transaction costs can be observed. Let z_t^s and z_t^h denote the factors explaining transaction costs of the farm household for selling or buying labor, respectively.

Moreover, we assume that family members have heterogeneous skills to work off-farm and therefore receive different off-farm wages. We further assume that the order in which family members work off-farm corresponds to their skills implying that off-farm wage is a step-wise decreasing function of off-farm labor supply. As long as specific skills and off-farm wages of different family members cannot be observed, heterogeneity can be modeled using a continuous approximation of the step-wise labor wage function:

$$(5) \qquad P^s = \overline{P}^s + b^s\left(X_L^s, z_L^s\right)$$

In (5) $\overline{P}^s$ denotes the average regional labor wage, where z_L^s denotes the factors explaining heterogeneity of family labor regarding off-farm work and $b^s\left(X_L^s, z_L^s\right)$ denotes increase or decrease in the labor wage expected by the farm household, where according to our expositions above b^s is non-increasing in labor supply. Obviously, taking heterogeneity and variable transaction costs into account, the effective revenues from off-farm employment result as a functions of supplied labor time:

$$(6) \qquad f\left(X_L^s, z_L^s, z_t^s, z_f^s\right) = \overline{P}^s X_L^s + \int_0^{X_L^s} \left[b\left(X_L^s, z_L^s\right) - TC^s\left(X_L^s, z_t^s\right)\right] dX_L^s - \delta^s TC_f^s\left(z_f^s\right),$$

where δ^s equals one, if $X_L^s > 0$ and zero otherwise, $TC_f^s\left(z_f^s\right)$ denotes fixed transaction costs and z_f^s are factors explaining fixed transaction costs of supplying off-farm labor.

Analogously, to introduce heterogeneity of on-farm labor, we assume that the agricultural labor wage is constant, while the productivity of on-farm labor varies across hired workers (Benjamin, 1992). Assuming the order in which workers are hired corresponds to on-farm productivity implies that the effective on-farm wage is a step-wise increasing function of hired on-farm labor. Again as long as productivity variances of hired on-farm workers are not observable, heterogeneity can be modeled using a continuous approximation of the step-wise labor cost function:

$$(7) \qquad P^h = \overline{P}^h + b^h\left(X_L^h, z_L^h\right)$$

In (7) $\overline{P}^h$ denotes the average regional agricultural labor wage, where z_L^h denotes the factors explaining heterogeneity of hired on-farm labor and $b^h\left(X_L^h, z_L^h\right)$ denotes an increase or decrease of the effective labor wage expected by the farm household. Again, according to our expositions above b^h is non-decreasing in labor demand. Obviously, taking heterogeneity and variable transaction costs on the labor demand side into account, the effective labor costs result as a functions of demanded labor time:

$$(8) \quad g\left(X_L^h, z_L^h, z_t^h, z_f^h\right) = \overline{P}^s X_L^h + \int_0^{X_L^h} \left[b^h\left(X_L^h, z_L^h\right) + TC^h\left(X_L^h, z_t^h\right)\right] dX_L^h + \delta^h TC_f^h\left(z_f^h\right),$$

where δ^h equals one, if $X_L^h > 0$ and zero otherwise, $TC_f^h\left(z_f^h\right)$ denotes fixed transaction costs and z_f^h are factors explaining fixed transaction costs of demanding on-farm labor.

Using the labor income and cost function g and f, respectively, the budget constraint can be expressed as in (4). As mentioned above (see section 1), this framework is applicable for several kinds of labor market imperfections including fixed, constant marginal (proportional) and variable marginal transaction costs as well as heterogeneity. It follows directly from the definition of f and g above that curvature properties of these functions correspond to market imperfection. For example, in the absence of heterogeneity and variable marginal transaction costs both functions become linear, with

$$(9) \quad f(.) = \left(P_L - TC_p^s\right) X_L^s - TC_f^s\left(z_f^s\right) \quad \text{and} \quad g(.) = \left(P_L + TC_p^h\right) X_L^h + TC_f^h\left(z_f^h\right).$$

Hence, once households participate in labor markets marginal off-farm income or marginal costs for hired labor are equal to the exogenously given wage rate (P_L) corrected for proportional transaction costs (TC_p^s and TC_p^h). Thus, if households participate at least in one labor market the farm household model becomes separable and delivers standard microeconomic comparative static results (Sadoulet et al., 1998). Of course, if fixed or proportional transaction costs are too high, households still abstain from labor market participation and stay autarkic implying a non-separable FHM (Key et al., 2000). In contrast, when labor markets are assumed to be imperfectly competitive due to heterogeneity or variable marginal transaction costs both functions become nonlinear. In this case, the price of family labor (P_L^*) is endogenously determined and the production and consumption decisions are simultaneously determined by the solution of the equation system (1) to (4). Note in particular that in contrast to fixed or proportional transaction costs, in case of heterogeneity or variable marginal transaction costs non-separability results although households actually participate in labor markets. However, although non-linearity of the f or g function clearly indicates labor market imperfection due to heterogeneity or variable marginal transaction costs or both, it is generally impossible to derive the partial impacts of variable marginal transaction costs or heterogeneity from observed curvature properties of the f and g functions alone.

As the FTC creates discontinuities in the f and g functions, the solutions to the maximization problem (1)-(4) cannot be found by simply solving the first order conditions. Thus, we follow Key et al. (2000) and decompose the solution in two steps. At the first step we solve for the optimal solution conditional on the labor market participation regime (δ^h and δ^s), and then choosing the market participation regime that leads to the highest level of utility. Thus, assuming there exists an interior solution for a given labor market regime (δ^h and δ^s) the optimal quantities of consumption and production goods, and the allocation of time, are determined ($\lambda, \phi, \mu > 0$; $C_m, C_a, C_L, X_c, X_a > 0$, $X_L, X_v < 0$, $X_L^s > 0$ if $\delta^s = 1$ and $X_L^s = 0$ otherwise, and $X_L^h > 0$ if $\delta^h = 1$ and $X_L^h = 0$ otherwise).

$$(10) \quad \frac{\partial U(.)}{\partial C_i} - \lambda P_i = 0 \quad i \in \{m, a, L\}$$

$$(11) \quad \phi \frac{\partial G(.)}{\partial X_i} + \lambda P_i = 0 \quad i \in \{c, a, v, L\}$$

(12) $\dfrac{\partial f(.)}{\partial X_L^s} = P_L^* \quad \text{if} \quad \delta^s = 1$

(13) $\dfrac{\partial g(.)}{\partial X_L^h} = P_L^* \quad \text{if} \quad \delta^h = 1$

(14) $\sum_{i\in\{c,a,v\}} P_i X_i - g\left(X_L^h\right) + f\left(X_L^s\right) + E - \sum_{i\in\{m,a\}} P_i C_i = 0$

(15) $G(x,r) = 0$

(16) $T_L + X_L + \delta^h X_L^h - \delta^s X_L^s - C_L = 0$

Here $\lambda, \phi > 0$ are Lagrangian multipliers associated with the budget and the technology constraints, respectively. $P_L^* = \mu/\lambda$ 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 wage rate.

In general, comparative static derived from the equations system (10) to (16) differs for each of the four labor market regimes. However, for simplicity in the next chapter we will focus comparative static on the regime $\delta^s, \delta^h = 1$, i.e. assuming that the farm household simultaneously supplies off-farm labor and demands on-farm labor. Note also that we empirically identified this regime as the dominant labor market regime in our farm survey of Mid-West Poland.

3 COMPARATIVE STATIC

To facilitate the comparative static analysis we transform the primal decision problem (1)-(4) into a dual representation (Diewert, 1982). First we define a dual restricted profit function $\Pi(p,r) \equiv \max_x \{px | G(x,r) = 0\}$, where p is the 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 $e\left(p,U^0\right) \equiv \min_c \left\{pc | U(c) \geq U^0\right\}$. Here p is the price vector of the consumption goods and U^0 is the obtainable utility level. According to Shepard's lemma, we can derive the Hicksian compensated demand function, with $\partial e(.)/\partial P_i = C_i^H\left(p,U^0\right); \forall i \in \{m,a,L\}$. Substituting the indirect utility function $V(p,Y)$ for U^0, 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, conditions (12) and (13) define the off-farm labor supply $X_L^s = X_L^s(P_L^*)$ and the demand for hired labor $X_L^h = X_L^h(P_L^*)$ as implicit functions of the endogenous labor price (P_L^*).

Substituting the defined dual and implicit functions into the time constraint (16) results in:

(17) $T_L + X_L(p,r) + X_L^h(P_L^*) - X_L^s(P_L^*) - C_L(p,Y) = 0,$

where

(18) $Y = \Pi(.) - g\left[X_L^h(.)\right] + f\left[X_L^s(.)\right] + P_L^*\left[T_L + X_L^h(.) - X_L^s(.)\right] + E = \sum_{i\in CG} P_i C_i$

Equation (17) implicitly defines the shadow wage (P_L^*) around the optimal solution of the non-separable model. Hence, $P_L^* = \chi(p,r,T_L,E)$ is an implicit function of exogenous prices for consumption and production goods (p), fixed resources (r), total time available (T_L) and exogenous transfers (E).

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 exogenous prices $(P_j | j = c, a, v, m)$. In the case of non-separability, we can decompose the farm household reactions into the following two components (de Janvry et al., 1991; Sonoda and Maruyama, 1999):

$$(19) \quad \frac{dZ}{dP_j} = \left.\frac{\partial Z}{\partial P_j}\right|_{P_L^* = \text{const.}} + \frac{\partial Z}{\partial P_L^*}\frac{dP_L^*}{dP_j}$$

The first term (direct component) on the right-hand side represents the supply or demand reactions to changes in the exogenous prices 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 exogenous price.

In order to determine the indirect component of the non-separable version, we have to derive the shadow price adjustment from equation (17), applying the implicit function theorem (de Janvry et al., 1991):

$$(20) \quad \frac{dP_L^*}{dP_j} = -\frac{\frac{\partial X_L}{\partial P_j} - \frac{\partial C_L}{\partial P_j} - \frac{\partial C_L}{\partial Y}\frac{\partial Y}{\partial P_j}}{\frac{\partial X_L}{\partial P_L^*} + \frac{\partial X_L^h}{\partial P_L^*} - \frac{\partial X_L^s}{\partial P_L^*} - \frac{\partial C_L^H}{\partial P_L^*}} = -\frac{\frac{\partial X_L}{\partial P_j} - \frac{\partial C_L^H}{\partial P_j} + \frac{\partial C_L}{\partial Y}(X_j - C_j)}{\frac{\partial X_L}{\partial P_L^*} + \frac{\partial X_L^h}{\partial P_L^*} - \frac{\partial X_L^s}{\partial P_L^*} - \frac{\partial C_L^H}{\partial P_L^*}}$$

The numerator on the right-hand side represents the change in the time allocation due to increasing exogenous prices. The denominator of equation (20) indicates the change in the time allocation caused by changes in the internal wage rate. Given the convexity of $\Pi(.)$ and the concavity of $e(.)$ in prices the denominator is always positive as long as it is assumed that $g(.)$ is convex in X_L^h and $f(.)$ is concave in X_L^s,

Substituting equation (20) into expression (19) yields the farm households' economic adjustments:

$$(21) \quad \frac{dX_i}{dP_j} = \frac{\partial X_i}{\partial P_j} + \frac{\partial X_i}{\partial P_L^*}\frac{dP_L^*}{dP_j};\ i = \{c, a, v, L\}$$

$$(22) \quad \frac{dC_i}{dP_j} = \frac{\partial C_i^H}{\partial P_j} + \frac{\partial C_i}{\partial Y}(X_j - C_j) + \frac{\partial C_i^H}{\partial P_L^*}\frac{dP_L^*}{dP_j};\ i = \{m, a, L\}$$

$$(23) \quad \frac{dX_L^s}{dP_j} = \frac{\partial X_L^s}{\partial P_L^*}\frac{dP_L^*}{dP_j}$$

$$(24) \quad \frac{\partial X_L^h}{\partial P_j} = \frac{\partial X_L^h}{\partial P_L^*}\frac{dP_L^*}{dP_j}$$

Equation (21) indicates the production adjustments, where the first term on the right-hand side denotes the direct component and the second term is the indirect component. Equation (22) represents households' consumption responses, where the first and second term on the right-hand side are the direct substitution and income effects, respectively, and the third term denotes the corresponding indirect component. The last two equations (23) and (24) represent farm households' adjustments regarding the supply of family labor off-farm and the demand for hired labor, respectively. These adjustments include only the indirect component.

Assuming separability, farm households' production and consumption adjustments coincide with the direct components of the non-separable version. Labor market adjustments residually result from the time constraint, after production and consumption decisions are made:

$$(25)\quad \frac{dX_L^{sn}}{dP_j} = \frac{d\left(T_L - X_L - C_L\right)}{dP_j} = -\frac{dX_L}{dP_j} - \frac{dC_L}{dP_j}$$

where $X_L^{sn} = X_L^s - X_L^h$ is net supply of labor.

Based on equations (20) to (24), we derive the complete comparative static for all exogenous prices. In particular, we compare the adjustments within the non-separable version with those of the separable framework. The results are summarized in table 1.

Table 1: Theoretical effects of exogenous price changes

		non-separable model				separable model				
		P_c	P_a	P_v	P_m	P_c	P_a	P_v	P_L	P_m
farm	X_c	?	?	?	?	+	?	(-)	(-)	0
	X_a	?	?	?	?	?	+	(-)	(-)	0
	$\lvert X_v \rvert$	?	?	?	?	(+)	(+)	-	(-)	0
	$\lvert X_L \rvert$	?	?	?	?	(+)	(+)	(-)	-	0
consumption	C_m	(+)	(+)	(-)	?	(+)	(+)	(-)	(+)	(-)
	C_a	(+)	?	(-)	?	(+)	?	(-)	(+)	?
	C_L	?	?	?	?	(+)	(+)	(-)	?	?
labor market	X_L^{sn}	(-)	(-)	(+)	?	(-)	(-)	(+)	(+)	?
	X_L^s	(-)	(-)	(+)	?					
	X_L^h	(+)	(+)	(-)	?					
	P_L^*	(+)	(+)	(-)	?					

Notes: It is assumed that goods are not inferior, technologies are not regressive, and households are net supplier of labor and self-produced agricultural goods.

0	=	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 all allocation effects are theoretically ambiguous, mainly caused by undetermined or partly counteracting shadow price components. However, assuming labor and variable inputs are complements and consumption goods are net-substitutes, the direction of most labor market reactions and some consumption adjustments becomes clear. In this case the internal wage rate increases with increasing prices of agricultural outputs (P_c, P_a) and decreasing variable input prices (P_v).

Furthermore, the analysis indicates that the adjustment effects in the farm household framework differ between the non-separable and the separable model version (table 1). That is, labor market imperfections have an impact on adjustments to exogenous price changes.

4 EMPIRICAL SPECIFICATION

To clarify the direction and quantify the extent of the farm household reactions, we estimate a fully specified non-separable farm household model. Based on the estimated parameters we derive price elasticities, which capture 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

(SNQ)[2] form (Diewert and Wales, 1987, 1992; Kohli, 1993). To ensure global convexity, we apply the method proposed by Koebel et al. (2000, 2003) (see below). The consumption decisions of the farm households are specified by an AIDS consumer demand system (Deaton and Muellbauer, 1980). To include imperfection of labor markets we assume a quadratic form for the labor cost (g) and labor income (f) function, respectively.[3]

The econometric estimation of the proposed model is carried out in four steps. First, we determine the internal wage of the household by estimating the shadow price of labor on the farm. Methodologically we follow Lopez (1984) who estimated a restricted profit function with labor as a quasi-fix factor. Assuming constant returns to labor Lopez (1984) could directly derive shadow prices of labor from the estimated profit function. In this case the SNQ profit function is defined as follows:

$$(26)\quad \Pi(p_n,r_n,X_{Ln}) = X_{Ln}\Pi^L(p_n,r_n) = X_{Ln}\left(\begin{array}{l}\sum_{i\in\{c,a,v\}}\alpha_i P_{in} + \frac{1}{2}w^{-1}\sum_{i\in\{c,a,v\}}\sum_{j\in\{c,a,v\}}\beta_{ij}P_{in}P_{jn}\\ +\sum_{i\in\{c,a,v\}}\sum_{j\in\{g,k\}}\delta_{ij}P_{in}R_{jn} + \frac{1}{2}w\sum_{i\in\{g,k\}}\sum_{j\in\{g,k\}}\gamma_{ij}R_{in}R_{jn}\end{array}\right)$$

and the corresponding netput equations are

$$(27)\quad X_{in}(p_n,r_n,X_{Ln}) = X_{Ln}\left(\begin{array}{l}\alpha_i + w_n^{-1}\sum_{j\in\{c,a,v\}}\beta_{ij}P_{jn} - \frac{1}{2}\theta_i w_n^{-2}\sum_{j\in\{c,a,v\}}\sum_{k\in\{c,a,v\}}\beta_{jk}P_{jn}P_{kn}\\ +\sum_{j\in\{g,k,L\}}\delta_{ij}R_{jn} + \frac{1}{2}\theta_i\sum_{j\in\{g,k,L\}}\sum_{k\in\{g,k,L\}}\gamma_{jk}R_{jn}R_{kn}\end{array}\right)$$

Here, n indicates the observation (household), Π is the profit function, Π^L is the profit function per unit of labor, X_{Ln} is the labor deployed on the farm and $w_n = \sum_{i\in\{c,a,v\}}\theta_i P_{in}$ is a factor to normalize prices, where $\theta_i = \sum_n P_{in}|X_{in}| \big/ \sum_n\sum_{j\in PG}P_{jn}|X_{jn}|;\ i\in\{c,a,v\}$ are the weights of the individual netput prices. Further, $p_n = (P_{an},P_{cn},P_{vn})$ indicate the price indices of the netputs and $X_{in};\ i\in\{c,a,v\}$ denote the quantity indices of the netputs. $r_n = (R_{gn},R_{kn})$ represent the quasi-fixed factors land (R_g) and capital (R_k), and α, β, δ, γ are the parameters to be estimated. To identify all β coefficients, we impose the following restrictions: $\sum_{j\in\{c,a,v\}}\beta_{ij}\overline{P_j} = 0;\ i\in\{c,a,v\}$, where $\overline{P_j}$ are the mean prices (Diewert and Wales, 1987, p. 54).

Now, the shadow prices of labor can be obtained by

$$(28)\quad P_{Ln} = \frac{\partial\Pi(p_n,r_n,X_{Ln})}{\partial X_{Ln}} = \Pi^L(p_n,r_n)$$

In the second step we analyze the labor supply and labor demand of the households. It follows from our theoretical model, that if a household participates as a seller in the off-farm labor market, the internal wage rate P_L^* equals the effective off-farm labor wage P_L^s, while if a household participates as a buyer in the on-farm labor market the internal wage rate P_L^* equals the effective on-farm labor wage P_L^h. Thus, the corresponding labor supply and demand functions could be econometrically estimated based on equations (6) and (8), respectively. However, since labor supply and labor demand are contingent on the decision of the household to participate as a seller or buyer in the off-farm and on-farm labor market, respectively (Greene, 2002), estimating labor supply or labor demand functions might be plagued by a sample selection (simultaneity) bias. To account for a sample selection bias, that generally can occur when supply or demand functions are estimated under market imperfection, a two-stage switching regression model with endogenous switching can be applied (Goetz, 1992; Key et al., 2000; Sadoulet et al., 1998). For our special case this approach corresponds to the Heckman sample selection model (Heckman, 1976).[4]

Following the Heckman procedure, estimating labor supply includes two regression equations, one equation determining sample selection at the first stage and a second regression model determining the effective labor wage at the second stage

(29) $\delta_n^{s*} = \gamma^s z_n^s + u_n^s, \quad \delta_n^s = 1 \text{ if } \delta_n^{s*} > 0 \quad \text{and} \quad \delta_n^s = 0 \text{ otherwise}$

(30) $P_{Ln}^* = \beta^s zz_n^s + \beta_x^s X_{Ln}^s + \varepsilon_n^s \quad \text{observed when} \quad \delta_n^s = 1$

The first part of the Heckman procedure is represented by a probit estimation of the first sample selection equation and the second part corresponds to a normal OLS regression of the effective labor wage equation including the inverse Mills ratio as additional explanatory variable (Greene, 2002). In (29) z_n^s corresponds to factors explaining participation in the off-farm labor market, which include factors explaining fixed transaction costs, z_f^s, variable transaction costs, z_t^s, as well as factors explaining heterogeneity, z_L^s. However, at this stage of analysis we don't want to distinguish explicitly between these various factors. In particular, we include the following variables in z^s: D_c a dummy variable that is one if there are children in the household (family members younger than 14 years), R_g the amount of land farmed by the household, N_w the number of family members in working age (between 14 and 60 years old), A_h and $A_h{}^2$, the age and squared age of the head of the family, D_f a dummy variable that is one if the head of the family is female and zero otherwise, D_r; $r \in [1,8]$ dummy variables for eight different regions.

In (30) zz_n^s corresponds to factors explaining the effective off-farm labor wage, which partly include factors of variable transaction costs, z_t^s, as well as factors explaining heterogeneity, z_L^s. In particular, besides D_f, N_w, A_h, $A_h{}^2$ and D_r $r \in [1,8]$ zz^s includes D_p as a dummy variable that is one if one or more family members are permanently employed outside the farm. u_n^s and ε_n^s are error terms, which are assumed to be jointly normal distributed, and β^s and γ^s are parameters to be estimated.

Analogously to labor supply the labor demand function is estimated following the Heckman procedure. Thus, the following two regression equation are estimated:

(31) $\delta_n^{h*} = \gamma^h z_n^h + u_n^h, \quad \delta_n^h = 1 \; if \; \delta_n^{h*} > 0 \quad \text{and} \quad \delta_n^h = 0 \text{otherwise}$

(32) $P_{Ln}^* = \beta^h zz_n^h + \beta_x^h X_{Ln}^h + \varepsilon_n^h \quad \text{observed when} \quad \delta_n^h = 1$

where in (31) z_n^h corresponds to factors explaining participation in the on-farm labor market, which include factors explaining fixed transaction costs, z_f^h, variable transaction costs, z_t^h, as well as factors explaining heterogeneity, z_L^h. However, at this stage of analysis we don't want to distinguish explicitly between these various factors. In particular, we include the following variables in z^h: D_c, R_g, N_w, A_h and $A_h{}^2$, D_f, D_r; $r \in [1,8]$ and D_p, while beside R_g and D_r; $r \in [1,8]$ we only include one additional dummy variable D_o that is one if workers are hired via a cooperative and zero otherwise in zz^h in (32). u_n^h and ε_n^h are error terms, which are assumed to be jointly normal distributed, and $beta^h$ and γ^h are parameters to be estimated.

The off-farm labor revenue function $\left(f\left(X_L^s\right)\right)$ and the cost function for hired labor $\left(g\left(X_L^h\right)\right)$ can be obtained from the estimations described above:

(33) $f\left(X_L^s\right) = \int_0^{X_L^s} \left(\beta^s zz_n^s + \beta_x^s X_L^s\right) dX_L^s = \alpha^s + \beta^s zz_n^s \, X_L^s + \frac{1}{2}\beta_x^s \, X_L^{s\,2} \quad \text{with}$

and

(34) $g\left(X_L^h\right) = \int_0^{X_L^h} \left(\beta^h zz_n^h + \beta_x^h X_L^h\right) dX_L^h = \alpha^h + \beta^h zz_n^h X_L^h + \frac{1}{2}\beta_x^h {X_L^h}^2$ with

where α^s and α^h are unknown parameters, which could account for fixed transaction costs.

A concave labor revenue function (f) requires a negative parameter β_x^s and a convex cost function for hired labor (g) requires a positive parameter β_x^h. If the estimated parameters β_x^s and β_x^h have the right sign, the standard errors of these parameters returned by the Heckman estimation allow to test by a simple t-test if the labor revenue and labor cost function are significantly concave and convex, respectively.

In the third step we again estimate the netput equations of a SNQ profit function. However, this time we consider labor as variable input. Thus, we have four netputs $(X_i;\, i \in \{c,a,v,L\})$ and two quasi-fixed inputs $(R_i;\, i \in \{g,k\})$. The price of labor (P_L) is taken from the results of the first step (equation (28)):

$$(35)\quad X_{in}(p_n, r_n) = \alpha_i + w_n^{-1} \sum_{j\in\{c,a,v,L\}} \beta_{ij} P_{jn} - \frac{1}{2}\theta_i w_n^{-2} \sum_{j\in\{c,a,v,L\}} \sum_{k\in\{c,a,v,L\}} \beta_{jk} P_{jn} P_{kn} + \sum_{j\in\{g,k\}} \delta_{ij} R_{jn} + \frac{1}{2}\theta_i \sum_{j\in\{g,k\}} \sum_{k\in\{g,k\}} \gamma_{jk} R_{jn} R_{kn}$$

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, 1980):

$$(36)\quad W_{in} = \alpha_i + \sum_{j\in\{m,a,L\}} \gamma_{ij} \ln P_{jn} + \beta_i \ln \frac{Y_n}{\wp_n}$$

$$(37)\quad \ln \wp_n = \alpha_0 + \sum_{i\in\{m,a,L\}} \alpha_i \ln P_{in} + \frac{1}{2} \sum_{i\in\{m,a,L\}} \sum_{j\in\{m,a,L\}} \gamma_{ij} \ln P_{in} \ln P_{jn}$$

Here, $W_{in} = P_{in}C_{in}/Y_n;\ i \in \{m,a,L\}$ are the budget shares, where Y_n indicates the full income. $\wp_n$ is the translog consumer price index, $P_{in};\ i \in \{m,a,L\}$ indicate the consumer price indices of the aggregated commodity groups, and α, β, and γ are the parameters to be estimated[5].

5 DATA AND EMPIRICAL RESULTS

Data used for the estimations are based on an accounting survey of 202 agricultural households in several regions around Poznan (Mid-West Poland) in 1994. The data were collected and published by the Institute for Agriculture and Food Industries (IERiGZ) in Warsaw.

On the production side, market goods (X_c) consist of all crop products, while animal products are considered as (possibly) home-consumed goods (X_a). All relevant variable inputs of the farms are subsumed in netput X_v. Labor (X_L) includes both family $\left(X_L^f\right)$ and hired labor $\left(X_L^h\right)$. Land (R_g) and capital (R_k) are considered as quasi-fixed factors. On the consumption side, C_m includes all purchased consumption goods. The self-produced goods (C_a) correspond conceptually to the home-consumed animal products (X_a). The amount of leisure (C_L) is determined by calculating the yearly available time (T_L) of households (household members older than 14 years $\times$ 10 hours per day $\times$ 365 days) minus on-farm $\left(X_L^f\right)$ and off-farm (X_L^s) family labor.

The sample contains two farms that do not produce any animal products. These two farm households are removed from the sample to have a more homogeneous sample and to avoid an imputation of the unknown prices of animal products. Appendix table A1 gives an overview of main sample characteristics.

All estimations and calculations are carried out by the (free) statistical software "R" (R Development Core Team, 2004, see also http://www.r-project.org), using the add-on packages "micEcon" (Henningsen, 2005) and "systemfit" (Hamann and Henningsen, 2004).

5.1 Estimation results

In the first step the three netput equations of the SNQ profit function (27) are estimated. The estimation results are presented in appendix table A2. The R^2 values are 0.71, 0.29 and 0.69 for X_c, X_a and X_v, respectively, and more than 75% of the parameters are significantly different from zero.

While the homogeneity and symmetry conditions are imposed in this estimation, the monotonicity and convexity conditions are checked afterwards. For our results monotonicity is fulfilled at all observations, but the estimated profit function is not convex in prices. In a first attempt, we tried to impose convexity by a non-linear estimation using the Cholesky decomposition (Lau, 1978b). Since the estimation of the restricted non-linear netput equations did not converge, we choose a new procedure suggested by Koebel et al. (2000, 2003). It is based on the minimum distance and asymptotic least squares estimation (Gourieroux et al., 1985; Kodde et al., 1990), and is asymptotically equivalent to a (successful) non-linear estimation with convexity imposed. First, the estimation results of the unrestricted (linear) netput equations are used to calculate the Hessian matrix of the unrestricted profit function. Second, the weighted difference between this unrestricted and a restricted Hessian is minimized. Finally, restricted coefficients are identified by an asymptotic least squares (ALS) framework.

The weighting matrix for the minimization of the difference between the unrestricted and the restricted Hessian is the inverse of the variance-covariance matrix of the Hessian, which can be derived from the variance-covariance matrix of the estimated coefficients. To restrict the Hessian to be positive semi-definite we use the Cholesky factorization.[6]

The parameter estimates and R^2 values of the restricted profit function are presented in appendix table A3. The R^2 values are almost identical to the unrestricted model. This shows that the data do not unreasonably contradict the convexity constraint. The homogeneity and symmetry conditions are not affected by the imposition of convexity, and monotonicity is still fulfilled for all observations. Thus, the estimated profit function fully complies with microeconomic theory.

The shadow prices of labor calculated from the restricted profit function have reasonable values for all but one farm household. This farm household has a negative shadow price and, therefore, it is removed from the sample. Hence, the sample used for the further analysis includes 199 farm households.

In the second step the labor supply and demand of the households are analyzed. The results regarding the supply of labor (eq. (30) and (29)) are shown on the left-hand side of table 2. The probability that the household supplies labor increases significantly if the number of family members in working age increases, if the head of the household is female, if there are children in this household, and if the household resides in region 4 (Leszczynskie). The R^2 value of the estimated shadow price equation for labor supplying households is 0.36. The shadow prices are significantly influenced by the amount of supplied labor, the age of the head of the family and

Table 2: Estimated Coefficients of Labor Market Analysis

Regressor	labor supply				labor demand			
	1st step: probit		2nd step: OLS		1st step: probit		2nd step: OLS	
Constant	-0.207		18.296		1.386		30.351	***
X_L^s			-0.007	*				
X_L^h							0.021	***
N_w	0.144	*	-1.803		-0.291	***		
D_c	0.523	**						
D_p			6.681		-0.356			
A_h	-0.017		2.232	**	-0.045			
D_f	0.481	*	-7.714		-0.135			
A_h^2	0.000		-0.025	**	0.000			
D_o							13.024	
R_g	-0.013				0.062	***	0.868	***
D_2	-0.048		-25.110	***	-0.209		-20.033	***
D_3	0.335		-19.247	***	-0.407		-18.050	**
D_4	0.843	**	-13.432	*	-0.006		1.869	
D_5	0.519		-9.904		-0.076		-15.514	**
D_6	-0.552		-5.240		1.046	**	-16.473	**
D_7	0.047		5.894		0.344		12.298	
D_8	0.444		-17.056	**	-0.131		-12.601	
IMR			-4.646				-1.454	
R^2			0.359				0.509	

Notes: IMR = inverse Mills ratio.

"*", "**" and "***" denote statistical significance at the 10%, 5% and 1% level, respectively.

the region. The estimated parameter of the inverse Mills ratio is not significantly different from zero, indicating that there is no sample selection bias. As expected the estimated parameter of the amount of supplied labor is negative. Hence, the labor revenue function is concave with respect to supplied labor.

The results regarding the demand for hired labor (eq. (32) and (31)) are shown on the right-hand side of table 2. The probability that the household hires labor increases significantly with an increasing amount of land, with a decreasing number of family members in working age, and if the household resides in region 6 (Poznanskie). The R^2 value of the estimated shadow price equation for labor hiring households is 0.51. The shadow prices are significantly influenced by the amount of hired labor, the amount of land and the region. As on the labor supply side the estimated parameter of the inverse Mills ratio is not significantly different from zero, indicating that there is no sample selection bias for labor hiring households. As expected the estimated parameter of the amount of supplied labor is positive. Hence, the labor cost function is convex with respect to hired labor.

In the third step the four netput equations of the SNQ profit function (35) are estimated. The parameter estimates and R^2 values are presented in appendix table A4. The R^2 values are 0.74, 0.49, 0.82 and 0.28 for X_c, X_a, X_v, and X_L, respectively, and more than half of the parameters are significantly different from zero.

Again, the homogeneity and symmetry conditions are imposed in the estimation, and the monotonicity and convexity condition are checked afterwards. Monotonicity is fulfilled at 97.5% of the observations, but the estimated profit function is not convex in prices. Hence, convexity is enforced using the same method as for the profit function in the first step. The parameter estimates and R^2 values of the restricted profit function are presented in appendix table A5. Again, the R^2 values are almost identical to the unrestricted model showing that the data do not unreasonably contradict the convexity constraint. Since the homogeneity and symmetry conditions are maintained in the imposition of convexity, and the restricted profit function fulfills monotonicity at 97.0% of the observations, microeconomic theory is satisfied for almost the complete sample.

In the fourth step the three budget share equations of the Almost Ideal Demand System (36) are estimated. The estimation results are presented in appendix table A6. The R^2 values are 0.36, 0.55 and 0.46 for W_m, W_a and W_L, respectively, and almost all parameters are significantly different from zero. While the adding-up, homogeneity and symmetry conditions are imposed on the estimated parameters, the monotonicity and concavity condition are checked after the estimation. For our results monotonicity is fulfilled at 99.5% of the observations and concavity is fulfilled at 85.9% of the observations. Thus, the estimated demand system meets the conditions derived from microeconomic demand theory at a very large range of the sample.

5.2 Elasticities

The traditional price elasticities on production side and the traditional price and income elasticities on demand side are presented in appendix tables A7 and A8, respectively. We compute the price elasticities in the farm household complex as a function of the relevant traditional price and income elasticities. All these elasticities are based on the underlying estimated parameters and calculated using the sample mean values of the relevant variables. These elasticities correspond to the differentials in the comparative static analysis.

Table 3: Price elasticities

	non-separable model				separable model				
	P_c	P_a	P_v	P_m	P_c	P_a	P_v	P_L	P_m
X_c	-0.11	0.50	-0.22	0.08	0.14	0.79	-0.52	-0.41	0.00
X_a	0.41	0.37	-0.72	0.03	0.50	0.47	-0.83	-0.14	0.00
X_v	0.30	0.78	-1.06	0.01	0.33	0.82	-1.09	-0.05	0.00
X_L	0.06	-0.16	0.30	0.10	0.38	0.21	-0.08	-0.52	0.00
C_m	0.40	0.64	-0.53	-0.73	0.16	0.37	-0.26	0.42	-0.65
C_a	0.20	-0.46	-0.29	0.50	0.15	-0.51	-0.24	0.12	0.52
C_L	0.28	0.41	-0.48	-0.14	0.36	0.51	-0.58	-0.03	-0.17
X_L^{sn}	-11.14	-12.69	12.94	3.56	-19.50	-22.21	22.64	9.31	6.23
X_L^s	-4.10	-4.67	4.75	1.31					
X_L^h	3.74	4.26	-4.34	-1.19					
X_L^f	-0.16	-0.43	0.58	0.18					
P_L	0.63	0.71	-0.73	-0.20					

Table 3 gives an overview of the elasticities within the non-separable and the separable framework. In the non-separable model the exogenous prices that directly influence the production side have a considerable impact on the internal wage rate with shadow price elasticities of 0.63, 0.71 and -0.71 for P_c, P_a and P_v, respectively. On the other hand the price of commercial consumption good has a much less impact on the internal wage rate with a shadow price elasticity of -0.20. Interestingly, we observe in the non-separable model an inverse supply response to own-price changes of the produced market good (X_c).

As expected, most important differences between the two model versions are found regarding the labor market reactions. The adjustments of (net) supplied labor, consumed leisure and labor deployed on the farm are generally smaller if there are labor market imperfections (non-separable model) compared to a situation without labor market imperfections (separable model). However, most differences between the non-separable and the separable model are moderate.

6 CONCLUDING REMARKS

This paper provides a theoretical and empirical analysis of price responses of farm households under imperfect labor markets in Mid-West Poland. In particular, an interdependent FHM approach is derived that explicitly takes transaction costs and heterogeneity of labor into account. The approach contains the following advantages: (i) In contrast to existing approaches, which take only fixed (FTC) and constant marginal (proportional, PTC) transaction costs into account, our approach additionally takes variable marginal transaction costs as well as heterogeneity of labor into account. (ii) In contrast to most empirical analyses of interdependent FHMs, which use reduced forms of a non-separable FHM, we estimate a full non-separable FHM based on flexible functional forms on the production and consumption side. In particular, applying a new method proposed by Koebel et al. (2000, 2003) allows us to ensure global convexity of the profit function, which is always a problem when estimating flexible profit functions. (iii) The approach is applicable for several kinds of labor market imperfections, e.g. institutional restrictions like binding hours settled by collective agreements, transaction costs due to search, monitoring or commuting costs or heterogeneity of family and non-family or heterogeneity of on-farm and off-farm labor. (iv) It allows an analysis of farm household decisions under various labor market regimes including the case that farms simultaneously hire on-farm labor and sell off-farm labor, a case which is theoretically excluded if only FTCs and PTCs are analyzed and labor is treated as homogeneous good. (v) It provides a simple empirical test for separability of the FHM approach.

Theoretical analysis delivers the following results: In contrast to former approaches taking only FTC and PTC into account, in our more general approach non-separability not only occurs if households are autarkic, but can also occur when households actually participate in labor markets. Comparative static analyses suggest that when labor markets are imperfect price responses of the farm household are generally ambiguous mainly due to counteracting shadow price effects. Furthermore, price responses generally differ between the non-separable and the separable model version indicating the potential importance of interdependent FHM as the adequate tool of agricultural policy analysis when labor markets are imperfect. However, for most price responses econometric analysis using individual household data from Mid-West Poland indicates only moderate differences between the two model versions. Exemptions are crop production and labor market supply, respectively, for which significant differences in price responses for the separable and non-separable FHM have been found. For crop production the non-separable FHM indicates an inverse supply response.

NOTES

[1]Christian H.C.A. Henning is Full Professor and Arne Henningsen is Ph.D. student, Department of Agricultural Economics, University of Kiel, Germany. Paper presented at the EAAE Seminar on Institutional Units in Agriculture, held in Wye, UK, April 9-10, 2005.

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

[3]The quadratic form can be interpreted as a second order approximation of the true labor cost and income functions.

[4]Estimating labor supply and labor demand functions using two separate Heckman models we implicitly assume that the decisions to participate in the off-farm and on-farm labor market are independent from each other, i.e. the error terms of the probit regression determining off-farm and on-farm labor market participation are uncorrelated. Otherwise, we would have to apply a bivariate probit model estimating both equations simultaneously (Greene, 2002). For simplicity we assume that participation decisions are independent although in general we could also estimate a bivariate probit model.

[5]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, 1992). 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, 1980), we chose an iterative estimation procedure proposed by Michalek and Keyzer (1992, p. 145).

[6] 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 of Koebel et al. (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.

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Appendix A: Tables

Table A1: Characteristics of the Sample

variable	unit	mean	minimum	maximum	std.deviation
P_cX_c	1000 PLZ	132258	10451	1189412	133724
P_aX_a	1000 PLZ	212570	2669	2526524	239835
P_vX_v	1000 PLZ	211960	13480	2204671	213479
P_mC_m	1000 PLZ	91469	26365	280176	42853
P_aC_a	1000 PLZ	19041	1625	41853	7606
X_L	hours	3686	400	9843	1717
X_L^h	hours	211	0	2085	365
X_L^s	hours	446	0	4000	876
$X_L^s - X_L^h$	hours	235	-2085	4000	1002
X_L^f	hours	3475	400	9236	1705
C_L	hours	8716	1361	22698	4172
R_g	ha	14.7	1.2	101.5	12.4
R_k	1000 PLZ	649191	43960	4492025	554120

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

Table A2: Estimation Results of 1st step Profit Function (unrestricted)

Parameter	$i=c$		$i=a$		$i=v$	
α_i	-1.72	(-0.73)	20.12	(4.31)	-17.36	(-5.14)
β_{ic}	-14.85	(-1.12)	19.77	(2.68)	-4.92	(-0.37)
β_{ia}	19.77	(2.68)	61.62	(5.76)	-81.39	(-8.04)
β_{iv}	-4.92	(-0.37)	-81.39	(-8.04)	86.31	(5.08)
δ_{ig}	6258	(11.37)	1002	(0.93)	-4306	(-5.37)
δ_{ik}	0.08	(5.77)	0.21	(7.47)	-0.11	(-5.36)
γ_{gg}			-1157392	(-6.45)		
γ_{gk}			36.73	(7.59)		
γ_{kk}			-0.00126	(-9.79)		
R^2	0.71		0.29		0.69	

Notes: t-values in parentheses. The standard errors of the coeffi cients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258).

Table A3: Estimation Results of 1st step Profit Function (restricted)

Parameter	$i=c$	$i=a$	$i=v$
α_i	-2.28	20.31	-17.03
β_{ic}	3.31	14.64	-17.95
β_{ia}	14.64	64.69	-79.32
β_{iv}	-17.95	-79.32	97.27
δ_{ig}	6169	1024	-4294
δ_{ik}	0.09	0.21	-0.11
γ_{gg}		-1149245	
γ_{gk}		36.60	
γ_{kk}		-0.00126	
R^2	0.71	0.28	0.69

Table A4: Estimation Results of Final Profit Function (unrestricted)

Parameter	$i=c$		$i=a$		$i=v$		$i=L$	
α_i	-29632	(4.31)	31200	(-0.73)	-3850	(-1.12)	-62575	(-5.14)
β_{ic}	12679	(0.24)	104118	(3.04)	-78518	(-1.47)	-38279	(-5.09)
β_{ia}	104118	(3.04)	101865	(1.61)	-188508	(-3.49)	-17475	(-1.30)
β_{iv}	-78518	(-1.47)	-188508	(-3.49)	253009	(3.42)	14016	(1.23)
β_{iL}	-38279	(-5.09)	-17475	(-1.30)	14016	(1.23)	41739	(8.33)
δ_{ig}	6980	(11.91)	336	(0.31)	-6324	(-7.49)	-3220	(-9.22)
δ_{ik}	0.12	(9.15)	0.29	(12.31)	-0.17	(-9.49)	0.01	(0.99)
γ_{gg}			-165.87	(-3.41)				
γ_{gk}			$9.77 \cdot 10^{-3}$	(9.17)				
γ_{kk}			$-3.54 \cdot 10^{-7}$	(-24.28)				
R^2	0.74		0.49		0.82		0.28	

Notes: t-values in parentheses. The standard errors of the coeffi cients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258).

Table A5: Estimation Results of Final Profit Function (restricted)

Parameter	$i=c$	$i=a$	$i=v$	$i=L$
α_i	-32638	32285	-3280	-62762
β_{ic}	71504	72782	-107302	-36984
β_{ia}	72782	101486	-158814	-15453
β_{iv}	-107302	-158814	255517	10599
β_{iL}	-36984	-15453	10599	41838
δ_{ig}	6905	279	-6186	-3212
δ_{ik}	0.13	0.29	-0.17	0.01
γ_{gg}		-169.11		
γ_{gk}		$9.82 \cdot 10^{-3}$		
γ_{kk}		$-3.57 \cdot 10^{-7}$		
R^2	0.74	0.49	0.82	0.28

Table A6: Estimation Results of the AIDS

Parameter	$i=m$		$i=a$		$i=L$	
α_i	0.04	(0.41)	0.05	(2.22)	0.91	(9.22)
β_i	-0.11	(6.92)	-0.03	(6.44)	0.14	(7.79)
γ_{im}	0.18	(7.56)	0.05	(4.35)	-0.23	(10.27)
γ_{ia}	0.05	(4.35)	0.02	(1.73)	-0.07	(11.83)
γ_{iL}	-0.23	(10.27)	-0.07	(11.83)	0.31	(12.09)
R^2	0.36		0.55		0.46	

Notes: t-values in parentheses. The standard errors of the coeffi cients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258). α_0 is set to 16.7, because this value gives the highest likelihood value of the AIDS Model.

Table A7: Price Elasticities of (Final) Profit Function (restricted)

	P_c	P_a	P_v	P_L
X_c	0.566	0.563	-0.728	-0.401
X_a	0.358	0.467	-0.694	-0.131
X_v	0.458	0.686	-1.112	-0.031
X_L	0.374	0.192	-0.047	-0.520

Table A8: Price and Income elasticities - AIDS Model

	Price elasticities						Income
	Hicksian Elasticities			Marshallian Elasticities			Elasticities
	P_m	P_a	P_L	P_m	P_a	P_L	Y
C_m	-0.517	0.145	0.372	-0.652	0.114	-0.005	0.543
C_a	0.642	-0.721	0.079	0.518	-0.749	-0.264	0.495
C_L	0.134	0.007	-0.141	-0.168	-0.062	-0.977	1.206