Econometric Estimation of Farm Household Decisions in the Presence of Labor Markets Imperfections

Christian H.C.A. Henning and Arne Henningsen

Department of Agricultural Economics
University of Kiel
Olshausenstr. 40
D-24098 Kiel (Germany)
http://www.uni-kiel.de/agrarpol/

corresponding author:
Arne Henningsen
Telephone: +49-431-880 4445
E-mail: ahenningsen@email.uni-kiel.de

Paper prepared for presentation at the Nordic Econometric Meeting, Tartu, Estonia, May 24-26, 2007.

Abstract

This paper analyzes production, consumption and labor market decisions of farm households in the presence of labor market imperfections. We present an econometric estimation strategy that solves several selectivity and endogeneity problem. An empirical model is estimated using data from Mid-West Poland. The results show that transaction costs and labor heterogeneity significantly influence household behavior.

keywords: farm household model, market imperfection, rural labor markets, selectivity, transaction costs

JEL classification: Q12, J22, D43, C51

1 Introduction

Economic development requires an adjustment of the resource allocation. One of the most important processes is the migration of labor from the agricultural to the non-agricultural sector (Larson and Mundlak, 1997). However, labor markets and especially rural labor markets are often underdeveloped and plagued by considerable transaction costs.

In this paper we analyze production, consumption and labor market decisions of farm households taking labor market imperfections explicitly into account. While traditional microeconomic models generally neglect the interdependence between production and consumption decisions, farm household models (FHM) have been developed to explicitly account for these linkages (Lopez, 1984; Strauss, 1986; de Janvry et al., 1991). If all relevant markets exist and are not plagued by transaction costs, consumption preferences and consumer prices do not influence production decisions, but production behavior does influence consumption decisions, because profit from production contributes to the income of the household. This implies that production behavior can be optimized first, and consumption decisions can be made later. Hence, production and consumption decisions are separable. Household models that account for these one-way linkage are generally called *recursive* or *separable*.

On the other hand, many markets are disturbed by transaction costs and, if transaction costs are sufficiently high, households find it unprofitable to either buy or sell a good in the market and remain autarkic (de Janvry et al., 1991). The household's internal valuation of these goods does no longer depend on exogenous market prices, but results from an internal equilibrium of consumption and production decisions. Hence, production and consumption decisions are no longer separable. Household models that account for these two-way linkages are called *interdependent* or *non-separable*.

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 et al., 1992), or food markets (de Janvry et al., 1991; Goetz, 1992; Omamo, 1998; Skoufias, 1994; Abdulai and Delgado, 1999). However, non-separability makes theoretical and, in particular, empirical analyses more difficult. Therefore, most empirical analyses assume separable FHMs or use reduced forms of a non-separable FHM.

While virtually all FHM approaches assume that markets are either absent or perfect, Henning and Henningsen (2007) analyzed the case of existing but imperfect markets. They showed that non-proportional variable transaction costs or (observed) heterogeneity result in an interdependency between production and consumption decisions even if the farm household participates in the market.

We estimate this generalized FHM approach econometrically using farm household data from Poland. The estimation procedure utilized allows us to consider both potential selectivity and endogeneity problems. Furthermore, we explicitly test for the significance of labor market imperfections due to non-proportional variable transaction costs and heterogeneity as well as for the differences between price elasticities calculated for different degrees of labor market imperfection.

2 Theoretical Model

In this section we shortly present the theoretical farm household model of Henning and Henningsen (2007). It is a static model of price responses of farm households in imperfect and perfect labor markets. The farm household is assumed to maximize utility subject to a technology, time, and budget constraint. Therefore, farm households solve the following maximization problem:

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

subject to

$$G(x,r) = 0 \qquad \text{(production function)} \tag{2}$$

$$T_L - |X_L| + X_L^h - X_L^s - C_L \geq 0 \qquad \text{(time constraint)} \tag{3}$$

$$P_m C_m \leq P_c X_c + P_a(X_a - C_a) - P_v|X_v| - g(X_L^h) + f(X_L^s) + E \qquad \text{(budget constraint)} \tag{4}$$

where $U(c)$ is the farm household's utility function, which is monotonically increasing and strictly quasi-concave, and 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 well-behaved multi-input multi-output production function (2) (Lau, 1978a), where x is a vector of production goods, expressed as netputs, and r is a vector of quasi-fixed factors. The farm household produces pure market goods ($X_c > 0$) and goods that are partly consumed by the household ($X_a > 0$). It uses variable intermediate 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 total time available. $|X_L| = X_L^f + X_L^h$ is the total of on-farm labor time subdivided into family labor (X_L^f) and hired labor (X_L^h), and X_L^s denotes off-farm family labor. There are four possible regimes of labor market participation. First, the household simultaneously sells family labor and hires labor. Second, farmers neither sell nor hire labor (autarky). Third, households only sell off-farm labor and fourth, they only hire on-farm labor. Earlier studies have neglected the regime in which households simultaneously hire and supply labor. For instance, Sadoulet et al. (1998) argue that this labor market regime is rarely observed and that their theoretical model cannot explain this specific labor strategy. However, in our data set this regime is rather frequent, with 29% of households falling into that category (table 1).[1]

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 off-farm employment. In addition, it receives ($E > 0$) or pays ($E < 0$) transfers, which are determined exogenously. Here, P_i, $i \in \{m, a, c, v\}$, denote the exogenous consumer and producer prices.

[1] Simultaneously hiring on-farm labor and supplying off-farm labor can be rational with a strictly convex labor cost and a strictly concave labor income function. For instance, if the skills of the household members to work off-farm are very heterogeneous, it is rational to simultaneously supply high-priced labor of well-educated household members and hire cheap agricultural labor (see also Sadoulet et al., 1996). A more detailed explanation is provided in Henning and Henningsen (forthcoming).

A special emphasis is given to the modeling of labor markets, because it is well recognized that rural labor markets are often plagued by market imperfections. Henning and Henningsen (2007) show that non-proportional variable transaction costs (NTC) as well as observed heterogeneity of labor result in a non-linear labor income function for off-farm labor supply (f) and a non-linear labor cost function for hired on-farm labor (g). With no heterogeneity and no NTC, both functions are linear. In this case, once households participate in labor markets, marginal off-farm income or marginal costs for hired labor are equal to the exogenously given wage rate corrected for proportional transaction costs as well as for household-specific wage shifters. Thus, if households participate in one of the labor markets, 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 may still abstain from the labor market and stay autarkic.

In contrast, when labor markets are imperfectly competitive due to heterogeneity or NTC, both functions are non-linear. In this case, the internal shadow price of labor (P_L^*) is endogenously determined. Hence, non-separability of the FHM occurs even when households participate in labor markets. Theoretically, the curvature properties of the labor revenue function f and the labor cost function g are ambiguous. However, for analytical convenience, Henning and Henningsen (2007) assume f to be concave and g to be convex, since a non-concave labor revenue or a non-convex cost function makes the FHM approach less tractable.

Since fixed transaction costs create discontinuities in the f and g functions, solutions to the maximization problem (1) to (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. First, we solve for the optimal solution conditional on the labor market participation regime, and then choose the regime that leads to the highest utility. Assuming an interior solution for a given labor market regime (Y^h and Y^s), the optimal quantities of consumption and production goods and the allocation of time are determined by conditions (2) to (4) and the following equations with $\lambda, \phi, \mu > 0$; $C_m, C_a, C_L, X_c, X_a > 0$; $X_L, X_v < 0$; $X_L^s > 0$ if $Y^s = 1$ and $X_L^s = 0$ otherwise; $X_L^h > 0$ if $Y^h = 1$ and $X_L^h = 0$ otherwise.

$$\frac{\partial U(.)}{\partial C_i} - \lambda P_i^{(*)} = 0 \quad i \in \{m, a, L\} \tag{5}$$

$$\phi \frac{\partial G(.)}{\partial X_i} + \lambda P_i^{(*)} = 0 \quad i \in \{c, a, v, L\} \tag{6}$$

$$\frac{\partial f(.)}{\partial X_L^s} - P_L^* = 0 \quad \text{if} \quad Y^s = 1 \tag{7}$$

$$\frac{\partial g(.)}{\partial X_L^h} - P_L^* = 0 \quad \text{if} \quad Y^h = 1 \tag{8}$$

where λ, ϕ are Lagrangian multipliers associated with the budget and the technology constraints, respectively. $P_L^* = \mu/\lambda$ denotes the unobservable shadow wage in the case of non-separability, where μ is the Lagrangian multiplier associated with the time constraint. In the separable version, P_L^* corresponds to the exogenous wage rate corrected for proportional transaction costs and individual wage shifters.

The first-order conditions (5) to (8) show that in equilibrium the marginal profit of farm work, marginal revenue of off-farm work, marginal costs of hired labor, and marginal utility of leisure (valuated in terms of money) are all equal.

3 Comparative Statics

In general, comparative statics are derived from the first-order conditions (2) to (4) and (5) to (8) and thus differ for each labor market regime. However, for simplicity we assume that the farm household simultaneously supplies off-farm labor and demands on-farm labor. Following the standard FHM literature (de Janvry et al., 1991), comparative statics of a non-separable FHM can be decomposed into the following two components:

$$\frac{\mathrm{d}\,Q}{\mathrm{d}\,P_j} = \left.\frac{\partial Q}{\partial P_j}\right|_{P_L^*=\text{const.}} + \frac{\partial Q}{\partial P_L^*}\frac{\mathrm{d}\,P_L^*}{\mathrm{d}\,P_j}; \quad j \in \{c, a, v, m\}; \quad Q \in \{X_{c,a,v,L}, C_{m,a,L}, X_L^{s,h}\} \tag{9}$$

The first term on the right (direct component) represents the supply or demand reactions to changes in the exogenous prices, assuming a constant labor price (P_L^*). The second term (indirect component) represents the adjustments to the changes in the shadow wage rate caused by changes in the same exogenous price.

Assuming separability, farm household's production and consumption adjustments coincide with the direct component of equation (9). In this case, a household's net-labor supply is obtained by subtracting farm labor input ($|X_L|$) and leisure (C_L) from its total labor endowment (T_L).

To determine the indirect component of the non-separable model, we derive the shadow price adjustment by applying the implicit function theorem to the time constraint (3) (de Janvry et al., 1991):

$$\frac{\mathrm{d}\,P_L^*}{\mathrm{d}\,P_j} = -\frac{\dfrac{\partial X_L}{\partial P_j} - \dfrac{\partial C_L}{\partial P_j}}{\dfrac{\partial X_L}{\partial P_L^*} + \dfrac{\partial X_L^h}{\partial P_L^*} - \dfrac{\partial X_L^s}{\partial P_L^*} - \dfrac{\partial C_L^H}{\partial P_L^*}} \tag{10}$$

The numerator on the right represents the change in time allocation due to increasing exogenous prices. The denominator of equation (10) indicates the change in time allocation caused by changes of the shadow wage rate. Equation (10) differs from a corresponding standard non-separable FHM assuming absent labor markets by the term $\Lambda = \partial X_L^h/\partial P_L^* - \partial X_L^s/\partial P_L^*$ in the denominator. This term measures the degree of labor market imperfection due to NTC or heterogeneity. Λ is implicitly determined by the first-order conditions (7) and (8), whereby: $\partial X_L^s/\partial P_L^* = \left(\partial^2 f/\partial {X_L^s}^2\right)^{-1}$ and $\partial X_L^h/\partial P_L^* = \left(\partial^2 g/\partial {X_L^h}^2\right)^{-1}$. Λ is always positive if f is concave and g is convex. As indicated earlier, the degree of labor market imperfection increases with the second-order differentials, $\partial^2 f/\partial {X_L^s}^2$ and $\partial^2 g/\partial {X_L^h}^2$, measured in absolute terms. In the extreme case of infinitely high NTC and labor heterogeneity, Λ approaches zero; hence, comparative statics of the model in (9) approximate the comparative statics derived from an autarkic labor market regime. In the opposite extreme case of zero NTC and perfect labor homogeneity, f and g are linear functions and Λ becomes infinity, implying that the induced shadow wage adjustment (10) is zero. Thus, the comparative statics of the model (9) would be approximating those of a separable FHM.[2]

4 Empirical Specification

We fully specify a non-separable farm household model that can be econometrically estimated to assess the question if and to what extent labor market imperfection influences price responses of farm households.

4.1 Production Technology

The production technology (2) is represented by a multi-input multi-output profit function from the symmetric normalized quadratic (SNQ) form (Diewert and Wales, 1987, 1992; Kohli, 1993):

$$\begin{aligned}\Pi\left(p_{pn}, r_n\right) = & \sum_{i\in\{c,a,v,L\}} \alpha_i P_{in} + \frac{1}{2} w_n^{-1} \sum_{i\in\{c,a,v,L\}} \sum_{j\in\{c,a,v,L\}} \beta^*_{ij} P_{in} P_{jn} \\ & + \sum_{i\in\{c,a,v,L\}} \sum_{j\in\{g,k\}} \delta_{ij} P_{in} R_{jn} + \frac{1}{2} w_n \sum_{i\in\{g,k\}} \sum_{j\in\{g,k\}} \gamma_{ij} R_{in} R_{jn}\end{aligned} \tag{11}$$

where n indicates the observation (farm/household), $w_n = \sum_{i\in\{c,a,v,L\}} \theta_i P_{in}$ is a factor to normalize prices, $\theta_i = \sum_n P_{in} \left|X_{in}\right| / \sum_n \sum_{j\in\{c,a,v,L\}} P_{jn} \left|X_{jn}\right|$; $i \in \{c,a,v,L\}$ are predetermined weights of the individual netput prices, $p_{pn} = (P_{an}, P_{cn}, P_{vn}, P_{Ln})$ indicates the netput prices, X_{in}; $i \in \{c,a,v,L\}$ denotes the quantity indices of the netputs, $r_n = (R_{gn}, R_{kn})$ represents the quasi-fixed factors land (R_g) and capital (R_k), and all αs, βs, δs, and γs are parameters to be estimated. Homogeneity of degree one in prices is automatically attained by the functional form.

The corresponding netput equations can be obtained using Hotelling's Lemma:

$$\begin{aligned}X_{in}\left(p_{pn}, r_n\right) = \alpha_i + w_n^{-1} \sum_{j\in\{c,a,v,L\}} \beta_{ij} P_{jn} - \frac{1}{2} \theta_i w_n^{-2} \sum_{j\in\{c,a,v,L\}} \sum_{k\in\{c,a,v,L\}} \beta_{jk} P_{jn} P_{kn} \\ + \sum_{j\in\{g,k\}} \delta_{ij} R_{jn} + \frac{1}{2} \theta_i \sum_{j\in\{g,k\}} \sum_{k\in\{g,k\}} \gamma_{jk} R_{jn} R_{kn} \quad \forall\, i \in \{c,a,v,L\}\end{aligned} \tag{12}$$

where $\beta_{ij} = (\beta^*_{ij} + \beta^*_{ji})/2 \;\forall\; i,j \in \{c,a,v,L\}$. To identify all βs, we impose the restrictions $\sum_{j\in\{c,a,v,L\}} \beta_{ij} \overline{P_j} = 0$; $i \in \{c,a,v,L\}$, where $\overline{P_j}$ are the mean prices (Diewert and Wales, 1987, p. 54).

[2] The complete comparative statics for all exogenous prices based on equations (9) and (10) is available in Henning and Henningsen (forthcoming).

4.2 Consumption Decisions

The preferences of the farm households (1) and the corresponding consumption decisions are specified by the Almost Ideal Demand System (AIDS) (Deaton and Muellbauer, 1980):

$$\ln e_n(p_n, U_n) = \alpha_0 + \sum_{i\in\{m,a,L\}} \alpha_i \ln P_{in} + \frac{1}{2} \sum_{i\in\{m,a,L\}} \sum_{j\in\{m,a,L\}} \gamma^*_{ij} \ln P_{in} \ln P_{jn} + \beta_0 U_n \prod_{i\in\{m,a,L\}} p_i^{\beta_i} \tag{13}$$

where $e_n(p_n, U_n)$ is the expenditure function that indicates the minimum expenditure to obtain utility level U_n given consumer prices $p_n = \{P_{mn}, P_{an}, P_{Ln}\}$, and all αs, βs, and γs are parameters. Homogeneity of degree one in prices requires $\sum_{i\in\{m,a,L\}} \alpha_i = 1$, $\sum_{i\in\{m,a,L\}} \beta_i = 0$, $\sum_{i\in\{m,a,L\}} \gamma^*_{ij} = 0$, and $\sum_{j\in\{m,a,L\}} \gamma^*_{ij} = 0$.

The demand equations, expressed in expenditure shares, can be obtained by Shepard's Lemma and a few transformations:

$$W_{in} = \alpha_i + \sum_{j\in\{m,a,L\}} \gamma_{ij} \ln P_{jn} + \beta_i \ln \frac{Y_n}{\wp_n} \quad \forall\, i \in \{m, a, L\} \tag{14}$$

$$\text{with } \ln \wp_n = \alpha_0 + \sum_{i\in\{m,a,L\}} \alpha_i \ln P_{in} + \frac{1}{2} \sum_{i\in\{m,a,L\}} \sum_{j\in\{m,a,L\}} \gamma_{ij} \ln P_{in} \ln P_{jn} \tag{15}$$

where $W_{in} = P_{in}C_{in}/Y_n$; $i \in \{m, a, L\}$ are the expenditure shares, Y_n indicates full income, $\wp_n$ is the translog consumer price index, and $\gamma_{ij} = (\gamma^*_{ij} + \gamma^*_{ji})/2 \;\forall\, i, j \in \{m, a, L\}$.

4.3 Labor Market Decisions

To allow imperfect labor markets due to transaction costs and heterogeneity, we assume a quadratic form for the labor income function $f(X^s_L)$ and the labor cost function $g(X^h_L)$ in (4), which can be interpreted as second-order approximations of the true labor cost and income functions, respectively. According to our theoretical expositions above, assuming quadratic f and g functions implies that the corresponding shadow wages are linear functions:

$$P^*_L = \beta^s_0 + X^s_L \beta^s_1 + z^{s\prime} \beta^s \tag{16}$$

$$P^*_L = \beta^h_0 + X^h_L \beta^h_1 + z^{h\prime} \beta^h \tag{17}$$

According to the theoretical model of Henning and Henningsen (2007), the vector z^s includes factors that explain variable transaction costs of supplying labor and the average skill level of a farm household as well as a proxy for the average regional wage level. Analogously, the vector z^h includes factors explaining variable transaction costs of hiring labor and the average skill of hired on-farm labor as well as a proxy for the average regional wage level. Moreover, since the quadratic functions are second-order approximations of the true f and g functions, their (local) curvature properties are fully captured by the coefficients β^s_1 and β^h_1, respectively. Accordingly, we can test for the significance of labor market imperfections due to nonproportional variable transaction costs and heterogeneity in off-farm and in on-farm labor markets with a t-test. The null hypotheses correspond to $H_0 : \beta_1^h = 0$ and $H_0 : \beta_1^s = 0$.[3] Non-separability is implied if both null hypotheses are rejected. However, even if one of the null hypotheses cannot be rejected, non-separability can still occur if the farm household does not participate in the corresponding labor market owing to high fixed or proportional transaction costs.[4]

5 Estimation Strategy

The econometric estimation of the empirical model specified above is not straightforward, because shadow prices of labor cannot be observed directly. Therefore, we use a two-stage estimation strategy. We estimate shadow prices of labor at the first stage and at the second stage, we estimate separately the SNQ profit function (12), the Almost Ideal Demand System (14, 15) and the linear labor wage equations (16, 17).

5.1 Estimating Shadow Values of Labor (Stage 1)

We follow Lopez (1984) to estimate the shadow prices of labor and estimate a restricted profit function with labor as a quasi-fixed input. Assuming constant returns to labor, Lopez (1984) derived the shadow wages of the households as shadow price of labor on the farm. For this application, a symmetric normalized quadratic (SNQ) profit function (Diewert and Wales, 1987, 1992; Kohli, 1993) has following form:

$$\Pi\left(p_{pn}, r_n, X_{Ln}\right) = X_{Ln} \left(\begin{array}{l} \displaystyle\sum_{i \in \{c,a,v\}} \alpha_i P_{in} + \frac{1}{2} w_n^{-1} \sum_{i \in \{c,a,v\}} \sum_{j \in \{c,a,v\}} \beta_{ij} P_{in} P_{jn} \\ \displaystyle + \sum_{i \in \{c,a,v\}} \sum_{j \in \{g,k\}} \delta_{ij} P_{in} R_{jn} + \frac{1}{2} w_n \sum_{i \in \{g,k\}} \sum_{j \in \{g,k\}} \gamma_{ij} R_{in} R_{jn} \end{array} \right) \tag{18}$$

where $p_{pn} = (P_{an}, P_{cn}, P_{vn})$ indicates the netput prices, and all other variables and parameters are analogously defined as in equation (11) and (12).

[3] This estimation strategy does not permit the estimation of fixed transaction costs, because they have no (direct) impact on the shadow price. However, because we are only interested in the impact of imperfect labor markets on price responses, we do not need to identify fixed transaction costs at this stage and we let them be captured by exogenous transfers (E).

[4] Non-linearity of the labor revenue and labor cost functions is a sufficient, but not a necessary condition for non-separability. It is, however, a necessary condition if households participate in labor markets. Even if the labor revenue and labor cost function are both linear, fixed or proportional transaction costs could be so high that farms abstain from labor markets and thus, their production and consumption decisions are no longer separable. Hence, if our statistical test rejects linearity of the labor revenue and labor cost functions, we can conclude that the FHM is generally non-separable. However, if our test does not reject linearity, we can conclude that the FHM is separable for households that participate in labor markets; nevertheless non-separability could still be observed in autarkic households. Other tests of separability have been suggested for the latter case (see for example Benjamin, 1992). However, we did not apply these additional tests because in our specific empirical application our test was sufficient to identify non-separability (see section "Data and Empirical Results").

The netput quantities per unit of labor that correspond to this profit function can be obtained by Hotelling's Lemma:

$$\begin{aligned}\frac{X_{in}\left(p_{pn},r_n,X_{Ln}\right)}{X_{Ln}} &= \alpha_i + w_n^{-1}\sum_{j\in\{c,a,v\}}\beta_{ij}P_{jn} - \frac{1}{2}\theta_i w_n^{-2}\sum_{j\in\{c,a,v\}}\sum_{k\in\{c,a,v\}}\beta_{jk}P_{jn}P_{kn} \\ &+ \sum_{j\in\{g,k\}}\delta_{ij}R_{jn} + \frac{1}{2}\theta_i\sum_{j\in\{g,k\}}\sum_{k\in\{g,k\}}\gamma_{jk}R_{jn}R_{kn} \quad \forall\, i\in\{c,a,v\}\end{aligned} \tag{19}$$

Finally, the shadow prices of labor can be obtained from the estimation results by

$$P_{Ln}^{*} = \frac{\partial\widehat{\Pi}_n\left(p_{pn},r_n,X_{Ln}\right)}{\partial X_{Ln}} \tag{20}$$

where $\widehat{\Pi}_n(p_{pn},r_n,X_{Ln}) = \sum_{i\in\{c,a,v\}} P_{in}\widehat{X}_{in}$ is the fitted variable profit of the n^{th} farm and $\widehat{X}_{in}(p_{pn},r_n,X_{Ln})$ are the fitted values of the netput quantities.

Microeconomic theory generally requires that profit functions are convex in all netput prices, which is not the case in many empirical estimations. Therefore, we impose convexity of the profit function (19), applying a three-step procedure suggested by Koebel et al. (2003) based on the minimum distance and asymptotic least squares estimation (Gourieroux et al., 1985; Kodde et al., 1990).[5]

In a first stage, the (linear) netput equations of the profit function (19) are estimated without convexity restrictions. Based on these estimation results, the Hessian matrix of the profit function with respect to netput prices ($\widehat{H}^u$) is calculated.

In a second stage, we minimize the weighted difference between this unrestricted Hessian and a Hessian ($\widehat{H}^c$) that is restricted to be positive semi-definite by the Cholesky factorization:[6]

$$\widehat{h}^c = \underset{\widehat{h}^c}{\operatorname{argmin}}\left(\widehat{h}^c-\widehat{h}^u\right)'\left(\frac{\partial h}{\partial\beta'}Cov(\widehat{\beta}^u)\frac{\partial h'}{\partial\beta}\right)^{-1}\left(\widehat{h}^c-\widehat{h}^u\right)$$

with $\widehat{h}^{u,c} = \operatorname{vecli}\widehat{H}^{u,c}$, $\widehat{H}^c = U'U$, $U_{ij} = 0\ \forall\ j>i$, and vecli is an operator that creates a vector of all linear independent values of a matrix. The weighting matrix for the minimization of the difference between the unrestricted and the restricted Hessian matrix is the inverse of the variance-covariance matrix of the Hessian matrix, which can be derived from the coefficient variance-covariance matrix of the unrestricted estimation.

[5] We first tried to impose convexity by a non-linear estimation using the Cholesky decomposition (Lau, 1978b). However, the estimation of the restricted non-linear netput equations did not converge. The new procedure suggested by Koebel et al. (2003) circumvents this non-linear estimation and is asymptotically equivalent to a (successful) non-linear estimation with convexity imposed.

[6] To retain convexity of the SNQ profit function, it would be sufficient to minimize the difference between the estimated (unrestricted) β coefficients and the (linearly independent) values of a restricted β coefficient matrix (Koebel, 1998). However, this procedure adjusts only the β-coefficients, while the approach of Koebel et al. (2003) adjusts *all* coefficients. Thus, the fit of the constrained model is much better, due to the flexibility of the other coefficients. Both approaches yield the same βs.

In a third stage, the restricted coefficients $\widehat{\beta}^c$ are identified from the restricted Hessian $\widehat{H}^c$ and the unrestricted coefficients $\widehat{\beta}^u$ by an asymptotic least squares (ALS) framework:

$$\widehat{\beta}^c = \widehat{\beta}^u + Cov(\widehat{\beta}^u)\frac{\partial h'}{\partial \beta}\left(\frac{\partial h}{\partial \beta'}Cov(\widehat{\beta}^u)\frac{\partial h'}{\partial \beta}\right)^{-1}(\widehat{h}^c - \widehat{h}^u)$$

Since this procedure does not provide a variance covariance matrix of the coefficients, we obtained it by bootstrapping (Efron, 1979; Efron and Tibshirani, 1993).

5.2 Farm Technology (Stage 2a)

Given the estimated shadow prices of labor, we estimate the SNQ netput equations (12). Again, we impose convexity with the method of Koebel et al. (2003). However, the price of labor (P_L^*) is endogenous and a generated regressor. We use a three-stage least squares (3SLS) estimation with the variables z (see below) as instrumental variables for P_L^*, to account for the endogeneity and the generation of P_L^* (Pagan, 1984) and to allow for contemporaneous correlation of the disturbance terms.

5.3 Consumption (Stage 2b)

Analogously, given the estimated shadow prices of leisure (labor), we estimate the demand system (14, 15). In addition to P_L^* being endogenous and a generated regressor, the full income variable (Y) in the consumption decision specification might be endogenous and depends on P_L^*. To avoid estimation biases, we utilize a three-stage least squares (3SLS) estimation, in which we use the variables z (see below) as instruments for P_L^* and Y. To avoid non-linear estimation, the share equations of the AIDS are estimated by the "Iterated Linear Least Squares Estimator" (ILLE) proposed by Blundell and Robin (1999). Since Henningsen (2003, 2007) showed that choosing a wrong value for the intercept of the translog price index (15), α_0, might cause biased results, we estimate the model with many different values of α_0 and choose the value that gives the highest likelihood value.

5.4 Labor Market Decisions (Stage 2c)

Given the estimated shadow prices of labor, we estimate the two linear labor wage functions (16) and (17). However, these estimations might be plagued by a sample selection bias and an endogeneity problem.[7]

The endogeneity problem arises because the regressors X_L^s and X_L^h are probably correlated with the disturbance terms. To overcome this problem, we use a 2SLS estimation and substitute fitted values ($\widehat{X}_L^s, \widehat{X}_L^h$) for the observed quantities of supplied and hired labor (X_L^s, X_L^h). According to our theory, the optimal labor market allocation (X_L^s, X_L^h) of households that supply and demand labor simultaneously depends on the first-order conditions (5)–(8). For households that

[7] The deviations between the estimated and the unobserved (true) shadow prices of labor get a part of the regular error terms ν^s and ν^h of the shadow price equations (23) and (24). We assume that these deviations are neither correlated with the regressors z^s and z^h nor with the variables used as instruments for X_L^s and X_L^h in the 2SLS estimation. Note that we do not have to assume that the deviations are uncorrelated with the regressors X_L^s and X_L^h because X_L^s and X_L^h are not used as instruments in the 2SLS estimation.

only supply labor, the optimal amount of supplied labor (X_L^s) depends only on conditions (5)–(7), while for households that only demand labor, the optimal quantity of hired labor (X_L^h) depends only on conditions (5), (6), and (8). Therefore, the impact of exogenous variables on the amount of traded labor (X_L^s, X_L^h) depends on the labor market regime. Hence, the first stage of this 2SLS estimation corresponds to a switching regression model.

The sample selection bias occurs because these equations can only be estimated for households that participate in labor markets. To correct for selectivity, we apply an extended Heckman procedure and add selectivity terms (λ) to these equations, which can be interpreted as an extension of the two-stage probit method for simultaneous equation models with selectivity suggested by Lee et al. (1980). Overall, a consistent estimation of these functions requires the estimation of the following eight equations:

- Market participation equations (estimated as a bivariate probit model):

$$Y^{s*} = z'\gamma^s + \varepsilon^s \quad \text{with } Y^{s*} > 0 \text{ if } X_L^s > 0 \text{ and } Y^{s*} \leq 0 \text{ if } X_L^s = 0 \tag{21}$$
$$Y^{h*} = z'\gamma^h + \varepsilon^h \quad \text{with } Y^{h*} > 0 \text{ if } X_L^h > 0 \text{ and } Y^{h*} \leq 0 \text{ if } X_L^h = 0 \tag{22}$$

- Shadow wage equations (second stage of the 2SLS estimation):

$$P_L^* = \beta_0^s + \widehat{X}_L^s\beta_1^s + z^{s\prime}\beta^s + \sigma^s\lambda^s + \nu^s \quad \text{if } Y^{s*} > 0 \tag{23}$$
$$P_L^* = \beta_0^h + \widehat{X}_L^h\beta_1^h + z^{h\prime}\beta^h + \sigma^h\lambda^h + \nu^h \quad \text{if } Y^{h*} > 0 \tag{24}$$

- Labor supply and demand equations (first stage of the 2SLS estimation):

$$X_L^s = z_x^{b\prime}\delta_s^b + \sigma_s^{bs}\lambda^{bs} + \sigma_s^{bh}\lambda^{bh} + \xi_s^b \quad \text{if } Y^{s*} > 0 \wedge Y^{h*} > 0 \tag{25}$$
$$X_L^s = z_x^{s\prime}\delta_s^s + \sigma_s^{ss}\lambda^{ss} + \sigma_s^{sh}\lambda^{sh} + \xi_s^s \quad \text{if } Y^{s*} > 0 \wedge Y^{h*} \leq 0 \tag{26}$$
$$X_L^h = z_x^{b\prime}\delta_h^b + \sigma_h^{bs}\lambda^{bs} + \sigma_h^{bh}\lambda^{bh} + \xi_h^b \quad \text{if } Y^{h*} > 0 \wedge Y^{s*} > 0 \tag{27}$$
$$X_L^h = z_x^{h\prime}\delta_h^h + \sigma_h^{hs}\lambda^{hs} + \sigma_h^{hh}\lambda^{hh} + \xi_h^h \quad \text{if } Y^{h*} > 0 \wedge Y^{s*} \leq 0 \tag{28}$$

where z are factors influencing labor market participation; z_x^b, z_x^s, and z_x^h are factors influencing the quantity of supplied and hired labor (depending on the labor market regime); all ε, ν, and ξ denote the error terms; and all γ, β, σ, and δ are parameters or parameter vectors to be estimated.

We assume that the residuals of the participation equations (21, 22), ε^s and ε^h, have a bivariate normal distribution:

$$\begin{pmatrix} \varepsilon^s \\ \varepsilon^h \end{pmatrix} \sim N\left(\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{bmatrix} 1 & \rho \\ & 1 \end{bmatrix}\right) \tag{29}$$

Further, we assume a joint normal distribution of ε^s, ε^h, $\widetilde{\nu}^s$ and $\widetilde{\nu}^h$ with covariances $\sigma^s = cov(\widetilde{\nu}^s, \varepsilon^s)$ and $\sigma^h = cov(\widetilde{\nu}^h, \varepsilon^h)$, where $\widetilde{\nu}^s$ and $\widetilde{\nu}^h$ would be the error terms of equations (23) and (24), respectively, without selectivity terms. From this we can obtain the conditional expectations of the error terms (Heckman, 1976):

$$E[\widetilde{\nu}^s | Y^{s*} > 0] = \sigma^s \lambda^s \tag{30}$$

$$E[\widetilde{\nu}^h | Y^{h*} > 0] = \sigma^h \lambda^h \tag{31}$$

with

$$\lambda^s = \frac{\phi\left(z'\gamma^s\right)}{\Phi\left(z'\gamma^s\right)} \tag{32}$$

$$\lambda^h = \frac{\phi\left(z'\gamma^h\right)}{\Phi\left(z'\gamma^h\right)} \tag{33}$$

Furthermore, we assume a joint normal distribution of ε^s, ε^h, $\widetilde{\xi}^b_s$, $\widetilde{\xi}^s_s$, $\widetilde{\xi}^b_h$, and $\widetilde{\xi}^h_h$ with covariances $\sigma^{bs}_s = cov(\widetilde{\xi}^b_s, \varepsilon^s)$, $\sigma^{bh}_s = cov(\widetilde{\xi}^b_s, \varepsilon^h)$, $\sigma^{ss}_s = cov(\widetilde{\xi}^s_s, \varepsilon^s)$, $\sigma^{sh}_s = cov(\widetilde{\xi}^s_s, \varepsilon^h)$, $\sigma^{bs}_h = cov(\widetilde{\xi}^b_h, \varepsilon^s)$, $\sigma^{bh}_h = cov(\widetilde{\xi}^b_h, \varepsilon^h)$, $\sigma^{hs}_h = cov(\widetilde{\xi}^h_h, \varepsilon^s)$, and $\sigma^{hh}_h = cov(\widetilde{\xi}^h_h, \varepsilon^h)$, where $\widetilde{\xi}^b_s$, $\widetilde{\xi}^s_s$, $\widetilde{\xi}^b_h$, and $\widetilde{\xi}^h_h$ would be the error terms of equations (25), (26), (27), and (28), respectively, without selectivity terms. From this we can obtain the conditional expectation of the error terms

$$E\left[\widetilde{\xi}^b_s | Y^{s*} > 0 \;\wedge\; Y^{h*} > 0\right] = \sigma^{bs}_s \lambda^{bs} + \sigma^{bh}_s \lambda^{bh} \tag{34}$$

$$E\left[\widetilde{\xi}^s_s | Y^{s*} > 0 \;\wedge\; Y^{h*} \leq 0\right] = \sigma^{ss}_s \lambda^{ss} + \sigma^{sh}_s \lambda^{sh} \tag{35}$$

$$E\left[\widetilde{\xi}^b_h | Y^{s*} > 0 \;\wedge\; Y^{h*} > 0\right] = \sigma^{bs}_h \lambda^{bs} + \sigma^{bh}_h \lambda^{bh} \tag{36}$$

$$E\left[\widetilde{\xi}^h_h | Y^{s*} \leq 0 \;\wedge\; Y^{h*} > 0\right] = \sigma^{hs}_h \lambda^{hs} + \sigma^{hh}_h \lambda^{hh} \tag{37}$$

where the λs are defined as follows:

$$\lambda^{bs} = \frac{\phi\left(z'\gamma^s\right)\Phi\left(\frac{z'\gamma^h - \rho z'\gamma^s}{\sqrt{1-\rho^2}}\right)}{\Phi_2\left(z'\gamma^s, z'\gamma^h\right)}, \qquad \lambda^{bh} = \frac{\phi\left(z'\gamma^h\right)\Phi\left(\frac{z'\gamma^s - \rho z'\gamma^h}{\sqrt{1-\rho^2}}\right)}{\Phi_2\left(z'\gamma^s, z'\gamma^h\right)} \tag{38}$$

$$\lambda^{ss} = \frac{\phi\left(z'\gamma^s\right)\Phi\left(\frac{-z'\gamma^h + \rho z'\gamma^s}{\sqrt{1-\rho^2}}\right)}{\Phi^*_2\left(z'\gamma^s, -z'\gamma^h\right)}, \qquad \lambda^{sh} = -\frac{\phi\left(z'\gamma^h\right)\Phi\left(\frac{z'\gamma^s - \rho z'\gamma^h}{\sqrt{1-\rho^2}}\right)}{\Phi^*_2\left(z'\gamma^s, -z'\gamma^h\right)} \tag{39}$$

$$\lambda^{hs} = -\frac{\phi\left(z'\gamma^s\right)\Phi\left(\frac{z'\gamma^h - \rho z'\gamma^s}{\sqrt{1-\rho^2}}\right)}{\Phi^*_2\left(-z'\gamma^s, z'\gamma^h\right)}, \qquad \lambda^{hh} = \frac{\phi\left(z'\gamma^h\right)\Phi\left(\frac{-z'\gamma^s + \rho z'\gamma^h}{\sqrt{1-\rho^2}}\right)}{\Phi^*_2\left(-z'\gamma^s, z'\gamma^h\right)} \tag{40}$$

where $\phi()$ and $\Phi()$ denote the probability density (pdf) and cumulative distribution (cdf) function of a standard normal distribution, respectively, and Φ_2 and Φ^*_2 are the cumulative distribution (cdf) functions of a bivariate standard normal distribution with correlations ρ and $-\rho$, respectively (Tunali, 1986; Henning and Henningsen, 2007).[8]

[8] These selectivity terms have been derived independently by Tunali (1986) and Henning and Henningsen (2007). A detailed derivation of these terms is available in Henning and Henningsen (forthcoming). Saha et al. (1994) presents slightly different selectivity terms. To make sure that we are using the correct selectivity terms, we calculated the conditional expectation values by numerical integration and Monte Carlo simulation using the (free) statistical software R (R Development Core Team, 2005, see also `http://www.r-project.org`), and the add-on packages adapt (Genz et al., 2005b), mvtnorm (Genz et al., 2005a), and MASS (Venables and Ripley, 2002). While the formulas in (38) to (40) perfectly fit the numerical calculations, the formulas of Saha et al. (1994) did not.

Based on the estimation results of the bivariate probit model (21) and (21), equations (32), (33), and (38) to (40) are used to compute the selectivity terms $(\widehat{\lambda})$, which are then substituted for the true λs in equations (23) to (28). The estimated results of equations (25) to (28) are then used to obtain fitted values $(\widehat{X}_L^s, \widehat{X}_L^h)$ that are used to estimate the second stage of the 2SLS estimation of equations (23) and (24). Finally, the variance covariance matrix of the second stage coefficients are computed with the formula given in Lee et al. (1980) to obtain consistent standard errors.

6 Data and Empirical Results

Data are based on an accounting survey of 202 agricultural households in several regions around Poznan (Mid-West Poland) in 1994. The data were collected by the Institute for Agriculture and Food Industries in Warsaw (IERiGZ, 1995). Additional regional data are taken from Glowny Urzad Statystyczny (1996) and Zawadzki (1994). Sample characteristics of different labor market regimes are presented in table 1.

The empirical specification of the theoretical model is as follows. On the production side, market goods (X_c) consist of all crop products, while animal products are considered as partly home-consumed goods (X_a). All relevant variable inputs of the farms are subsumed in netput X_v. Labor (X_L) includes both family (X_L^f) and hired labor (X_L^h). 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 minus on-farm (X_L^f) and off-farm (X_L^s) family labor.[9]

Variables influencing the shadow price of labor from production side include land and capital endowments (R_g, R_k) as well as variable output and input prices (P_c, P_a, P_v). Variables influencing the shadow price from the consumer side include household composition and consumer prices. Household composition is measured by the number of family members up to 14 years (N_k), between 15 and 60 years (N_w), and older than 60 years (N_o), as well as sex (D_f), age (A_h), and age squared (A_h^2) of the household head, because these variables might influence the preferences for leisure.

The variable and fixed transaction costs on the labor markets are explained by the number of cars owned by the household (N_c), the regional density of the road and railroad network (W_i), the regional number of telephones per 1,000 population (W_t), the regional unemployment rate (W_u), and the proportion of the population that lives in rural areas (W_r). Furthermore, we assume that the average off-farm skill level of farm households depends on the number of family members that are of working age (N_w), the number of family members older than 60 years (N_o), and the average level of human capital. Since no data on education is available, we follow Vakis

[9] It is assumed that each household member between 15 years and 60 years has 10 hours per day and each household member older than 60 years has five hours per day available for work and/or leisure. The annual available time of the household is calculated by multiplying the total hours per day of all household members by 365. We use the share of off-farm labor in total labor endowment (X_L^s/T_L) instead of the absolute amount of supplied labor (X_L^s) as an explanatory variable in the off-farm labor wage equation to account for different household sizes. Hence, we assume that the share of skilled and unskilled labor in the total household would not significantly vary with the family size. Using the absolute amount of off-farm labor supply instead does not change the main results, i.e. significant and negative impact on the effective off-farm wage rate.

Table 1: Characteristics of the Different Labor Regimes

Variable	Unit	All	Sup. & Dem.	Only Sup.	Only Dem.	Autarkic
Number		199	57	47	61	34
N_k	number	1.3	1.5	1.3	1.4	0.7
N_w	number	2.8	2.8	3.2	2.4	3.0
N_o	number	0.7	0.6	0.6	0.8	0.7
A_h	years	43	41	44	43	45
T_L	hours	11399	11110	12891	10082	12185
$\|X_L\|$	hours	3686	3579	3372	4040	3668
X_L^h	hours	211	278	0	430	0
X_L^s	hours	446	515	1266	0	0
X_L^n	hours	235	237	1266	-430	0
X_L^f	hours	3475	3301	3372	3610	3668
C_L	hours	7478	7295	8254	6473	8517
$P_m C_m$	1000 PLZ	91469	105939	78012	97792	74467
$P_a C_a$	1000 PLZ	19041	18487	19245	19939	18076
$P_c X_c$	1000 PLZ	132258	157581	65883	180020	95869
$P_a X_a$	1000 PLZ	212570	220643	123997	300046	164531
$P_v\|X_v\|$	1000 PLZ	211960	232143	117552	299629	151343
R_g	ha	14.7	16.9	9.4	18.3	11.7
R_k	1000 PLZ	649191	788881	425398	816534	424132
R_k/R_g	1000 PLZ / ha	46921	49666	48516	48134	37938
N_c	number	0.9	1.0	0.8	0.9	0.8
W_u	%	19	20	19	18	20
W_i	km/100 km^2	58	55	60	60	57
W_t	1/1000 popul.	48	47	49	49	47
W_r	%	45	44	50	43	46
$\widetilde{P}_L$	Poland = 100	88	85	90	89	88
P_L^*	1000 PLZ/h	38	46	30	44	28

Note: Calculations are based on IERiGZ (1995). PLZ = Polish Zloty. Variables: N_k = number of family members up to 14 years, N_w = number of family members between 15 and 60 years, N_o = number of family members older than 60 years, A_h = age of the household head, T_L = total time available, $|X_L|$ = labor input on the farm, X_L^h = hired labor, X_L^s = supplied labor, X_L^n = net supplied labor, X_L^f = family labor input on the farm, C_L = leisure, $P_m C_m$ = value of consumed market goods, $P_a C_a$ = value of consumed self-produced goods, $P_c X_c$ = value of produced crop products, $P_a X_a$ = value of produced animal products, $P_v|X_v|$ = value of utilized variable inputs, R_g = amount of land of the farm, R_k = amount of capital of the farm, N_c = number of cars owned by the household, W_u = regional unemployment rate, W_i = regional density of the road and railroad network, W_t = regional density of telephones, W_r = proportion of the population that lives in rural areas, $\widetilde{P}_L$ = relative average regional wage level, P_L^* = endogenous shadow price of labor.

et al. (2003) and interpret sex (D_f), age (A_h), and age squared (A_h^2) of the household head as an indicator of average human capital. Finally, the average skill level of hired workers is explained by the mechanization on the farm, measured as capital intensity (R_k/R_g).

The sample contains two farms that do not produce any animal products, which are removed to provide a more homogeneous sample and to avoid imputing the unknown prices of animal products.

6.1 Estimation results

This section presents the main estimation results. More detailed results are available in the appendix. All estimations and calculations are carried out by the (free) statistical software "R" (R Development Core Team, 2005, see also `http://www.r-project.org`), using the add-on packages "micEcon" (Henningsen and Toomet, 2005), "systemfit" (Hamann and Henningsen, 2006), and "VGAM" (Yee and Wild, 1996).

Table 2: Estimation Results of the 1st-Stage Profit Function with Convexity Imposed

Parameter	$i = c$		$i = a$		$i = v$	
	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)
α_i	-2.28	(-0.57)	20.3	(3.16)	-17.0	(-3.21)
β_{ic}	3.31	(0.81)	14.6	(2.34)	-17.9	(-1.99)
β_{ia}	14.6	(2.34)	64.7	(2.93)	-79.3	(-3.16)
β_{iv}	-17.9	(-1.99)	-79.3	(-3.16)	97.3	(3.30)
δ_{ig}	6170	(4.60)	1024	(0.59)	-4294	(-2.26)
δ_{ik}	0.0855	(2.92)	0.208	(4.81)	-0.110	(-3.87)
γ_{gg}	-1149343	(-1.72)				
γ_{gk}	36.6	(1.89)				
γ_{kk}	$-1.26 \cdot 10^{-3}$	(-2.26)				
R^2	0.708		0.283		0.686	

Note: For definitions of the estimated coefficients see equation (19). The standard errors of the coefficients are obtained using the bootstrap resampling method (Efron, 1979; Efron and Tibshirani, 1993).

The three netput equations of the SNQ profit function (19) are estimated in the first step. Estimation results are shown in table 2. Since homogeneity and convexity are imposed and monotonicity is fulfilled at all observations, this estimated profit function fully complies with microeconomic theory. The R^2 values are almost identical to the model without convexity imposed, indicating that the data do not unreasonably contradict the convexity constraint (see appendix table A1). The shadow prices of labor calculated from the restricted profit function have reasonable values for all but one farm household. This household has a negative shadow price and is therefore removed from the sample. Hence, the sample used for further analyses includes 199 farm households.

Table 3 presents the estimates of the restricted second-step profit function (12). The R^2 values are almost identical to the model without convexity imposed, indicating that the data do not unreasonably contradict the convexity constraint (see appendix table A2). Since homogeneity and convexity are imposed and monotonicity is fulfilled at 97.0% of the observations, the estimated profit function almost completely complies with microeconomic theory.

Estimation results of the Almost Ideal Demand System (14, 15) are shown in table 4. The intercept of the translog price index (15), α_0, is set to 10.8, because this value gives the highest likelihood value of the AIDS Model. Since Homogeneity[10] and symmetry are imposed,

[10] Homogeneity of degree one in prices of the expenditure function implies homogeneity of degree zero in prices and income as well as "adding-up" of the demand functions.

Table 3: Estimation Results of the 2nd-Stage Profit Function

Parameter	$i = c$		$i = a$		$i = v$		$i = L$	
	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)
α_i	-31261	(-2.31)	33699	(2.07)	-5480	(-0.37)	-62939	(-6.95)
β_{ic}	53083	(1.86)	64866	(2.75)	-84580	(-2.13)	-33368	(-3.46)
β_{ia}	64866	(2.75)	116773	(2.47)	-168328	(-2.68)	-13311	(-0.63)
β_{iv}	-84580	(-2.13)	-168328	(-2.68)	247344	(2.72)	5564	(0.32)
β_{iL}	-33368	(-3.46)	-13311	(-0.63)	5564	(0.32)	41115	(6.28)
δ_{ig}	6815	(4.59)	303	(0.14)	-6087	(-4.04)	-3181	(-2.81)
δ_{ik}	0.124	(4.40)	0.291	(7.49)	-0.167	(-6.97)	$7.87 \cdot 10^{-3}$	(0.20)
γ_{gg}	-172	(-1.28)						
γ_{gk}	$9.84 \cdot 10^{-3}$	(2.09)						
γ_{kk}	$-3.55 \cdot 10^{-7}$	(-2.26)						
R^2	0.747		0.492		0.821		0.278	

Note: For definitions of the estimated coefficients see equation (12). The standard errors of the coefficients are obtained using the bootstrap resampling method (Efron, 1979; Efron and Tibshirani, 1993).

Table 4: Estimation Results of the AIDS

Parameter	$i = m$		$i = a$		$i = L$	
	Coef.	(t-val.)	Coef.	(t-val.)	Coef.	(t-val.)
α_i	0.555	(9.86)	0.185	(14.79)	0.260	(4.18)
β_i	-0.170	(-9.15)	-0.031	(-7.36)	0.201	(9.95)
γ_{im}	0.034	(1.28)	0.021	(0.79)	-0.055	(-5.34)
γ_{ia}	0.021	(0.79)	0.010	(0.35)	-0.031	(-9.36)
γ_{iL}	-0.055	(-5.34)	-0.031	(-9.36)	0.086	(7.97)
R^2	0.409		0.585		0.504	

Note: For definitions of the estimated coefficients see equation (14). The standard errors of the coefficients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258).

monotonicity is fulfilled at 99.5% of the observations and concavity is fulfilled at 88.4% of the observations, the estimated demand system largely complies with microeconomic theory.

Table 5 presents the estimates of the off-farm and on-farm labor wage functions.[11] The bivariate probit estimation shows that labor demand and supply decisions are not significantly correlated in the sample (ρ is not significantly different from zero). The probability that a household supplies off-farm labor increases significantly with the number of household members of working age (N_w) and with the rural nature of the region (W_r).

The probability that a household demands labor significantly depends on the capital endowment (R_k), the endowment of family labor (N_w, N_o), the age of the head of the household

[11] It is somewhat disconcerting that many z variables in table 5 do not have a statistically significant effect on labor market participation and effective wages. To some extent this is caused by multicollinearity of the regional variables. Although multicollinearity does not result in biased estimates, it reduces the precision of the estimated parameters of the correlated regressors, which leads to larger standard errors and thus, to less statistical significance. However, since we are predominantly interested in the effect of the traded quantities of labor on the effective wages, the lack of statistical significance of the z variables has only minor negative consequences on the essential part of this paper. A note on exclusion variables in the labor market estimations is given in the appendix.

Table 5: Estimated Coefficients of Labor Market Equations

Regressor	Labor Supply		Labor Demand	
	1st Step: Probit	2nd Step: 2SLS	1st Step: Probit	2nd Step: 2SLS
Constant	-0.196	103.929 *	3.988	-31.012
X_L^s/T_L		-73.567 **		
X_L^h				0.047 ***
N_k	0.129		0.084	
N_w	0.158 *	-3.496 *	-0.382 ***	
N_o	-0.022	-3.945	-0.296 **	
D_f	0.388	-6.448	-0.199	
A_h	-0.003	2.190 *	-0.119 *	
A_h^2	-7.1·10^{-5}	-0.025 *	1.3·10^{-3} *	
R_g	0.008		0.005	
R_k	-6.5·10^{-7}		1.9·10^{-6} ***	
R_k/R_g	1.0·10^{-5}		-7.2·10^{-6}	2.1·10^{-4} **
P_c	3.091		3.836	
P_a	0.252		-0.115	
P_v	-1.608		-3.906	
N_c	0.142	-1.652	-0.139	4.511
W_u	-0.025	-0.427	-0.010	2.841 **
W_i	-0.030	-0.136	0.001	0.733 *
W_t	-0.007	-0.542	0.012	-0.217
W_r	0.034 **	-0.639 **	-0.030 *	-1.004 **
$\widetilde{P}_L$	-0.014	-0.184	0.005	0.112
IMR Supply		-1.737		
IMR Demand				-15.987 **
ρ	-0.099		-0.099	
R^2		0.307		0.425

Note: *, **, and *** denote statistical significance at the 10%, 5% and 1% level, respectively. Wald test of the joint significance of the exclusion variables: labor supply $\chi^2 = 9.595$, df = 7, p-value = 0.213; labor demand $\chi^2 = 41.531$, df = 11, p-value = 0.00002. Variables: X_L^s = supplied labor [hours], T_L = total time available [hours], X_L^h = hired labor [hours], N_k = number of family members up to 14 years, N_w = number of family members between 15 and 60 years, N_o = number of family members older than 60 years, D_f = sex of the household head (male=0, female=1), A_h = age of the household head, R_g = amount of land of the farm [ha], R_k = amount of capital of the farm [1000 PLZ], P_c = price index of crop products (average=1), P_a = price index of animal products (average=1), P_v = price index of variable inputs (average=1), N_c = number of cars owned by the household, W_u = regional unemployment rate [%], W_i = regional density of the road and railroad network [km/100 km^2], W_t = regional number of telephones per 1,000 population, W_r = proportion of the population that lives in rural areas [%], $\widetilde{P}_L$ = relative average regional wage level (Poland=100), IMR = inverse Mill's ratio.

(A_h, A_h^2), and the rural nature of the region (W_r). As expected, the probability increases with the capital endowment and decreases with the endowment of family labor. We also observe the expected signs for the age and squared age of the household head, i.e. we observe a u-shaped relation between age and the probability to hire on-farm labor with the lowest probability at the age of 44.4 years. Furthermore, the probability to hire labor decreases with the rural nature of the region.

The effective off-farm wage is significantly influenced by the proportion of supplied labor (X_L^s/T_L), the number of family members of working age (N_w), the age of the head of the household (A_h, A_h^2), and the rural nature of the region (W_r). Larger households and those in more rural areas receive a significantly lower effective off-farm wage. The coefficients of the age and squared age of the household head have the expected signs; i.e. we observe an inverse u-shaped relation between age and the effective off-farm wage with the highest wage at the age of 44.2 years. The estimated parameter of the inverse Mill's ratio is not significantly different from zero, indicating that there is no sample selection bias.

The effective on-farm wage is significantly influenced by the amount of hired labor (X_L^h), the capital intensity on the farm (R_k/R_g), the regional unemployment rate (W_u), the regional density of the road and railroad network (W_i), and the rurality of the region (W_r). As expected, farms with a higher degree of mechanization pay higher wages because better skills are required on these farms. The negative impact of the rural nature and the positive impact of the road and railroad network on the effective on-farm wage might reflect heterogeneity of the average regional wages that is not captured in the regional data published by the statistical office ($\widetilde{P}_L$). The positive effect of the regional unemployment rate is counter-intuitive. However, it might be correlated with some other regional variable not included in the analysis. In contrast to the labor supply side, the estimated parameter of the inverse Mill's ratio is significantly different from zero, indicating that an OLS estimation for labor-hiring households would be biased due to non-random sample selection.

Since the focus of this paper is on market imperfection due to NTC and heterogeneity, the parameters $\beta_1^s = \partial P_L^*/\partial X_L^s$ and $\beta_1^h = \partial P_L^*/\partial X_L^h$ are of particular interest. Recall that these coefficients measure the degree of market imperfection due to NTC and heterogeneity and thus are of particular relevance.

As can be seen from table 5, the effect of labor supply on the off-farm wage rate (β_1^s) is significantly negative. This indicates a concave labor revenue function and, hence, increasing marginal NTC or heterogeneity of off-farm labor skills. If an average household increases off-farm labor supply by 1%, marginal revenue falls by 0.075%. If this household doubles the amount of supplied labor from 446 to 892 hours per year, the marginal revenue decreases from 38498 to 35618 PLZ per hour.

The on-farm wage rate increases significantly with hired labor (table 5), indicating a convex labor cost function and thus the presence of increasing NTC or heterogeneity. Market imperfections appear more pronounced in on-farm labor markets than in off-farm labor markets. If an average household increases the amount of hired labor by 1%, the marginal cost rises by 0.259%. If this household doubles the amount of hired labor from 211 to 422 hours per year, the marginal cost increases from 38498 to 48467 PLZ per hour.

We conclude that our estimated FHM is non-separable because the t-tests reject both null hypotheses.

6.2 Elasticities

Given our estimation results, we calculate the full set of price elasticities according to equations (9) and (10) using sample means. Elasticities for perfect labor markets (separable model) are computed using equation (9), setting the second term on the right (the indirect component) equal to zero. Elasticities for imperfect labor markets (non-separable model) are calculated for all four labor market regimes defined in the theoretical section. A detailed derivation of the FHM elasticities is available in Henning and Henningsen (forthcoming).

To assess whether the degree of market imperfection has an impact on farm price responses, we compare the corresponding price elasticities across labor market regimes. The variance covariance matrices of the estimated price elasticities are calculated from the variance covariance matrices of the estimated coefficients using the approximate formula of Klein (1953, p. 258), also known as the "delta method:"

$$Cov\left[\varepsilon(\beta)\right] \approx \frac{\partial \varepsilon}{\partial \beta'}\, Cov[\beta]\, \frac{\partial \varepsilon'}{\partial \beta}$$

where ε are the price elasticities and β are the estimated coefficients.

The variance covariance matrices of the differences between elasticities derived for different labor market regimes are computed analogously:

$$Cov\left[\varepsilon^1(\beta) - \varepsilon^2(\beta)\right] \approx \left(\frac{\partial \varepsilon^1}{\partial \beta'} - \frac{\partial \varepsilon^2}{\partial \beta'}\right) Cov[\beta] \left(\frac{\partial \varepsilon^{1\prime}}{\partial \beta} - \frac{\partial \varepsilon^{2\prime}}{\partial \beta}\right)$$

where ε^i are the price elasticities for labor market regime i and β are the estimated coefficients.

Table 6 summarizes the main results and shows the elasticities for three labor market regimes: perfect, imperfect, and missing labor markets. All remaining elasticities and their standard errors are available in the appendix.

Overall, we observe mixed results. For all consumer goods, crop products, and farm labor input, the degree of labor market imperfection has a significant influence on price responses. By contrast, price elasticities for animal products and variable inputs do not significantly differ across labor market regimes, indicating that the degree of market imperfection has only a negligible impact on household's price responses.

How can these results be explained? According to equation (9), for any good Q and any exogenous price P_j, $j \in \{c, a, v, m\}$, the difference in price elasticities between perfect and imperfect/missing labor market regimes equals $(\partial Q / \partial P_L^*)\,(P_L^* / Q) \cdot (\mathrm{d}\, P_L^* / \mathrm{d}\, P_j)\,(P_j / P_L^*)$. The first term denotes the cross-price elasticity for good Q with respect to the wage rate and the second term is the shadow price elasticity. The latter measures the impact of an exogenous price change on the shadow price of labor, while the first measures the change of the consumed or produced quantity of good Q induced by a change in the shadow price of labor.

Differences in price elasticities can thus result from either high cross-price elasticities or high shadow price elasticities, or both. Relatively high cross-price elasticities are observed for crop products (-0.36), farm labor input (-0.51) and purchased consumer goods (0.45) (see table 6). For these goods, we also observe the largest and statistically significant differences in price elasticities across market regimes. High shadow price elasticities were obtained for missing markets, while low values were found for imperfect labor markets. This reinforces our finding that the degree of imperfection due to NTC or heterogeneity is moderate. Among all commodity prices, the one for purchased consumer goods (P_m) has the lowest impact on the shadow price for labor, as can be seen from the right-hand column of table 6. This can be explained with reference to

Table 6: Estimated Price Elasticities of Farm Households

	P_c		P_a		P_v		P_m		P_L	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
Perfect labor market (separable model)										
X_c	0.43^a	(1.99)	0.50^a	(2.90)	-0.57^a	(-2.03)	0.00^a		-0.36	(-3.77)
X_a	0.32^a	(2.90)	0.53^a	(2.49)	-0.73^a	(-2.62)	0.00^a		-0.12	(-0.88)
X_v	0.36^a	(2.03)	0.73^a	(2.62)	-1.08^a	(-2.69)	0.00^a		-0.00	(-0.01)
X_L	0.34^a	(3.77)	0.17^a	(0.88)	-0.00^a	(-0.01)	0.00^a		-0.51	(-6.29)
C_m	0.13^a	(6.08)	0.33^a	(3.26)	-0.21^a	(-6.08)	-0.67^a	(-6.80)	0.45	(4.20)
C_a	0.17^a	(7.70)	-0.55^a	(-1.25)	-0.27^a	(-7.70)	0.50^a	(1.20)	0.18	(0.41)
C_L	0.43^a	(42.25)	0.61^a	(39.18)	-0.69^a	(-42.25)	-0.19^a	(-9.46)	-0.07	(-3.22)
X_L^n	-19.15^a	(-13.18)	-22.20^a	(-7.11)	22.00^a	(9.08)	6.16^a	(9.46)	10.30	(7.07)
X_L^f	0.34^a	(3.77)	0.17^a	(0.88)	-0.00^a	(-0.01)	0.00^a		-0.51	(-6.29)
P_L^*	0.00^a		0.00^a		0.00^a		0.00^a		1.00	
Imperfect labor market (non-separable model: supplying and hiring labor)										
X_c	0.28^b	(1.53)	0.33^b	(2.09)	-0.40^b	(-1.55)	0.05^b	(2.56)		
X_a	0.27^a	(2.44)	0.48^a	(2.31)	-0.68^a	(-2.27)	0.02^a	(0.86)		
X_v	0.36^a	(2.10)	0.73^a	(2.57)	-1.08^a	(-2.62)	0.00^a	(0.01)		
X_L	0.14^b	(1.51)	-0.06^b	(-0.41)	0.23^b	(1.84)	0.07^b	(3.11)		
C_m	0.30^b	(5.87)	0.52^b	(4.64)	-0.40^b	(-6.42)	-0.72^b	(-7.28)		
C_a	0.22^b	(7.50)	-0.49^b	(-1.13)	-0.33^b	(-8.20)	0.49^b	(1.17)		
C_L	0.36^b	(15.23)	0.52^b	(17.96)	-0.60^b	(-20.81)	-0.17^b	(-7.99)		
X_L^n	-13.41^a	(-3.12)	-15.55^a	(-3.10)	15.41^a	(3.11)	4.31^a	(3.10)		
X_L^s	-5.47	(-3.46)	-6.34	(-3.28)	6.29	(3.38)	1.76	(3.28)		
X_L^h	1.30	(1.35)	1.51	(1.18)	-1.50	(-1.27)	-0.42	(-1.18)		
X_L^f	0.04^{ab}	(0.14)	-0.19^{ab}	(-0.55)	0.37^{ab}	(1.12)	0.11^{ab}	(1.17)		
P_L^*	0.40^b	(3.60)	0.46^b	(3.39)	-0.46^b	(-3.51)	-0.13^b	(-3.40)		
Missing labor market (non-separable model: autarkic in labor)										
X_c	-0.07^c	(-0.51)	-0.07^c	(-0.49)	0.00^c	(0.01)	0.16^c	(3.40)		
X_a	0.16^a	(0.88)	0.35^a	(1.32)	-0.55^a	(-1.44)	0.05^a	(0.92)		
X_v	0.35^a	(1.84)	0.72^a	(2.24)	-1.08^a	(-2.37)	0.00^a	(0.01)		
X_L	-0.35^c	(-5.77)	-0.63^c	(-9.15)	0.80^c	(11.88)	0.22^c	(6.00)		
C_m	0.69^c	(10.50)	0.97^c	(8.51)	-0.85^c	(-11.88)	-0.85^c	(-8.75)		
C_a	0.35^c	(5.16)	-0.34^c	(-0.82)	-0.48^c	(-6.07)	0.44^c	(1.08)		
C_L	0.17^c	(5.77)	0.31^c	(9.15)	-0.39^c	(-11.88)	-0.11^c	(-6.00)		
X_L^n	0.00^b		0.00^b		0.00^b		0.00^b			
X_L^f	-0.35^b	(-5.77)	-0.63^b	(-9.15)	0.80^b	(11.88)	0.22^b	(6.00)		
P_L^*	1.36^c	(9.17)	1.58^c	(9.44)	-1.56^c	(-9.79)	-0.44^c	(-5.65)		

Note: Variables: $X_{\cdot}$ = netput quantities, $C_{\cdot}$ = consumed quantities, $P_{\cdot}$ = exogenous prices, $P_{\cdot}^*$ = endogenous shadow prices; subscripts: c = crop products, a = animal products, v = variable inputs, L = labor/leisure; superscripts of X_L (labor quantities): f = family labor on the farm, h = hired, s = supplied, n = net supplied. For each specific elasticity the values that have a common alphabetic character do not differ significantly. For instance, the elasticity of X_c with respect to P_c has different letters for all three types of labor market imperfections, which means that these three values significantly differ. On the other hand, the elasticity of X_a with respect to P_a has the same letter for all three types of labor market imperfections, which means that these three values do not differ significantly.

equation (14), where the numerator captures the commodity specific income and substitution effects. The lower these effects, the lower are the shadow price elasticities.

Table 6 also shows that adjustments of net labor supply ($X_L^n = X_L^s - X_L^h$) do not differ significantly between perfect and imperfect labor markets. However, for both regimes, these adjustments differ significantly from zero. Of course, labor adjustment is zero for missing markets.

Finally, in the Polish case, market imperfection reduces household's responses to exogenous price changes on the production side, i.e. most price elasticities decrease in absolute terms with the degree of market imperfection. For example, for perfect labor markets crop output and farm labor input show a clear positive response with respect to increased crop prices. These responses are significantly smaller if labor markets are imperfect, and become negative in missing labor markets, implying even an inverse supply response.

7 Conclusion

This paper analyzes production, consumption and labor market decisions of farm households in the presence of labor market imperfections. Comparative static analysis indicates that price responses deviate from perfect labor markets, even when the household buys or sells labor, if NTC or labor heterogeneity exist. Furthermore, price elasticities in imperfect labor markets generally lie between the corresponding elasticities in absent and perfect labor markets.

We present an econometric estimation strategy that solves several selectivity and endogeneity problem. The model also provides a quantitative measure of the degree of market imperfection due to NTC and heterogeneity, and allows for a test of whether NTC and heterogeneity can be excluded from the estimation without loss of explanatory power.

Applying the model to farm household data from Mid-West Poland shows that NTC and heterogeneity play a significant role in explaining households' behavior. However, in the Polish case, market imperfection due to NTC or heterogeneity is rather moderate, with the effect of NTC and heterogeneity more pronounced when hiring on-farm labor than supplying off-farm labor. Econometric estimation of our generalized FHM approach is rather cumbersome, because we have to control simultaneously for various possible endogeneity and selectivity biases. Therefore, the question arises if this more complex model is worth the effort. From the perspective of policy makers, we must ask whether incorporating NTC and heterogeneity provides estimates of elasticities that are quite different from what could have been obtained otherwise. Here our analysis delivers mixed results. While differences are statistically significant and are considerable for all consumer and most producer goods, they are not for animal products and variable inputs.

Appendix

A1 Exclusion Variables

In a two-step Heckman estimation, the variables that are regressors in the first-step selection equation (say, x_1) but are not regressors in the second-step regression equation (say, x_2) are called "exclusion variables." If there are no exclusion variables ($x_1 \subseteq x_2$), the sample correction term in the second step (say, λ) is likely to be highly correlated with the other regressors in x_2 because λ is a (non-linear) function of a linear combination of the variables in x_1 ($\lambda = \phi(x_1{}'\gamma)/\Phi(x_1{}'\gamma)$, where γ are the coefficients of the selection equation and ϕ and Φ are probability density function (pdf) and the cumulative distribution function (cdf) of the standard normal distribution, respectively). Hence, the purpose of exclusion variables is to reduce the correlation among the regressors (multicollinearity) in the second-step estimation. Although high multicollinearity does not result in biased estimates, it leads to large standard errors, which means that the estimates are rather imprecise.

The exclusion variables for the equations explaining the shadow price of labor can be identified from table 5. The exclusion variables for the marginal revenue of labor supply (23) are the number of kids (N_k), land and capital endowment of the farm (R_g, R_k); the capital intensity on the farm (R_k/R_g); and the prices of farm netputs (P_c, P_a, P_v). The exclusion variables for the marginal cost of labor demand (24) are the age pattern of the household (N_k, N_w, N_o); sex, age, and age squared of the head of the household (D_f, A_h, A_h^2); land and capital endowment of the farm (R_g, R_k); and the prices of farm netputs (P_c, P_a, P_v).

The exclusion variables for the equations explaining the quantity of supplied labor (25) and (26) are variables that are in z but not in z_x^b and z_x^s, respectively. The exclusion variables for the equations explaining the quantity of hired labor (27) and (28) are variables that are in z but not in z_x^b and z_x^h, respectively. Theoretically, the exclusion variables in (25) and (27) are the variables that are in z_f^s or z_f^h but not in z^π, z^u, z^s, or z^h, the exclusion variables in (26) are the variables that are in z_f^s, z_f^h or z^h but not in z^π, z^u or z^s, and the exclusion variables in (28) are the variables that are in z_f^s, z_f^h or z^s but not in z^π, z^u or z^h. However, in practice, our data set does not include any variables that influence fixed transaction costs (z_f^s, z_f^h) but do not influence variable transaction costs or the average skill level (z^s, z^h). Thus, given the specification of the z variables in section "Data and Empirical Results", we have an exclusion variable only in (26) (R_K/R_g) but not in the other three X equations. Although this leads to multicollinearity, it does not matter in our special case because we are interested in the fitted values but not the estimated coefficients. As long as multicollinearity is not so high that it rules out estimation, we can calculate fitted values that are orthogonal to the error terms of the estimations of the shadow price of labor (given that the regressors are not correlated with these error terms, too).

A2 Estimation Results

A2.1 First-Stage Profit Function

Table A1: Estimation Results of the Unrestricted 1st-Stage Profit Function

Parameter	$i = c$		$i = a$		$i = v$	
	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)
α_i	-1.72	(-0.73)	20.1	(4.31)	-17.4	(-5.14)
β_{ic}	-14.8	(-1.12)	19.8	(2.68)	-4.92	(-0.37)
β_{ia}	19.8	(2.68)	61.6	(5.76)	-81.4	(-8.04)
β_{iv}	-4.92	(-0.37)	-81.4	(-8.04)	86.3	(5.08)
δ_{ig}	6258	(11.37)	1002	(0.93)	-4306	(-5.37)
δ_{ik}	0.0829	(5.77)	0.209	(7.47)	-0.111	(-5.36)
γ_{gg}	-1157392	(-6.45)				
γ_{gk}	36.7	(7.59)				
γ_{kk}	$-1.26{\cdot}10^{-3}$	(-9.79)				
R^2	0.709		0.286		0.685	

Note: For definitions of the estimated coefficients see equation (19). The standard errors of the coefficients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258). Monotonicity is fulfilled at 100% of the observations. The estimation results with convexity imposed are presented in table 2.

Shadow Prices of Labor

One estimated shadow price is negative. The other shadow prices have a mean of 38498 PLZ/h and a median of 30236 PLZ/h. In 1994 the average gross wage in Poland was 32820 PLZ/h. 68% of the estimated shadow prices deviate less than 50% from this value.

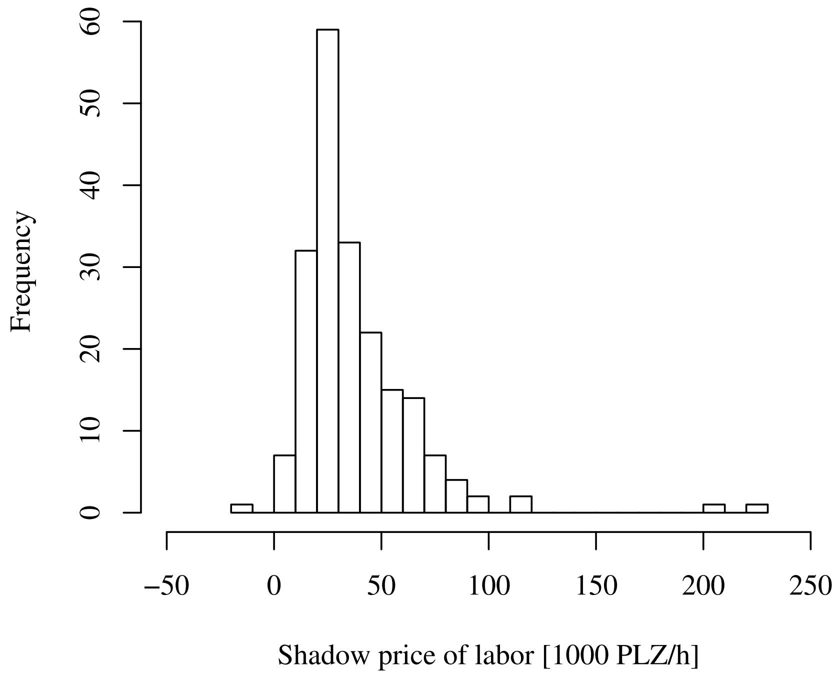

Figure A1: Distribution of the estimated shadow prices of labor

A2.2 Second-Stage Profit Function

Table A2: Estimation Results of the Unrestricted 2nd-Stage Profit Function

Parameter	$i = c$		$i = a$		$i = v$		$i = L$	
	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)	Coef.	(t-val)
α_i	-28774	(-3.22)	32491	(2.05)	-6714	(-0.57)	-62854	(-12.61)
β_{ic}	879	(0.02)	95377	(2.76)	-61671	(-1.14)	-34585	(-4.22)
β_{ia}	95377	(2.76)	76676	(1.19)	-162987	(-2.97)	-9066	(-0.63)
β_{iv}	-61671	(-1.14)	-162987	(-2.97)	221688	(2.95)	2970	(0.24)
β_{iL}	-34585	(-4.22)	-9066	(-0.63)	2970	(0.24)	40681	(7.48)
δ_{ig}	6896	(11.68)	131	(0.12)	-6000	(-7.02)	-3158	(-8.95)
δ_{ik}	0.121	(9.02)	0.292	(12.21)	-0.166	(-9.31)	$7.41 \cdot 10^{-3}$	(0.93)
γ_{gg}	-173	(-3.55)						
γ_{gk}	$9.88 \cdot 10^{-3}$	(9.24)						
γ_{kk}	$-3.55 \cdot 10^{-7}$	(-24.28)						
R^2	0.746		0.494		0.821		0.283	

Note: For definitions of the estimated coefficients see equation (12). The standard errors of the coefficients that have not been directly estimated are calculated with the formula of Klein (1953, p. 258). Monotonicity is fulfilled at 98.0% of the observations. The estimation results with convexity imposed are presented in table 3.

Table A3: Price Elasticities of the Restricted 2nd-Stage Profit Function

	P_c		P_a		P_v		P_L	
	Coef.	(t-val.)	Coef.	(t-val.)	Coef.	(t-val.)	Coef.	(t-val.)
X_c	0.429	(1.99)	0.503	(2.90)	-0.567	(-2.03)	-0.364	(-3.77)
X_a	0.320	(2.90)	0.533	(2.49)	-0.735	(-2.62)	-0.117	(-0.88)
X_v	0.356	(2.03)	0.726	(2.62)	-1.081	(-2.69)	-0.001	(-0.01)
X_L	0.340	(3.77)	0.172	(0.88)	-0.002	(-0.01)	-0.511	(-6.29)

A2.3 AIDS Model

Table A4: Price and Income Elasticities of the AIDS Model

	P_m		P_a		P_L	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
Hicksian Price Elasticities						
C_m	-0.554	(-5.67)	0.144	(1.53)	0.409	(8.59)
C_a	0.648	(1.55)	-0.782	(-1.80)	0.134	(2.55)
C_L	0.176	(8.58)	0.014	(2.77)	-0.190	(-8.53)
Marshallian Price Elasticities						
C_m	-0.667	(-6.80)	0.119	(1.26)	0.149	(2.09)
C_a	0.503	(1.20)	-0.814	(-1.88)	-0.200	(-2.62)
C_L	-0.194	(-9.46)	-0.070	(-13.34)	-1.045	(-31.28)
Income Elasticities						
Y	0.399	(6.08)	0.511	(7.70)	1.308	(42.25)

A3 Estimated Farm-Household Elasticities

A3.1 Elasticities for Different Labor Regimes

Table A5: Price Elasticities of the Separable FHM (Calculated at Average Values of All Households)

	P_c		P_a		P_v		P_L		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	0.43	(1.99)	0.50	(2.90)	-0.57	(-2.03)	-0.36	(-3.77)	0.00	
X_a	0.32	(2.90)	0.53	(2.49)	-0.73	(-2.62)	-0.12	(-0.88)	0.00	
X_v	0.36	(2.03)	0.73	(2.62)	-1.08	(-2.69)	-0.00	(-0.01)	0.00	
X_L	0.34	(3.77)	0.17	(0.88)	-0.00	(-0.01)	-0.51	(-6.29)	0.00	
C_m	0.13	(6.08)	0.33	(3.26)	-0.21	(-6.08)	0.45	(4.20)	-0.67	(-6.80)
C_a	0.17	(7.70)	-0.55	(-1.25)	-0.27	(-7.70)	0.18	(0.41)	0.50	(1.20)
C_L	0.43	(42.25)	0.61	(39.18)	-0.69	(-42.25)	-0.07	(-3.22)	-0.19	(-9.46)
X_L^n	-19.15	(-13.18)	-22.20	(-7.11)	22.00	(9.08)	10.30	(7.07)	6.16	(9.46)
X_L^f	0.34	(3.77)	0.17	(0.88)	-0.00	(-0.01)	-0.51	(-6.29)	0.00	
P_L^*	0.00		0.00		0.00		1.00		0.00	

Table A6: Price Elasticities of the Non-separable FHM for Households that Both Supply and Hire Labor (Calculated at Average Values of All Households)

	P_c		P_a		P_v		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	0.28	(1.51)	0.33	(2.06)	-0.39	(-1.53)	0.05	(2.67)
X_a	0.27	(2.40)	0.48	(2.30)	-0.68	(-2.26)	0.02	(0.87)
X_v	0.36	(2.10)	0.73	(2.57)	-1.08	(-2.61)	0.00	(0.01)
X_L	0.13	(1.43)	-0.08	(-0.50)	0.24	(1.98)	0.07	(3.32)
C_m	0.30	(6.21)	0.53	(4.76)	-0.41	(-6.74)	-0.72	(-7.32)
C_a	0.23	(7.53)	-0.48	(-1.13)	-0.33	(-8.25)	0.48	(1.16)
C_L	0.35	(15.54)	0.52	(18.27)	-0.60	(-21.22)	-0.17	(-7.98)
X_L^h	1.52	(1.46)	1.76	(1.26)	-1.75	(-1.37)	-0.49	(-1.26)
X_L^s	-6.26	(-3.79)	-7.25	(-3.56)	7.19	(3.69)	2.01	(3.55)
X_L^n	-13.25	(-3.46)	-15.37	(-3.42)	15.23	(3.45)	4.26	(3.42)
X_L^f	0.04	(0.16)	-0.19	(-0.60)	0.37	(1.22)	0.10	(1.28)
P_L^*	0.42	(3.94)	0.49	(3.68)	-0.48	(-3.82)	-0.13	(-3.67)

Table A7: Price Elasticities of the Non-separable FHM for Households that Both Supply and Hire Labor (Calculated at Average Values of Households in this Labor Regime)

	P_c		P_a		P_v		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	0.28	(1.53)	0.33	(2.09)	-0.40	(-1.55)	0.05	(2.56)
X_a	0.27	(2.44)	0.48	(2.31)	-0.68	(-2.27)	0.02	(0.86)
X_v	0.36	(2.10)	0.73	(2.57)	-1.08	(-2.62)	0.00	(0.01)
X_L	0.14	(1.51)	-0.06	(-0.41)	0.23	(1.84)	0.07	(3.11)
C_m	0.30	(5.87)	0.52	(4.64)	-0.40	(-6.42)	-0.72	(-7.28)
C_a	0.22	(7.50)	-0.49	(-1.13)	-0.33	(-8.20)	0.49	(1.17)
C_L	0.36	(15.23)	0.52	(17.96)	-0.60	(-20.81)	-0.17	(-7.99)
X_L^h	1.30	(1.35)	1.51	(1.18)	-1.50	(-1.27)	-0.42	(-1.18)
X_L^s	-5.47	(-3.46)	-6.34	(-3.28)	6.29	(3.38)	1.76	(3.28)
X_L^n	-13.41	(-3.12)	-15.55	(-3.10)	15.41	(3.11)	4.31	(3.10)
X_L^f	0.04	(0.14)	-0.19	(-0.55)	0.37	(1.12)	0.11	(1.17)
P_L^*	0.40	(3.60)	0.46	(3.39)	-0.46	(-3.51)	-0.13	(-3.40)

Note: To focus on the effect of the labor market regime, only X_L^s, X_L^h, z^s and z^h are the average values of households in this labor regime, while X_c, X_a, X_v, X_L, C_m, X_a and C_L are taken from the whole sample. $X_L^F = X_L - X_L^H$ and $T_L = X_L^S + X_L^F + C_L$ are calculated residually.

Table A8: Price Elasticities of the Non-separable FHM for Households that only Supply Labor (Calculated at Average Values of Households in this Labor Regime)

	P_c		P_a		P_v		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	0.24	(1.05)	0.29	(1.23)	-0.35	(-1.16)	0.06	(1.13)
X_a	0.26	(2.06)	0.46	(2.14)	-0.67	(-2.14)	0.02	(0.71)
X_v	0.36	(2.10)	0.73	(2.55)	-1.08	(-2.60)	0.00	(0.01)
X_L	0.08	(0.35)	-0.13	(-0.46)	0.30	(1.10)	0.08	(1.17)
C_m	0.34	(1.93)	0.57	(2.52)	-0.45	(-2.20)	-0.73	(-6.51)
C_a	0.24	(3.69)	-0.47	(-1.09)	-0.35	(-4.52)	0.48	(1.16)
C_L	0.34	(4.09)	0.50	(5.20)	-0.58	(-6.08)	-0.16	(-4.94)
X_L^s	-2.22	(-1.16)	-2.58	(-1.15)	2.55	(1.16)	0.72	(1.15)
X_L^f	0.08	(0.10)	-0.13	(-0.14)	0.30	(0.32)	0.08	(0.32)
P_L^*	0.51	(1.19)	0.59	(1.18)	-0.59	(-1.19)	-0.16	(-1.18)

Note: see note below table A7.

Table A9: Price Elasticities of the Non-separable FHM for Households that only Hire Labor (Calculated at Average Values of Households in this Labor Regime)

	P_c		P_a		P_v		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	0.05	(0.33)	0.06	(0.41)	-0.13	(-0.56)	0.12	(3.32)
X_a	0.20	(1.28)	0.39	(1.65)	-0.59	(-1.69)	0.04	(0.91)
X_v	0.36	(1.97)	0.72	(2.37)	-1.08	(-2.46)	0.00	(0.01)
X_L	-0.19	(-2.56)	-0.45	(-4.59)	0.61	(6.94)	0.17	(5.35)
C_m	0.56	(9.20)	0.82	(7.10)	-0.70	(-9.84)	-0.80	(-8.25)
C_a	0.31	(5.71)	-0.38	(-0.92)	-0.43	(-6.70)	0.46	(1.11)
C_L	0.23	(8.30)	0.38	(10.99)	-0.46	(-13.92)	-0.13	(-6.62)
X_L^h	2.42	(0.40)	2.80	(0.40)	-2.78	(-0.40)	-0.78	(-0.40)
X_L^f	-0.54	(-8.30)	-0.88	(-10.99)	1.06	(13.92)	0.30	(6.62)
P_L^*	1.05	(8.01)	1.21	(7.39)	-1.20	(-7.92)	-0.34	(-5.61)

Note: see note below table A7.

Table A10: Price Elasticities of the Non-separable FHM for Autarkic Households (Calculated at Average Values of Households in this Labor Regime)

	P_c		P_a		P_v		P_m	
	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)	Elast.	(t-val.)
X_c	-0.07	(-0.51)	-0.07	(-0.49)	0.00	(0.01)	0.16	(3.40)
X_a	0.16	(0.88)	0.35	(1.32)	-0.55	(-1.44)	0.05	(0.92)
X_v	0.35	(1.84)	0.72	(2.24)	-1.08	(-2.37)	0.00	(0.01)
X_L	-0.35	(-5.77)	-0.63	(-9.15)	0.80	(11.88)	0.22	(6.00)
C_m	0.69	(10.50)	0.97	(8.51)	-0.85	(-11.88)	-0.85	(-8.75)
C_a	0.35	(5.16)	-0.34	(-0.82)	-0.48	(-6.07)	0.44	(1.08)
C_L	0.17	(5.77)	0.31	(9.15)	-0.39	(-11.88)	-0.11	(-6.00)
X_L^f	-0.35	(-5.77)	-0.63	(-9.15)	0.80	(11.88)	0.22	(6.00)
P_L^*	1.36	(9.17)	1.58	(9.44)	-1.56	(-9.79)	-0.44	(-5.65)

Note: see note below table A7.

A3.2 Differences between Labor Regimes

Table A11: Differences between Price Elasticities of the Separable FHM and the Non-separable FHM for Households that Supply as well as Demand Labor (Calculated at Average Values of All Households)

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.15	(2.43)	0.18	(2.73)	-0.18	(-2.55)	-0.05	(-2.67)
X_a	0.05	(0.87)	0.06	(0.78)	-0.06	(-0.81)	-0.02	(-0.87)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.21	(3.37)	0.25	(2.85)	-0.25	(-3.08)	-0.07	(-3.32)
C_m	-0.17	(-3.64)	-0.20	(-3.42)	0.20	(3.54)	0.06	(4.02)
C_a	-0.06	(-2.16)	-0.07	(-2.09)	0.06	(2.14)	0.02	(2.19)
C_L	0.08	(3.64)	0.09	(3.41)	-0.09	(-3.54)	-0.03	(-4.00)
X_L^n	-5.90	(-1.50)	-6.84	(-1.38)	6.77	(1.44)	1.90	(1.47)
X_L^f	0.30	(1.21)	0.36	(1.24)	-0.37	(-1.28)	-0.10	(-1.28)
P_L^*	-0.42	(-3.94)	-0.49	(-3.68)	0.48	(3.82)	0.13	(3.67)

Table A12: Differences between Price Elasticities of the Separable FHM and the Non-separable FHM for Households that Supply as well as Demand Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.15	(2.34)	0.17	(2.60)	-0.17	(-2.45)	-0.05	(-2.56)
X_a	0.05	(0.87)	0.05	(0.78)	-0.05	(-0.80)	-0.02	(-0.86)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.20	(3.14)	0.24	(2.71)	-0.23	(-2.90)	-0.07	(-3.11)
C_m	-0.16	(-3.37)	-0.19	(-3.19)	0.19	(3.29)	0.05	(3.66)
C_a	-0.05	(-2.10)	-0.06	(-2.03)	0.06	(2.08)	0.02	(2.13)
C_L	0.08	(3.37)	0.09	(3.18)	-0.09	(-3.29)	-0.02	(-3.65)
X_L^n	-5.74	(-1.30)	-6.66	(-1.21)	6.60	(1.26)	1.85	(1.28)
X_L^f	0.30	(1.08)	0.37	(1.13)	-0.38	(-1.17)	-0.11	(-1.17)
P_L^*	-0.40	(-3.60)	-0.46	(-3.39)	0.46	(3.51)	0.13	(3.40)

Table A13: Differences between Price Elasticities of the Separable FHM and the Non-separable FHM for Households that only Supply Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.19	(1.11)	0.22	(1.14)	-0.21	(-1.12)	-0.06	(-1.13)
X_a	0.06	(0.72)	0.07	(0.66)	-0.07	(-0.68)	-0.02	(-0.71)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.26	(1.17)	0.30	(1.15)	-0.30	(-1.16)	-0.08	(-1.17)
C_m	-0.21	(-1.18)	-0.24	(-1.17)	0.24	(1.18)	0.07	(1.19)
C_a	-0.07	(-1.08)	-0.08	(-1.07)	0.08	(1.08)	0.02	(1.08)
C_L	0.10	(1.18)	0.11	(1.17)	-0.11	(-1.18)	-0.03	(-1.19)
X_L^n	-16.93	(-7.30)	-19.62	(-5.46)	19.45	(6.26)	5.45	(6.53)
X_L^f	0.26	(0.32)	0.30	(0.32)	-0.30	(-0.32)	-0.08	(-0.32)
P_L^*	-0.51	(-1.19)	-0.59	(-1.18)	0.59	(1.19)	0.16	(1.18)

Table A14: Differences between Price Elasticities of the Separable FHM and the Non-separable FHM for Households that only Demand Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.38	(2.97)	0.44	(3.73)	-0.44	(-3.26)	-0.12	(-3.32)
X_a	0.12	(0.92)	0.14	(0.81)	-0.14	(-0.84)	-0.04	(-0.91)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.53	(6.19)	0.62	(4.30)	-0.61	(-5.01)	-0.17	(-5.35)
C_m	-0.43	(-6.86)	-0.50	(-6.38)	0.49	(6.75)	0.14	(8.39)
C_a	-0.14	(-2.52)	-0.16	(-2.45)	0.16	(2.51)	0.05	(2.52)
C_L	0.20	(6.88)	0.23	(6.35)	-0.23	(-6.76)	-0.06	(-8.27)
X_L^n	-21.57	(-3.43)	-25.00	(-3.23)	24.78	(3.34)	6.94	(3.35)
X_L^f	0.88	(9.79)	1.05	(6.42)	-1.06	(-7.87)	-0.30	(-6.62)
P_L^*	-1.05	(-8.01)	-1.21	(-7.39)	1.20	(7.92)	0.34	(5.61)

Table A15: Differences between Price Elasticities of the Separable FHM and the Non-separable FHM for Autarkic Households

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.50	(3.06)	0.57	(4.04)	-0.57	(-3.43)	-0.16	(-3.40)
X_a	0.16	(0.93)	0.19	(0.82)	-0.18	(-0.85)	-0.05	(-0.92)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.69	(7.97)	0.81	(4.99)	-0.80	(-6.00)	-0.22	(-6.00)
C_m	-0.56	(-8.19)	-0.65	(-8.22)	0.64	(8.52)	0.18	(9.49)
C_a	-0.18	(-2.58)	-0.21	(-2.54)	0.21	(2.59)	0.06	(2.55)
C_L	0.26	(8.24)	0.30	(8.17)	-0.30	(-8.57)	-0.08	(-9.36)
X_L^n	-19.15	(-13.18)	-22.20	(-7.11)	22.00	(9.08)	6.16	(9.46)
X_L^f	0.69	(7.97)	0.81	(4.99)	-0.80	(-6.00)	-0.22	(-6.00)
P_L^*	-1.36	(-9.17)	-1.58	(-9.44)	1.56	(9.79)	0.44	(5.65)

Table A16: Differences between Price Elasticities of the Households that Supply as well as Demand Labor and the Households that only Supply Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.04	(0.34)	0.05	(0.34)	-0.05	(-0.34)	-0.01	(-0.34)
X_a	0.01	(0.32)	0.01	(0.32)	-0.01	(-0.32)	-0.00	(-0.32)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.06	(0.34)	0.07	(0.34)	-0.06	(-0.34)	-0.02	(-0.34)
C_m	-0.05	(-0.34)	-0.05	(-0.34)	0.05	(0.34)	0.01	(0.34)
C_a	-0.01	(-0.34)	-0.02	(-0.34)	0.02	(0.34)	0.00	(0.34)
C_L	0.02	(0.34)	0.02	(0.34)	-0.02	(-0.34)	-0.01	(-0.34)
X_L^h	1.30	(0.47)	1.51	(0.47)	-1.50	(-0.47)	-0.42	(-0.47)
X_L^s	-3.25	(-6.98)	-3.77	(-5.67)	3.73	(6.32)	1.05	(5.84)
X_L^n	-11.19	(-4.70)	-12.97	(-4.65)	12.85	(4.68)	3.60	(4.66)
X_L^f	-0.04	(-0.07)	-0.06	(-0.10)	0.08	(0.12)	0.02	(0.12)
P_L^*	-0.11	(-0.34)	-0.13	(-0.34)	0.13	(0.34)	0.04	(0.34)

Table A17: Differences between Price Elasticities of the Households that Supply as well as Demand Labor and the Households that only Demand Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.24	(2.59)	0.27	(3.12)	-0.27	(-2.81)	-0.08	(-2.77)
X_a	0.08	(0.92)	0.09	(0.81)	-0.09	(-0.84)	-0.02	(-0.91)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.33	(4.17)	0.38	(3.52)	-0.38	(-3.81)	-0.11	(-3.77)
C_m	-0.26	(-4.17)	-0.31	(-4.20)	0.30	(4.23)	0.09	(4.28)
C_a	-0.09	(-2.28)	-0.10	(-2.25)	0.10	(2.29)	0.03	(2.25)
C_L	0.12	(4.17)	0.14	(4.20)	-0.14	(-4.23)	-0.04	(-4.27)
X_L^h	-1.11	(-0.21)	-1.29	(-0.21)	1.28	(0.21)	0.36	(0.21)
X_L^s	-5.47	(-3.46)	-6.34	(-3.28)	6.29	(3.38)	1.76	(3.28)
X_L^n	-15.83	(-1.53)	-18.35	(-1.53)	18.18	(1.53)	5.09	(1.53)
X_L^f	0.58	(2.13)	0.68	(2.11)	-0.69	(-2.17)	-0.19	(-2.11)
P_L^*	-0.65	(-4.25)	-0.75	(-4.31)	0.74	(4.33)	0.21	(3.64)

Table A18: Differences between Price Elasticities of the Households that Supply as well as Demand Labor and the Autarkic Households

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.35	(2.88)	0.41	(3.76)	-0.40	(-3.22)	-0.11	(-3.09)
X_a	0.11	(0.94)	0.13	(0.83)	-0.13	(-0.86)	-0.04	(-0.93)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.49	(6.25)	0.57	(4.68)	-0.56	(-5.32)	-0.16	(-4.89)
C_m	-0.39	(-5.79)	-0.46	(-6.27)	0.45	(6.15)	0.13	(5.76)
C_a	-0.13	(-2.47)	-0.15	(-2.47)	0.15	(2.50)	0.04	(2.42)
C_L	0.18	(5.82)	0.21	(6.26)	-0.21	(-6.19)	-0.06	(-5.74)
X_L^h	1.30	(1.35)	1.51	(1.18)	-1.50	(-1.27)	-0.42	(-1.18)
X_L^s	-5.47	(-3.46)	-6.34	(-3.28)	6.29	(3.38)	1.76	(3.28)
X_L^n	-13.41	(-3.12)	-15.55	(-3.10)	15.41	(3.11)	4.31	(3.10)
X_L^f	0.40	(1.41)	0.44	(1.32)	-0.42	(-1.30)	-0.12	(-1.30)
P_L^*	-0.96	(-5.76)	-1.11	(-6.30)	1.10	(6.15)	0.31	(4.32)

Table A19: Differences between Price Elasticities of the Households that only Supply Labor and the Households that only Demand Labor

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.20	(1.14)	0.23	(1.18)	-0.22	(-1.16)	-0.06	(-1.16)
X_a	0.06	(0.75)	0.07	(0.69)	-0.07	(-0.71)	-0.02	(-0.74)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.27	(1.22)	0.32	(1.20)	-0.31	(-1.21)	-0.09	(-1.21)
C_m	-0.22	(-1.22)	-0.25	(-1.22)	0.25	(1.22)	0.07	(1.22)
C_a	-0.07	(-1.11)	-0.08	(-1.11)	0.08	(1.11)	0.02	(1.11)
C_L	0.10	(1.22)	0.12	(1.22)	-0.12	(-1.22)	-0.03	(-1.22)
X_L^h	-2.42	(-0.30)	-2.80	(-0.30)	2.78	(0.30)	0.78	(0.30)
X_L^s	-2.22	(-1.16)	-2.58	(-1.15)	2.55	(1.16)	0.72	(1.15)
X_L^n	-4.64	(-0.58)	-5.38	(-0.58)	5.33	(0.58)	1.49	(0.58)
X_L^f	0.62	(0.76)	0.75	(0.79)	-0.76	(-0.82)	-0.21	(-0.81)
P_L^*	-0.54	(-1.22)	-0.62	(-1.22)	0.62	(1.22)	0.17	(1.20)

Table A20: Differences between Price Elasticities of the Households that only Supply Labor and the Autarkic Households

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.31	(1.67)	0.36	(1.80)	-0.36	(-1.73)	-0.10	(-1.70)
X_a	0.10	(0.86)	0.12	(0.77)	-0.11	(-0.80)	-0.03	(-0.85)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.43	(1.94)	0.50	(1.88)	-0.50	(-1.91)	-0.14	(-1.88)
C_m	-0.35	(-1.92)	-0.40	(-1.94)	0.40	(1.94)	0.11	(1.92)
C_a	-0.11	(-1.57)	-0.13	(-1.58)	0.13	(1.58)	0.04	(1.56)
C_L	0.16	(1.93)	0.19	(1.94)	-0.19	(-1.94)	-0.05	(-1.92)
X_L^s	-2.22	(-1.16)	-2.58	(-1.15)	2.55	(1.16)	0.72	(1.15)
X_L^n	-2.22	(-1.16)	-2.58	(-1.15)	2.55	(1.16)	0.72	(1.15)
X_L^f	0.43	(0.53)	0.50	(0.53)	-0.50	(-0.53)	-0.14	(-0.53)
P_L^*	-0.85	(-1.92)	-0.99	(-1.94)	0.98	(1.94)	0.27	(1.84)

Table A21: Differences between Price Elasticities of the Households that only Demand Labor and the Autarkic Households

	P_c		P_a		P_v		P_m	
	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)	Diff.	(t-val.)
X_c	0.11	(2.28)	0.13	(2.72)	-0.13	(-2.47)	-0.04	(-2.34)
X_a	0.04	(0.94)	0.04	(0.83)	-0.04	(-0.86)	-0.01	(-0.92)
X_v	0.00	(0.01)	0.00	(0.01)	-0.00	(-0.01)	-0.00	(-0.01)
X_L	0.16	(3.32)	0.19	(3.10)	-0.18	(-3.22)	-0.05	(-2.97)
C_m	-0.13	(-3.11)	-0.15	(-3.30)	0.15	(3.23)	0.04	(3.01)
C_a	-0.04	(-2.07)	-0.05	(-2.09)	0.05	(2.10)	0.01	(2.01)
C_L	0.06	(3.12)	0.07	(3.30)	-0.07	(-3.23)	-0.02	(-3.01)
X_L^h	2.42	(0.40)	2.80	(0.40)	-2.78	(-0.40)	-0.78	(-0.40)
X_L^n	2.42	(0.40)	2.80	(0.40)	-2.78	(-0.40)	-0.78	(-0.40)
X_L^f	-0.18	(-4.46)	-0.24	(-5.22)	0.26	(5.63)	0.07	(4.74)
P_L^*	-0.31	(-3.03)	-0.36	(-3.21)	0.36	(3.14)	0.10	(2.68)

References

Abdulai, Awudu and Christopher Linn Delgado, "Determinants of Nonfarm Earnings of Farm-Based Husbands and Wives in Northern Ghana," *American Journal of Agricultural Economics*, 1999, *81* (1), 117–130.

Benjamin, D., "Household Composition, Labor Market, and Labor Demand: Testing for Separation in Agricultural Household Models," *Econometrica*, 1992, *60*, 287–322.

Blundell, Richard W. and Jean Marc Robin, "Estimation in Large and Disaggregated Demand Systems: An Estimator for Conditionally Linear Systems," *Journal of Applied Econometrics*, 1999, *14*, 209–232.

de Janvry, Alain, Elisabeth Sadoulet, Marcel Fafchamps, and Mohammed Raki, "Structural Adjustment and the Peasantry in Morocco: A Computable Household Model," *European Review of Agricultural Economics*, 1992, *19* (4), 427–453.

_ , Marcel Fafchamps, and Elisabeth Sadoulet, "Peasant Household Behaviour with Missing Markets: Some Paradoxes Explained," *The Economic Journal*, 1991, *101* (409), 1400–1417.

Deaton, Angus and John Muellbauer, "An Almost Ideal Demand System," *The American Economic Review*, 1980, *70*, 312–326.

Diewert, Walter E. and Terence J. Wales, "Flexible Functional Forms and Global Curvature Conditions," *Econometrica*, 1987, *55* (1), 43–68.

_ and _ , "Quadratic Spline Models for Producer's Supply and Demand Functions," *International Economic Review*, 1992, *33*, 705–722.

Efron, Bradley, "Bootstrap Methods: Another Look at the Jackknife," *The Annals of Statistics*, 1979, *7* (1), 1–26.

_ and Robert J. Tibshirani, *An Introduction to the Bootstrap*, Vol. 57 of *Monographs on Statistics and Applied Probability*, New York, London: Chapman & Hall, 1993.

Genz, Alan, Frank Bretz, and Torsten Hothorn, *mvtnorm: Multivariate Normal and t Distribution* 2005. R package version 0.7-2, http://cran.r-project.org.

_ , Mike Meyer, Thomas Lumley, and Martin Maechler, *adapt: Multidimensional Numerical Integration* 2005. R package version 1.0-3, http://cran.r-project.org.

Glowny Urzad Statystyczny, "Informacja o Sytuacji Spoleczno - Gospodarczej Wojewodztw," Kwartalnik Nr 1-2 Warsaw 1996.

Goetz, Stephan J., "A Selectivity Model of Household Food Marketing Behavior in Sub-Sahara Africa," *American Journal of Agricultural Economics*, 1992, *74* (2), 444–452.

Gourieroux, C., A. Monfort, and A. Trognon, "Moindres Carres Asymptotiques," *Annales de l'INSEE*, 1985, *58*, 91–122.

Hamann, Jeff D. and Arne Henningsen, *systemfit: Simultaneous Equation Estimation* 2006. R package version 0.8-0, http://cran.r-project.org.

Heckman, J., "The Common Structure of Statistical Models of Truncation, Sample Selection, and Limited Dependent Variables and a Simple Estimator for Such Models," *Annals of Economic and Social Measurement*, 1976, *5*, 475–492.

Henning, Christian H. C. A. and Arne Henningsen, "Modeling Farm Households' Price Responses in the Presence of Transaction Costs and Heterogeneity in Labor Markets," *American Journal of Agricultural Economics*, 2007, *in press.* An electronic preprint is available on http://www.uni-kiel.de/agrarpol/ahenningsen/publications.html.

_ **and** _ , "AJAE Appendix: Modeling Farm Households' Price Responses in the Presence of Transaction Costs and Heterogeneity in Labor Markets," Unpublished manuscript. Available at: http://agecon.lib.umn.edu/ forthcoming.

Henningsen, A. and Ott Toomet, *micEcon: Tools for Microeconomic Analysis and Microeconomic Modeling* 2005. R package version 0.2-2, http://cran.r-project.org.

Henningsen, Arne, "How to estimate the "Almost Ideal Demand System"," Poster presented at the 25th International Conference of the IAAE, Durban, South Africa 2003.

_ , "Estimating Elasticities in the AIDS and LA-AIDS: Problems and Possible Solutions," 2007. Unpublished manuscript, Department of Agricultural Economics, University of Kiel.

IERiGZ, "Indywiualne wyniki rachunkowosci rolnej gospodarstw chlopskich - Rok 1991-1994 - Makroregion VIII - Srodkowo Zachodni," Unpublished data, personally requested from IERiGZ, Warsaw, Poland 1995.

Jacoby, H., "Shadow Wages and Peasant Family Labour Supply: An Econometric Application to the Peruvian Sierra," *Review of Economic Studies*, 1993, *60*, 903–921.

Key, N., Elisabeth Sadoulet, and Alain de Janvry, "Transaction Costs and Agricultural Household Supply Response," *American Journal of Agricultural Economics*, 2000, *82* (2), 245–259.

Klein, Lawrence R., *A Textbook of Econometrics*, New York: Row, Peterson and Co, 1953.

Kodde, D. A., F. C. Palm, and G. A. Pfann, "Asymptotic Least-Squares Estimation Efficiency Considerations and Applications," *Journal of Applied Econometrics*, 1990, *5*, 229–243.

Koebel, Bertrand, "Tests of Representative Firm Models: Results for German Manufacturing Industries," *Journal of Productivity Analysis*, 1998, *10*, 251–270.

_ **, Martin Falk, and Francois Laisney**, "Imposing and Testing Curvature Conditions on a Box-Cox Cost Function," *Journal of Business and Economic Statistics*, 2003, *21* (2), 319–335.

Kohli, Ulrich R., "A Symmetric Normalized Quadratic GNP Function and the US Demand for Imports and Supply of Exports," *International Economic Review*, 1993, *34* (1), 243–255.

Larson, Donald and Yair Mundlak, "On the Intersectoral Migration of Agricultural Labor," *Economic Development and Cultural Change*, 1997, *45* (2), 295–319.

Lau, Lawrence J., "Applications of Profit Functions," in Melvin Fuss and Daniel McFadden, eds., *Production Economics: A Dual Approach to Theory and Applications, Vol 1*, Amsterdam: North-Holland, 1978, pp. 133–216.

_ , "Testing and Imposing Monotonicity, Convexity and Quasi-Convexity Constraints," in Melvin Fuss and Daniel McFadden, eds., *Production Economics: A Dual Approach to Theory and Applications, Vol. 1*, Amsterdam: North-Holland, 1978, pp. 409–453.

Lee, Lungfei, G. S. Maddala, and R. P. Trost, "Asymptotic Covariance Matrices of Two-stage Probit and Two-stage Tobit Methods for Simultaneous Equations Models with Selectivity," *Econometrica*, 1980, *48* (2), 491–503.

Lopez, Ramon, "Estimating Labor Supply and Production Decisions of Self-Employed Farm Producers," *European Economic Review*, 1984, *24*, 61–82.

_ , "Structural Models of the Farm Household that Allow for Interdependent Utility and Profit Maximization Decisions," in I. Singh, L. Squire, and J. Strauss, eds., *Agricultural Household Models*, Baltimore: The John Hopkins University Press, 1986, pp. 306–325.

Omamo, Steven Were, "Transportation Costs and Smallholder Cropping Choices: An Application to Siaya District, Kenya," *American Journal of Agricultural Economics*, 1998, *80*, 1083–1095.

Pagan, Adrian, "Econometric Issues in the Analysis of Regressions with Generated Regressors," *International Economic Review*, 1984, *25* (1), 221–247.

R Development Core Team, *R: A Language and Environment for Statistical Computing* R Foundation for Statistical Computing 2005. ISBN 3-900051-07-0.

Sadoulet, Elisabeth, Alain de Janvry, and Catherine Benjamin, "Labor Market Imperfections and Selective Separability in Household Models: A Predictive Typology of Mexican Ejidatarios," Working Paper No. 786, Department of Agricultural and Resource Economics, University of California at Berkeley 1996.

_ , _ , and _ , "Household Behavior with Imperfect Labor Markets," *Industrial Relations*, 1998, *37* (1), 85–108.

Saha, Atanu, H. Alan Love, and Robert B. Schwart, "Adoption of Emerging Technologies under Output Uncertainty," *American Journal of Agricultural Economics*, 1994, *76* (4), 836–846.

Skoufias, Emmanuel, "Using Shadow Wages to Estimate Labor Supply of Agricultural Households," *American Journal of Agricultural Economics*, 1994, *76* (2), 215–227.

Strauss, John, "The Theory and Comparative Statics of Agricultural Household Models: A General Approach," in I. Singh, L. Squire, and J. Strauss, eds., *Agricultural Household Models: Extensions, Applications, and Policy*, Baltimore: Johns Hopkins University Press, 1986, pp. 71–91.

Thijssen, Geert J., "Estimating a Labour Supply Function of Farm Households," *European Review of Agricultural Economics*, 1988, *15* (1), 67–78.

Tunali, Insan, "A General Structure for Models of Double-Selection and an Application to a Joint Migration/Earning Process with Remigration," *Research in Labor Economics*, 1986, *8(B)*, 235–282.

Vakis, Renos, Elisabeth Sadoulet, and Alain de Janvry, "Measuring Transactions Costs from Observed Behavior: Market Choices in Peru," http://are.berkeley.edu/~sadoulet/papers/TC-wp.pdf 2003.

Venables, W. N. and B. D. Ripley, *Modern Applied Statistics with S*, fourth ed., New York: Springer, 2002.

Yee, T. W. and C. J. Wild, "Vector Generalized Additive Models," *Journal of the Royal Statistical Society, Series B, Methodological*, 1996, *58*, 481–493.

Zawadzki, Wlodzimierz, "Infrastruktura Techniczna - Glowny Warunek Wielofunkcyjnego Rozwoju Obszarow Wiejskich," Technical Report 365, IERiGZ, Warsaw 1994.