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Impact of topical policies on the future of small-scale farms in Poland – A multiobjective approach

Stefan WEGENER*, Jana FRITZSCH*, Gertrud BUCHENRIEDER*, Jarmila CURTISS** and Sergio GOMEZ Y PALOMA**

*Leibniz Institute of Agricultural Development in Central and Eastern Europe (IAMO) and **Institute for Prospective Technological Studies (IPTS)

wegener@iamo.de, fritzsch@iamo.de, buchenrieder@iamo.de, jarmilacurtiss@email.cz & sergio.gomez-y-paloma@ec.europa.eu

Abstract

Contrary to what was expected at the beginning of the transformation, semi-subsistence farm households (SFHs) have persevered. There is an ongoing debate about what could prompt SFHs to become more profitable or to exit farming. A number of policy measures within the Common Agricultural Policy address this issue. This contribution assesses the impact of selected EU rural development measures on SFHs in Poland. Under the heading of multiple criteria decision-making, different approaches have been discussed in the literature. In this contribution, a multiobjective linear programming household model using compromise programming is applied. Four household objectives are optimised simultaneously: net agricultural production, net non-farm income, and household cash balance are maximised, while agricultural labour input is minimised. All together, four representative SFH types were simulated. Simulation results show that fine-targeting of policy measures to specific household situations is a strong precondition for successful development. The differing results between the multiobjective approach as compared to programming with one objective are also discussed.

Keywords: Semi-subsistence agriculture, policy analysis, transition countries, multiobjective modelling

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1 Introduction[1]

Semi-subsistence farming in Central and Eastern Europe (CEE) was not a short- or medium-term phenomenon in the transition from centrally-planned towards market economies. As the experiences of nearly two decades have shown, semi-subsistence farming's (SFHs) importance has even grown during transition. It seems that SFHs of less than five hectares have become a persistent and economically non-negligible phenomenon in CEE. Indeed, they make up the majority (82% of 9.2 million) of farms in the New Member States (NMS) of the European Union (EU) and, according to Pouliquen (2001), referring to the late 1990s, contribute at least 50% to total agricultural production. Nevertheless, the majority of SFHs cannot provide sufficient income to secure an adequate level of livelihood for the related farm households (EC, 2004).

The existence of these small-scale subsistence-based farms is to a certain extent a legacy of the socialist era when agricultural workers employed by the state and collective farms were allowed to manage small plots for their family's consumption. At the beginning of the 1990s, the number of semi-subsistence farms further increased due to the collapse of the non-farm sector in rural areas. In some countries like Romania, the loss of employment opportunities in urban areas, together with land privatisation, led to a migration into rural areas to secure a minimum livelihood from agriculture (Buchenrieder and Knüpfer, 2001; Petrick and Weingarten, 2004). Semi-subsistence farming in such settings has played an important role as a socio-economic buffer (Buchenrieder and Knüpfer, 2001; Kostov and Lingard, 2002). However, the dual farm structure,

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with a few large commercial producers and a very large number of small-scale farms, is frequently perceived as inefficient and socio-economically non-sustainable (cf. Sarris et al., 1999; EC, 2004).

Given the history of farm restructuring in the established EU Member States, only a few semi-subsistence farms in the NMS can be expected to grow to commercially viable and socio-economically sustainable sizes (EC, 2004). Therefore, one of the key questions within the formulation process of the EU rural development policy is how can semi-subsistence farms be approached most effectively.

However, the high level of SFHs heterogeneity makes policy decisions difficult, particularly because research results indicate that semi-subsistence farmers are not very responsive to market and policy signals that would normally lead to farm exit or expansion (Mathijs and Noev, 2002; Kostov and Lingard, 2004). Historical evidence suggests that SFHs rather try to maintain the status quo when it comes to land and animals. On the other hand, SFHs strive to increase average household member income by diversifying their income sources through non-farm sector activities. There is growing evidence that in CEE, rural households commonly depend on non-farm sources for 30-60% of their income (Davis and Gaburici, 1999).

Having said this, it is clear that on-farm decisions, from choice of technology to choice of specialisation, are influenced not only by on-farm but also off-farm commitments and opportunities, as well as unearned income flows (such as social transfer payments and subsidies). This has further policy implications. For instance, policy support of agriculture and rural development in general may affect different types of SFHs differently, depending on the relative importance of on-farm income from subsistence and commercialisation versus off-farm income from non-farm activities and unearned income.

Concerning the impact of selected EU rural development measures on SFHs, three key questions arise:

1) How will the income situation of SFHs develop over time?
2) What impacts do existing policy measures have, e.g. which adaption strategy is the best for different types of SFHs?
3) What impacts do households' preferences have on the decision of SFHs to allocate their resources to farming or non-farming income activities?

This contribution assesses the impact of selected EU rural development measures on SFHs, focussing on these key questions using a multiobjective programming approach. SFHs are especially interesting for modellers because SFHs have to make a series of decisions to increase their livelihood, and maximising farm performance may not be the most important one. There are often other objectives like satisfying the family's daily food needs or saving farm labour for non-farm income activities that have to be equally taken into account. Moreover, according to Braun and Lohlein (2003), modelling the transition process from subsistence to market-oriented production not only has to take into account the use of resources, but also risk aversion, preferences for special activities, and motivations that may cause an SFH to maintain, e.g. a certain degree of self-sufficiency even at the cost of income losses.

These objectives are often contradictory and SFHs try to find a balance to satisfy their different needs. Commonly used mathematical programming approaches optimise only one objective function and do not catch these specifics of SFHs. This requires another methodology. In this contribution, a multiobjective linear programming household model using compromise programming is applied, thus explicitly considering additional objectives which may be relevant for SFHs.

Simulations are carried out for four exemplary Polish households representing major types of SFHs, namely rural diversifiers, rural pensioners, farmers, and rural newcomers, which have been identified and extensively described by Fritzsch et al. (2008). The main characteristics of the major types can be summarised as follows:

Rural diversifiers are characterised by the highest share of non-farm revenues in household net income and the highest level of formal schooling. The households of rural diversifiers use the highest share of their own agricultural production and produce the highest number of agricultural products to meet family demand. They also have a low share of social security benefits in net household income.

Rural pensioners receive high social security benefits, have a low non-farm income and operate small farms. Their main characteristic is a high average age.

Farmers cultivate the largest farms among SFHs, focus on crop production and are better integrated in markets than the other major types. Farmers also have the highest annual household cash balance.

Rural newcomers are the youngest and have very little experience as farm managers. They have the lowest annual household cash balance. Furthermore, their educational level is very low.

The paper is organised as follows: Section two discusses multiobjective programming, the applied compromise programming approach and the scenarios for policy analysis. Section three depicts the simulation results, and Section four concludes.

2 A multiobjective programming approach for policy analysis

When multiple objectives are considered in programming approaches, more than one optimal solution exists, as in general the objectives possess various, exclusive optimal solutions. Therefore, a choice has to be made out of the set of non-dominated[2] solutions by making assumptions about the preference structure of decision-makers or by eliciting preference information from decision-makers. Mathematical approaches for multiple criteria decision analyses have matured and there now exists a variety of methods and fields of applications. Figueira et al. (2005) provide an extensive overview to existing approaches.

Romero and Rehman (2003) discuss different methodological approaches for considering multiple objectives in agricultural decision models. One of these discussed approaches is compromise programming, which was used in this study and implemented with a multiobjective linear programming (MOLP) approach. In compromise programming, only subsets of the non-dominated set are considered based on the relative importance of the objectives for decision-makers, which is estimated by weights. In compromise programming, a utopian non-feasible ideal point is defined, which optimises all objective functions simultaneously. This point is calculated by simply combining the optimal solutions of the single objective functions within one vector. Assuming that non-dominated solutions that are closest to the ideal point would be preferred by decision-makers, the weighted distance to the ideal point is minimised. This results in non-dominated solutions with minimal weighted distances to the ideal point.

[2] A solution is called non-dominated if there is no other solution with a bigger value for at least one objective function, while the values for all other objective functions are bigger or equal when all objectives are to be maximised.

An advantage of compromise programming is that it results, under limited preference information, in solutions that better represent a possible choice of decision-makers due to the underlying idea of minimising the distance to the ideal point than, for instance, scalarising techniques like the weighted sum approach. Scalarising techniques are more appropriate for interactive decision-making support. Additionally, this model calculates – in contrast to goal programming – only non-dominated solutions. In contrast to the weighted sum approach, this model considers all solutions of the non-dominated set. However, it does require considerable modelling effort and in multiple criteria decision analysis it is not possible to state an absolute advantage of one approach over others for a certain problem (Romero and Rehman, 2003, p. 75 for further discussion). Teufel (2007) used compromise programming for simulating the effects of various technological interventions on small-scale milk producers in Punjab, and in this study the approach proved quite useful for simulating the behaviour of small-scale farms.

In order to consider the aims and certain possible strategies of households for policy scenarios, the constraint method is used. By setting lower or upper bounds, i.e., minimum or maximum levels, on certain model parameters, it is possible to consider aims in addition to the explicitly formulated objective functions. For the possible scenario, "diversify income sources", e.g. lower bounds (minimum levels) on agricultural and non-farm income could be set.

A MOLP model that represents a semi-subsistence farm household was implemented in GAMS[3] for the policy analysis. A farm household model consists of various income sources with their costs, labour use, and expenditure positions to assess the household's cash balance. In general, SFHs have limited resources in the form of land and physical assets. They usually have plentiful labour with low opportunity cost in the local economy, especially at certain times of the year. However, farming activities typically only partially contribute to household income. This is why for certain types of SFH, e.g. higher purchased input costs, the value of agriculture might increasingly erode in this form of enterprise. Moreover, keeping up with the standard of living with other parts of society greatly increases cash requirements. The option of no change strategies for such households seems increasingly untenable. Therefore, the structure of the model is adapted to explore and find the most acceptable

[3] GAMS: General Algebraic Modeling System.

household choices from a variety of options, such as non-farm employment, the adoption of agricultural technology, amalgamation of land into bigger holdings, and self-employment in non-farm businesses.

The following sections explain the model structure and SFHs objectives that are considered within the model. Also, the simulation assumptions are specified, as well as the analysed policy measures.

2.1 Implementation of MOLP for modelling major types of SFHs

The implemented farm household model considers three income activities as decision variables with their operational costs and labour inputs: (1) farming, (2) self-employment and (3) waged employment. Household labour is allocated to these three activities. In addition, the labour input to farming and self-employment can be complemented by hired labour, which is set as a parameter in policy scenarios, implying investments and the extension of a certain activity.

The following four objective functions are included in the programming approach:

1. Net agricultural production (max): This objective represents the household's possible preferences for agricultural production due to aims like food security or tradition.
2. Net non-farm income (max): This objective considers possible household preferences for the development of additional income sources or to reduce its dependency on farming.
3. Household cash balance (max): This objective shows directly whether (or not) the household will have a positive cash balance and will thus be able to cover all expenditures and save some money for future needs under the respective scenario. This objective is equivalent to the objective "maximise net household income", which is usually used in household models. The only difference is the subtraction of household expenditures, which includes expenditures for loan and credit repayments. Furthermore, interests, as well as investments in the farm and in self-employment, are included into household expenditures for calculating the annual household's cash balance in the model.

4. Agricultural labour use (min): This objective might be of relevance for households which seek to maintain agriculture on a certain scale due to tradition or for food security, but which are also considering additional income sources, or try to reduce agricultural labour input due to a high age.

In the following the equations of the programming approach are listed using GAMS notation. These consist of the four objective functions, the equations of the matrix (constraints), and the right-hand side (RHS) of the constraints, e.g. the bounds on resource use. Table 1 to Table 3 summarise the abbreviations that are used in Equation 1 to Equation 4.[4]

Equation 1: Objective functions of the programming model

$$\max \quad net\_agr\_prod = level(farm) * inc(farm) - level(farm) * o\_cost(farm) - ex\_labour(farm) + invest$$

$$\max \quad net\_off\_inc = \sum_{activity=2}^{3} [level(activity) * inc(activity) - level(activity) * o\_cost(activity) - ex\_labour(activity)]$$

$$\max \quad hh\_cash = \sum_{sub=1}^{1} subsidies(sub) + \sum_{oth=1}^{4} oth\_inc(oth) + net\_off\_inc + net\_agr\_prod - \sum_{ex=1}^{8} hh\_ex(ex) - own\_use - [level(farm) - own\_land] * land\_rent + level(farm) * SAPS$$

$$\min \quad labour(farm) = level(farm) * lab(farm)$$

Source: Fritzsch et al. (2008).

Equation 2: Calculation of labour input and its costs

$$labour(activity) = level(activity) * lab(activity)$$
$$own\_lab(activity) = labour(activity) - p\_lab(activity)$$
$$ex\_labour(activity) = p\_lab(activity) * lab\_cost(activity)$$

Source: Fritzsch et al. (2008).

[4] The terms "level(activity)" and "level(farm)" represent the decision variables of the model. The terms "inc(activity)" and "inc(farm)" minus the terms "o_cost(activity)" and "o_cost(farm)" (minus "land_rent" plus "SAPS" for the objective hh_cash) represent the objective coefficients. The term "lab(activity)" represents the coefficients of the labour restriction with "hh_lab" being the total labour use and "hh_lab_cap" the RHS.The other terms are parameters representing fixed items, e.g. expenditures and income from subsidies, and are thus just subtracted or added to the total of the respective functions.

Equation 3: Calculation of household labour use

$$hh\_lab = \sum_{oth\_act=1}^{5} oth\_lab(oth\_act) + \sum_{activity=1}^{3} own\_lab(activity)$$

Source: Fritzsch et al. (2008).

Table 1 Parameters in the programming model

Abbreviation	Description	Unit
Ex_labour(activity)	Household expenditures for paid labour	EUR
Hh_ex	Sum of household expenditures over expenditure positions	EUR
Hh_lab_cap	Household labour capacity	hours
inc(activity)	Turnover or gross income per unit of activity	EUR/hour and EUR/ha for farming
Invest	Lump-sum for return from investments (farm investment, invested TSSS payment)	EUR
lab(activity)	Labour input per unit of activity	hour/hour and hour/ha for farming
lab_cap(activity)	Labour capacity for activity	hour
lab_cost(activity)	Costs of paid labour per hour	EUR
land_cap	Capacity of land for farming	ha
Land_rent	Land rent per hectare rented land	EUR/ha
Minimum(activity)	Minimum level for each activity	ha for farming (land), hour for other activities
O_cost(activity)	Operational costs per unit of activity	EUR/hour and EUR/ha for farming
objwt(obj)	Weights for the objective functions	No unit
oth_inc(oth)	Other (non-earned) income	EUR
oth_lab(oth_act)	Household labour use for other activities	hour
Own_land	Own land in 2006 from survey data	ha
Own_use	Value of the own used agricultural production	EUR
P_lab(activity)	Paid labour input per activity	hour
SAPS	Payment from the single area payment scheme	EUR/ha
Subsidies(sub)	Received subsidies	EUR

Source: Fritzsch et al. (2008).

Note: Parameters are constants within the model that are determined by the modeller. Costs per unit of hired labour or per unit of income activity, as well as all model constraints, are typical parameters within a linear programming framework.

Equation 4: Bounds / RHS

$$land \leq level(farm) \leq land\_cap$$

$$0 \leq own\_lab(activity) \leq lab\_cap(activity) \quad \forall activities$$

$$0 \leq hh\_lab \leq hh\_lab\_cap$$

$$level(activity) \geq minimum(activity) \qquad \forall activities$$

Source: Fritzsch et al. (2008).

Table 2 Variables in the programming model

Abbreviation	Description	Unit
hh_cash_bal	Annual household cash balance	EUR
hh_lab	Used household labour	hour
labour(activity)	Labour use per activity	hour
level(activity)	Activity levels: farming, self-employment, and waged employment	hour and ha for farming
net_agr_prod	Net agricultural production	EUR
net_hh_inc	Net household income	EUR
net_off_inc	Net non-farm income	EUR
own_lab(activity)	Own labour input per activity	hour

Source: Fritzsch et al. (2008).

Note: Within a modelling framework, the word “variable” denotes what economists call an "endogenous variable" (Brooke et al., 1992). Variable values are chosen within the model so that an objective function is optimised. Simply put, variable values are what the model decides. Activity levels, labour use, and net household income are typical examples of variables.

Table 3 Sets in the programming model

Abbreviation	Description
Activity /farm, self, dep/	Three income activities: farming, self-employment, and waged work
Ex /energy, food, transp, farm_inv, self_inv, edu, support, o_ex/	Fourteen categories of household expenditures: energy, buildings, equipment, food, insurance policies, taxes, transport, farm investments, investments in agro tourism, investments in family business, interests and repayments of loans, education, support of other people, and other expenditures
Sub / retire/	One subsidy item: early retirement payment
Oth /pensions, benefits, remitt, other/	Four categories of other (non-earned) income: pensions, social benefits, remittances, and other income
oth_act /processing, household, education, childcare, leisure/	Five other household activities: processing, household keeping, education, taking care of children, sick, and older people, and leisure
Obj /net_agr_production, net_off_farm_inc, hh_cash_bal, agr_lab_input/	Four objectives: net agricultural production (max), net non-farm income (max), household's cash balance (max), and agricultural labour use (min)

Source: Fritzsch et al. (2008).

Note: In GAMS, sets define the indices for the parameters and variables.

2.2 Simulation parameters and scenarios for policy analyses

The simulation was carried out for one real household per major type of SFH using data from the household survey (Fritzsch et al., 2008) depicting the households' situation in 2006. The selected households had to represent their respective major types through their main characteristics i.e., the household's variables had to be comparable to the median value of the respective major type.

Since MOLP is used for simulating future policy impacts, assumptions on the future values of number of parameters entering the model had to be made. Costs and income parameters were increased by the growth forecasts of gross domestic product (GDP) (FAPRI, 2008) to calculate the parameters of the simulation year 2016 (51% for Poland). For agricultural income, the simulated increase of 150% was even higher considering the rapid increase of agricultural product prices from 2006 to 2007. Furthermore, based on expert assessments,

costs for education, transport, and energy were increased by 80%, and costs for farming were increased by 110%, as it can be assumed that these costs will rise above the GDP growth level.

The necessary weights (Table 4) of the single objectives were assessed based on survey results according to answers that the respondents gave in the face-to-face interviews. For every simulation household, the median values of the objective weights for the respective major type of SFH were used.

Table 4 Weights of objective functions for selected households

Household	Net agricultural production (max)	Net non-farm income (max)	Household's cash balance (max)	Agricultural labour use (min)
Rural diversifiers	0.09	0.55	0.27	0.09
Rural pensioners	0.26	0.17	0.31	0.26
Farmers	0.32	0.26	0.32	0.11
Rural newcomers	0.24	0.47	0.24	0.06

Source: Fritzsch et al. (2008).

The impact of policy measures was assessed by calculating the policy scenarios given in Table 5. The following five policy measures were combined for the scenarios:

1. Single Area Payment Scheme (SAPS)
2. Transitional semi-subsistence support
3. Farm investment support for the modernisation of agricultural holdings
4. Support for diversification into non-farm activities
5. Early retirement support.

A **baseline scenario** is understood as the situation in 2016, when direct payments are fully implemented, i.e., to 100% of agreed payments, in all three surveyed countries. The policy scenarios reflect different strategies onto which a household of a certain major type of SFH could embark. The scenario **"farm development"** presumes that the household will invest in farming activities and receives respective support from policy measures. In the scenario **"start self-employment"** it is assumed that the household will start a self-employed activity other than farming while receiving the respective support from policy measures. The scenario **"farm development and start self-employment"**

assumes that the household invests into farming and diversifies into self-employed activities. All assumptions of the single scenarios "farm development" and "start self-employment" are applied. The scenario **"stop agriculture"** presumes that the farm operator stops farming activities and receives respective payments from the early retirement scheme. In addition, all scenarios that did not imply giving up farming activities are calculated in two variants: (i) with transitional semi-subsistence support, and (ii) without.

By comparing the baseline scenario with the results of the seven policy scenarios, which impact the policy measures have on the development of SFHs of a certain major type can be assessed. Furthermore, it shows which adjustment strategy is the most beneficial option for the household in the future.

Table 5 Scenarios for policy analysis with regard to SFHs

Scenarios	**Policy measures**				
	SAPS	Semi-subsistence support	Farm investments	Diversification support	Early retirement
Baseline (**base**)	x				
Farm development with semi-subsistence support (**farm+sss**)	x	x	x		
Farm development without semi-subsistence support (**farm**)	x		x		
Start self-employment with semi-subsistence support (**self+sss**)	x	x		x	
Start self-employment without semi-subsistence support (**self**)	x			X	
Farm development and start self-employment with semi-subsistence support (**farm+self+sss**)	x	x	x	X	
Farm development and start self-employment without semi-subsistence support (**farm+self**)	x		x	X	
Stop agriculture (**retire**)					x

Source: Fritzsch et al. (2008).

The different strategies that the policy scenarios imply are implemented by setting respective bounds and parameters in these scenarios. Moreover, a household's specifics, e.g. its capacities and aims, are also implemented by

setting respective bounds. In the following these specific parameters and bounds are outlined.

Households have to hire 900 hours of paid labour[5] in the scenarios farm development, starting self-employment and farm development plus starting self-employment, and the parameter for hired labour is set to this value in these scenarios.

Lump-sums for returns from investments are considered in the farm development scenarios and scenarios including the transitional semi-subsistence support measure. In the farm development scenario, a lump-sum return of 15% of an investment of 10,000 EUR was agreed upon by all project experts. Hence, 1,500 EUR are added as a lump-sum to net agricultural production. These 1,500 EUR stand for the higher turnover net of higher operational costs. For the scenarios implying farm development or starting self-employment, yearly capital costs of the investments are added. For scenarios including the transitional semi-subsistence measure, a net return from the invested semi-subsistence payment of 100 EUR was agreed on and added as a lump-sum to net agricultural production.

Moreover, it was assumed that farm investments will cause changes in the production structure in favour of crop production. As the model displays average values for production activities, the gross agricultural income per hectare of farming is multiplied by 0.8 in farm investment scenarios, as well as the costs and labour input per hectare of farming in order to implement this assumption. This multiplier implies that the gross income per hectare, the operational costs per hectare, and the labour input per hectare will decrease in the case of farm investments.

The minimum activity level (lower bounds) depends on household aims, which were evaluated in the survey, thus taking the households philosophy of life explicitly into account. If the households of a major type stated on a median level a high importance for the aims of "be rooted to the soil", "conserve the heritage", "keep up family's traditions", and "enjoy rural lifestyle", the minimum level for the farming activity is set to 50% of the cultivated area in 2006. If these aims did not receive a high rating on a median level, the minimum level is set to zero, which allows for giving up farming activity.

[5] 900 hours equal 0.5 Annual Working Unit (AWU) as defined by Eurostat.

Likewise, a lower bound for waged employment was set to 30% of the activity level in 2006 if the household stated a high importance for the aim, "diversify income sources".

On the other hand, specific minimum levels were set in policy scenarios: In farm development scenarios and in scenarios with the transitional semi-subsistence support, the minimum level of the farming activity is set to the cultivated area of the base year 2006, assuming that the household will at least maintain the actual level for receiving support from this measure. Starting self-employment is modelled by allocating a minimum level of household labour to this activity. In these scenarios, the minimum activity level is set to 1,800 hours per year for the self-employment activity. As it is assumed that the household employs 900 hours of paid labour in these scenarios, a minimum level of 1,800 hours requires own labour input of at least 900 hours.

Upper bounds on labour capacities for the income activities are set according to the number of economically active household members, their age and education. The upper bound for farming depends on the strategy and their current allocation of time between domestic and agricultural work and non-farm activities, which was assessed in the survey. For farming, the labour capacity is set to the total labour capacity for income activities of the household.

Factors such as the educational level of the single household members determine whether they could do other activities than farming. In general, the following rules for setting the labour capacities are applied: The educational level of each single adult[6] household member is considered. For an educational level greater than or equal to "secondary school, grammar school", the total labour capacity of the household member is assumed as being available for all activities, including self-employment. If there are no household members with an educational level greater than or equal to "secondary school, grammar school", the labour capacity for self-employment is set to the level of labour input of one adult person of the household to either waged employment or farming in 2006. If the household did not have a family business in 2006, a labour capacity for self-employment is only assumed as being available in the respective diversification scenarios.

[6] A household member is considered an adult when older than 16 years.

In farm development scenarios it is assumed that the household becomes able to rent in more land up to a new land capacity, which corresponds to 200% of the capacity for the farming activity in 2006. In all other scenarios, the household cannot operate more land than it did in 2006, and in the early retirement scenario the capacity for farming is set to zero. For an in-depth description of all model parameters and simulation assumptions, see Fritzsch et al. (2008).

3 Simulation results

The different strategies implied by a policy scenario, such as developing and investing in the farm, affect households expenditures (e.g. credit costs, costs for rented in land, costs for own food consumption) and incomes (e.g. income per hectare farming, income from the different activities, subsidies) and thus affect the households' cash balance. Moreover, policy measures cause changes in household behaviour and its labour allocation between farm and non-farm income sources. The decision of the household about its labour allocation is driven by the changes in the net incomes from the different activities, but might also be influenced by its specific preferences for other objectives.

The following analysis begins by discussing the role of the households' preferences for the different objectives on their labour allocation. Second, the impact of the policy scenarios on the households' cash balances is considered. Finally, results from sensitivity analyses are depicted.

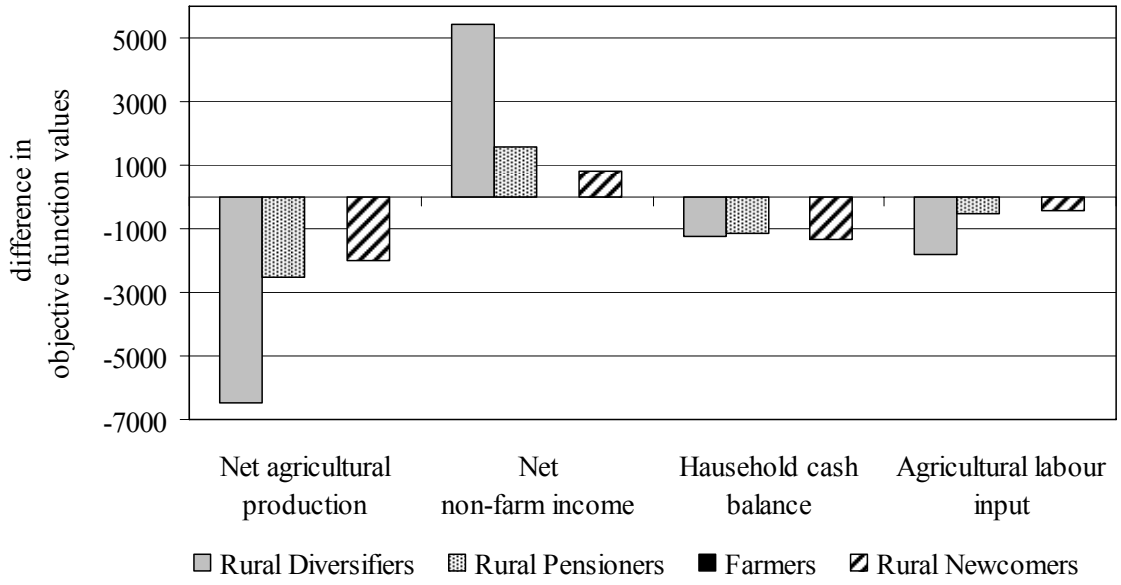
3.1 Impact of a household's preferences on its labour allocation

The weights of the household objectives derived from face to face interviews (Table 4) indicate the households' preferences for certain objectives. The rural diversifiers show a high preference for non-farm income, as the respective weight is most pronounced and the objective "maximise net agricultural production" receives only a low weight. For rural pensioners it appears that there are relatively small differences between the weights for the objectives. However, the weight for "minimise agricultural labour input" is most pronounced when compared to the other household groups. Farmers also show quite equal weights. Only the weight "minimise agricultural labour use" is at a lower level than the weights of the other objectives. On the other hand, the weights for maximise household cash balance and maximise net agricultural

production are more pronounced. For rural newcomers, the weight for net non-farm income is most pronounced.

In commonly used household programming approaches, net household income or the household cash balance is maximised only. Which impact the specific preferences for the different objectives in the MOLP apprach have on the allocation of household labour will be assesed in the following. This can be done by comparing the values of the objective functions resulting from the compromise solution of the MOLP approach, with those objective function values resulting from maximising the household cash balance only. Figure 1 shows the differences between the compromise objective function values and maximising only the household cash balance in the base scenario.

Figure 1 Deviation of objective function values in compromise solution of base scenario from values resulting from maximising household cash balance alone



Source: Calculations with data from Fritzsch et al. (2008).

It appears that the compromise solution for the farmers' households does not deviate from maximising the household cash balance alone. For all other households, the values for net non-farm income are increased, whereas the values for the other objectives are decreased. The reason is that these households

shift more labour to waged employment than they would when maximising only the household cash balance and in return accept a lower household cash balance.

For the rural diversifiers, the shift to non-farm activities is the largest that can be seen from the decrease in agricultural labour input. Also, the changes in net agricultural production and net non-farm income are the biggest. However, the loss in household cash balance is at a similar level to the other households, and the households can compensate for the loss of farming income quite well with non-farming income. In contrast, the rural newcomers have the lowest shift to waged employment but still have approximately the same losses in the household cash balance.

3.2 Impact of policy scenarios on the households cash balances

By comparing the household cash balances of the different policy scenarios, their impact on the livelihood of the households can be assessed, and hence which strategy (policy option) would be the best for the household determined.

Table 6 shows the development of the households' cash balances in 2016, when no rural development measures are applied (base scenario) as compared to its observed level in 2006. The results can be interpreted as the effect of the strategy "continue as it is" without policy induced changes. First, it appears that all households except the rural diversifiers had a negative household cash balance in 2006. This changes for the base scenario, and cash balances increase for all households but the rural pensioners. However, for the rural newcomers this increase is not large enough to result in a positive household cash balance.

Table 6 Comparison of household cash balance in 2006 with base scenario in 2016

	Rural diversifiers	Rural pensioners	Farmers	Rural newcomers
2006	+	-	-	-
2016 base	++	--	++	-+

Source: Fritzsch et al. (2008).

Notes: +: Household's cash balance is positive in 2006. -: Household's cash balance is negative in 2006. ++: Household's cash balance is positive in 2016 and increased in comparison to 2006. +-: Household's cash balance is positive in 2016 but decreased in comparison to 2006. -+: Household's cash balance is negative in 2016 but increased in comparison to 2006. --: Household's cash balance is negative in 2016 and decreased in comparison to 2006.

To analyse the households' cash balances under the different policy scenarios in more detail, Table 7 depicts the changes in the cash balances for each scenario and household compared to the base scenario. Additionally, Table 8 shows the ranks of the household cash balances for each scenario and household.

Table 7 Comparison of household cash balances in scenarios

	Rural diversifiers	Rural pensioners	Farmers	Rural newcomers
early retirement				
base	+	-	+	-
retire	++	--	+-	++
start self-employment without sss				
base	+	-	+	-
self	--	--	+-	--
farm investment without sss				
base	+	-	+	-
farm	++	++	++	++

Source: Fritzsch et al. (2008).

Notes: +: Household's cash balance is positive in base scenario. -: Household's cash balance is negative in base scenario. ++: Household's cash balance is positive in scenarios without transitional semi-subsistence payment and increased in comparison to base scenario. +-: Household's cash balance is positive in scenarios without transitional semi-subsistence payment but decreased in comparison to base scenario. -+: Household's cash balance is negative in scenarios without transitional semi-subsistence payment but increased in comparison to base scenario. --: Household's cash balance is negative in scenarios without transitional semi-subsistence payment and decreased in comparison to base scenario.

The desirability of the different strategies under the policy scenarios differs among the major types. For ***rural diversifiers***, farm development would result in higher cash balances compared to the base scenario. However, giving up the farming activity under the early retirement scenario would result in the highest cash balance. Those scenarios implying the start of self-employment result in the lowest cash balances. ***Rural pensioners*** seem to rely on the farming activity, as giving up farming would result in a decrease of the household cash balance compared to the already negative level of the base scenario. The best option would be farm development, and the second-best option to maintain the status quo as in the base scenario. The scenarios including the start of self-employment seem to be rather unlikely for the less educated and pensioner households, and

also show lower household cash balances. Also, the early retirement scenario is not an option. The ***farmers*** show the highest household cash balances under the farm development scenario. The second-best option would be to combine farm development with the start of self-employment, whereas only self-employment without farm development would result in lower cash balances compared to the base scenario. The lowest cash balance is achieved with early retirement. ***Rural newcomers*** would be best off in the farm development scenario and second-best in the early retirement scenario. The base scenario ranks third, with a negative household cash balance. Self-employment would result in the lowest cash balances.

Table 8 Ranks of household cash balances

Scenario	Rural diversifiers	Rural pensioners	Farmers	Rural newcomers
Baseline	4	3	5	4
Farm development with sss	2	1	1	1
Farm development	3	2	2	2
Start self-employment with sss	5	6	6	5
Start self-employment	8	8	7	8
Farm development and start self-employment with sss	6	4	3	6
Farm development and start self-employment	7	5	4	7
Stop agriculture	1	7	8	3

Source: Calculations with data from Fritzsch et al. (2008).

Besides maintaining the current situation, early retirement, and non-farm diversification of income activities, farm investment seems to be a sound strategy. Indeed, all of the simulated Polish households could profit from a farm development strategy compared to the base scenario. However, rural pensioners and newcomers would still remain on a relatively low level. Undertaking a self-employed activity other than farming is only an option for the farmers' household. Still, it has to be mentioned that setting up a family business is a

challanging task that only few households will be able to manage. Early retirement is only an option for the rural diversifier household. Rural newcomers would also achieve an increased cash balance under this scenario as compared to the base scenario. However, given their young average age they are mostly not eligible for this policy measure.

Table 9 Differences in the household's cash balances in diversification scenarios with and without the transitional semi-subsistence payment (self+sss net self, EUR)

	Rural diversifiers	Rural pensioners	Farmers	Rural newcomers
Poland	740	504	100	972

Source: Fritzsch et al. (2008).

As the policy scenarios were calculated with and without the transitional semi-subsistence support measure, the impact of this measure on the household cash balance can be assessed. In the scenarios that imply farm development, the effect of the transitional semi-subsistence measure on the households' cash balance was exactly the 100 EUR that were presumed in the model as the net return of investing the received money into the farm. Differing results were only obtained in the diversification scenarios. Table 9 depicts the difference in the household cash balance of the self-employment scenario with transitional semi-subsistence support as compared to the same scenario without the semi-subsistence support.

For the farmers, the effect also amounts only to the assumed 100 EUR net return from investment. However, for Polish rural diversifiers, rural pensioners, and rural newcomers, the effect was larger than the assumed net return of 100 EUR. The reason for these differing results is a shift of labour in these households to non-farm activities in diversification scenarios without the semi-subsistence measure, as in these scenarios there is no condition to maintain the current level of farming[7]. Households with an increase in the cash balance larger than 100 EUR in diversification scenarios with the semi-subsistence measure have a high preference for non-farm activities despite a lower income than from the farming activity. In those cases, the households are distracted from non-farm

[7] In scenarios including transitional semi-subsistence support and farm investment support, the minimum level of farming activity was set to the level of 2006.

activities when participating in the measure and are thus kept in farming, which on the other hand results in higher cash balances. However, these households have rational reasons for the specific preferences for non-farm income, and looking at the cash balance alone would not consider these reasons.

3.3 Sensitivity analysis

Sensitivity analyses have been carried out for the Polish rural newcomers' household. The model is triggered by three key assumptions: (i) turnover or gross income per unit of an activity, (ii) operational costs, and (iii) labour capacity. Especially for the farming activity there are some uncertainties, as the assumed growth rates for agricultural turnover and operational costs are based on experts' assessments. Therefore, the focus of the sensitivity analyses was laid on the parameter operational costs per unit activity and the following six sensitivity analyses were carried out:

1. 15% increase in operational costs per unit of farming
2. 30% increase in operational costs per unit of farming
3. 10% increase in operational costs per unit of self-employment
4. 10% decrease in operational costs per unit of self-employment
5. 10% increase in operational costs per unit of waged employment
6. 10% decrease in operational costs per unit of waged employment.

There were no alterations in the activity levels in all six analyses. However, there were impacts on net agricultural production and net non-farm income. This results in lower cash balances but does not change the quality of the strategies with one exception: when the operational costs per unit of farming are increased by 30%, early retirement results in a higher cash balance than farm development, which was not the case before. Moreover, the increased costs of farming result in a decrease of the value of net agricultural production by no more than 12%.

The effect of decreased or increased operational costs of non-farm income activities is straightforward. When the operational costs are increased, the net income from non-farm income activities decreases by no more than 5%, and vice versa. The following could be specifically observed:

1. Results for a 15% increase in operational costs per unit of farming: There was no impact on activity levels. Due to higher operational costs the value of the net agricultural production decreases by about 4% to 6% in the scenarios with farming.
2. Results for a 30% increase in operational costs per unit of farming: There was no impact on activity levels. The value of net agricultural production decreases by 7% to 12% in the scenarios including farming. Considering the decreased cash balances, the early retirement option becomes preferable to the farm development option for the simulated Polish rural newcomers' household.
3. Results for a 10% increase in operational costs per unit of self-employment: There was no impact on the activity levels. Non-farm income decreases by 3% in scenarios including the self-employment activity.
4. Results for a 10% decrease in operational costs per unit of self-employment: There was no impact on activity levels. Non-farm income increases by 3% to 4% in scenarios including the self-employment activity.
5. Results for a 10% increase in operational costs per unit of waged employment: There was no impact on activity levels. Non-farm income decreases by 0% to 4% in scenarios including the waged employment activity.
6. Results for a 10% decrease in operational costs per unit of waged employment: There was no impact on activity levels. Non-farm income increases by less than 1% to 5% in scenarios including the waged employment activity.

The sensitivity analyses revealed that the simulation results are stable for variations in the activities' operational costs.

4 Conclusions

Considering the impact of the single policy scenarios, it appears that all households but the rural diversifiers had a negative household cash balance in 2006. This situation changes for the base scenario and cash balances increase for all households but the rural pensioners. However, for the rural newcomers this increase is not big enough to result in a positive household cash balance. Early

retirement is the only option for the rural diversifiers that results in an increased household cash balance. Farm investment and development could improve the situation of all households, whereas starting a self-employed activity only seems advantageous for farmers.

The results show that targeting the various types of semi-subsistence is a strong precondition for success. Polish rural diversifiers earn sufficient income from waged employment and farming to maintain their standard of living. Given that they are, on average, relatively well educated, it is reasonable to assume that they will continue to do so until retirement, particularly since retirement is near for the majority of them. The recommendation here would be to prepare the ground for them to enjoy a poverty-free retirement. Rural pensioners were found to be non-viable under most policy scenarios. Given their high average ages, a well-functioning and generous social security system seems to be most beneficial for them. As they display mostly a negative cash balance, the pensions would not only have to be adapted to economic growth in terms of average percentage growth, but more generously to catch up for their grave situation. SFHs classified as farmers possess the greatest development potential. Even without additional policy measures these households are mostly in a comparatively good situation. Nevertheless, the farm investment measure could help them grow and prosper further. Yet the average age of farm owners is quite high. Thus, for this type of farm, the question of how to make the farm attractive to a potential successor or pension program are also important issues to be addressed. Overall, sectoral policy measures can greatly benefit this type of SFHs. Rural newcomers should be the focus of specific policy measures because they are relatively young, lack professional training in both farming activities and non-farm sectors, and in general their employability is rather limited. If they continue on as at present, their socio-economic situation is likely to further degrade. It would be in their best interest, on the one hand, to improve their employability in the non-farm labour market. On the other hand, to become capable of operating a farm economically successfully, they require advice on investment and production strategies as well as marketing ideas.

Using MOLP, the impact of various policy scenarios on SFHs has been assessed. It appears that considering several objectives in the programming approach can lead to additional insights. For example, the strong preference of Polish rural diversifiers for non-farm income sources was shown by using the

approach and led to different results. Mishra and Goodwin (1997) show that farms which receive significant income support through government farm programmes are less likely to work off-farm. Using the MOLP approach, this possible effect could be shown for the transitional semi-subsistence measure.

Moreover, results show that Polish farmers have a clear preference for agriculture while also having the best prospects in this activity. All other major simulated Polish household types seek income from non-farming sources. Indeed, they do so under most policy scenarios, even under the farm development scenario. Possible rational reasons for this behaviour might be better anticipated prospectives in the labour market and a more stable and secure income than from farming. The results underscore that to improve the situation of SFHs, it is crucial not to focus policy measures on the farming sector alone.

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