An Application of the Fuzzy Method in the Analysis of Family Farms

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Abstract
One of the most important characteristics of new
EU member states consists in the fact that the
importance of agriculture and rural areas is much
higher than in the EU15 states. This is especially
true with reference to Romania where even among
the new member states the economic and social
importance of agriculture is especially prominent.
As in most of the new member states a dual
agricultural structure has formed in Romania as
well. This situation raises several questions to be
answered: what are the reasons and how these
processes evolve following the EU accession? That
is: can small farms survive, will the heirs want to
continue farming? In order to achieve our research
goals we have used several data sources and
different study methods. Beyond literature, official
documents and case studies we used interviews
conducted with local specialists, as well as
statements and grant application materials made
available to us locally. With reference to
questionnairing we applied the gradual (multistage)
random selection. In conformity with the problem
to be examined and the nature of farms we did not

consider farms, but households as accounting or questioning units. As a result of our research we may assume that present land structure will not undergo fundamental change in the upcoming years. We may assert this both on the basis of the conducted interviews and founded on the fuzzy model drawn up on the database of our questionnairing. Thus it seems that the agricultural structure of Szeklerland is quite „crisis resistant." This is partially due to social determinants, partially to economic incentives and constraints (increasing food prices, lack of jobs, low income, etc.).

Keywords: agriculture, family farm, part-time farm, fuzzy modell, households.

Introduction

One of the most important characteristics of new EU member states consists in the fact that the importance of agriculture and rural areas is much higher than in the EU15 states. This is especially true with reference to Romania where even among the new member states the economic and social importance of agriculture is especially prominent. Differences are also striking regarding agricultural enterprise forms. As in most of the new member states a dual agricultural structure has formed in Romania, as well. That is beyond the large farms that despite their scarcity are still fulfilling a significant role both in production and in land-usage, a multitude of small farms are operational. In the case of Romania, this structure also shows significant regional differences as well: in mountain areas (that is also in Szeklerland) large farms are rather rare, small farms are more significant not only in their number, but also in land usage.

This situation raises several questions to be answered: what are the reasons and how these processes evolve following the EU accession? That is: can small farms survive, will the heirs want to continue farming? It turned out that beyond these originally phrased questions another similarly striking question arose: how do these farms deal with the economic crisis? It is especially important in Szeklerland as agriculture is one of the most significant branches of economy, one of the key sources of livelihood for rural households, it is part of rural

existence, a defining element of land use. In our research of 2010 that also contained our own empirical data collection, we considered it particularly important to study very small farms that could be found in very large numbers in Szeklerland. Especially given the fact that in our case the question always arises: what will happen to them in the future - will the fully or partially self-sufficient ones survive and be transformed into commodity producers or will they be liquidated? We attempted to find the appropriate research methods in order to answer these questions.

Methodology and Purpose of the study
Territorial delimitation, interviews, case studies

Szeklerland is an approximately 12 450 km² - sized piece of land which belonged to Hungary until 1920 and constituted the Eastern-Southeastern border of the country. After 1920, as a result of the peace agreement following World War I, it became part of Romania, geographically situated in the middle of the country. Between 1940-1944 it belonged to Hungary again. The majority of its inhabitants are still Szeklers. Szeklers are a Hungarian - speaking ethnical group who were settled to their present-day territory in order to defend the south-eastern border of Hungary. For this reason, they had enjoyed tax exemption for a long time, and they had formed a sense of freedom for themselves.

At the territorial delimitation of Szeklerland what poses special difficulty is that its borders do not coincide with the present administrative division and thus neither with the statistical system. However, we consider that it is a good compromise to view Szeklerland as consisting of the whole of Harghita and Covasna counties and the Marosszék part of Mures county. We have chosen this division as a solution.

In order to achieve our research goals we have used several data sources and different study methods. Through collecting and analyzing the literature of the domain as well as available documents we have clarified terms and we have identified the main characteristics of agriculture in Romania and in the Szeklerland. In order to prepare and interpret the empirical data collection we have conducted case studies with reference to the four microregions. Beyond literature and official documents, as sources for these case studies, we used interviews

conducted with local specialists, as well as statements and grant application materials made available to us locally.

In preparing the questionnairing and in interpreting the data we used interviews. When choosing our interviewees we tried to select different types of farms, respectively households. We have also conducted so-called expert interviews providing information on the given microregion's and the given farm types' main characteristics. These interviews have proven very useful in understanding the motivation of farms and households and in describing local conditions, informal relations and cooperation among farms.

Questionnairing, sample selection

With reference to questionnairing our initial consideration was to select a sample that was economically feasible but still suitable for generalizations. Given the fact that lists regarding the basic population (all the family farms in Szeklerland) were not available, we did not have the possibility to implement a simple random sampling. Therefore, we applied the gradual (multistage) random selection. This method proved expedient not only because it gave us the opportunity to eliminate the problems arising from the lack of a population frame, but also because we concentrated the sample regionally. Thus we managed to make the questionnairing less expensive and better controllable, and thus ultimately more reliable. The criteria and phases of the gradual sampling consisted in the following.

In the first phase we decided to sample in the different microregions. We drew up a work plan according to which we were to choose four microregions and to question 100 persons/microregion. Thus we also created the opportunity to achieve a sample that would be suitable for the analysis of features characterizing the entire Szeklerland, but also features specific for the given microregions. The microregional partial samples made the questionnairing easier while also giving us more useful research results in the development practice of the given microregion. Based on all the above (and taking into account basic population rates), we considered it feasible to choose 2 microregions in Harghita county, 1 in Covasna county and one in the Marosszék part of Mures county. We chose the Alcsík and the so-called Hegyalja microregions in Harghita county, in Covasna county the Targu Secuiesc Microregion that is essentially identical with the former Kézdiszék, while in Mures county we selected the Nyárádmente

microregion. This was followed by the selection of settlements according to the following method: from all the microregions three municipalities were selected for the sample from which characteristic villages from these municipalities were chosen so that both smaller and larger villages would be represented in suitable proportion to their population. The next step was the random selection of households to be questionned in these given villages. This was done on the basis of available maps. In conformity with the problem to be examined and the nature of farms we did not consider farms, but households as accounting or questioning units. This decision was supported by the fact that in the case of small farms the household and the farm are not separated with regards to the usage of production factors and neither to the spending of income. It has become more and more widespread also in international literature to create census of households and not farms in order to study the features and reactions of small farms.

Literature review
Fuzzy logic. A system close to the human rationaling and thinking.

If we say young or old, we talk about categories that are relative from many points of view: in a Pygmy tribe an old man does not mean the same age as in the case of a European person; a man at 50 considers himself middle aged; for a child, a human above 30 is old. But these categories do not have clear and set borders. We cannot say that one person at 34 is young, while another at 35 belongs to the middle aged group.

Lotfi A. Zadeh (1965) phrased the fuzzy theory defining it as the theory of non-crisp values and non-crisp membership. Such membership has no clear borders. Accordingly we can argue that a 34 year-old man is 45% young and 55% middle ages, while a man of 35 is only 42% young and 58% middle aged. The fuzzy logic expresses how humans think about things: inaccurately. This logic transfers the knowledge of the domain experts in computable data. The mapping relationship between the input and the output in a fuzzy system consists of a set of fuzzy IF-THEN rules. If we have domain experts, these rules are formulated by them; in other cases we can use an evolution of the rules and/or the membership functions.

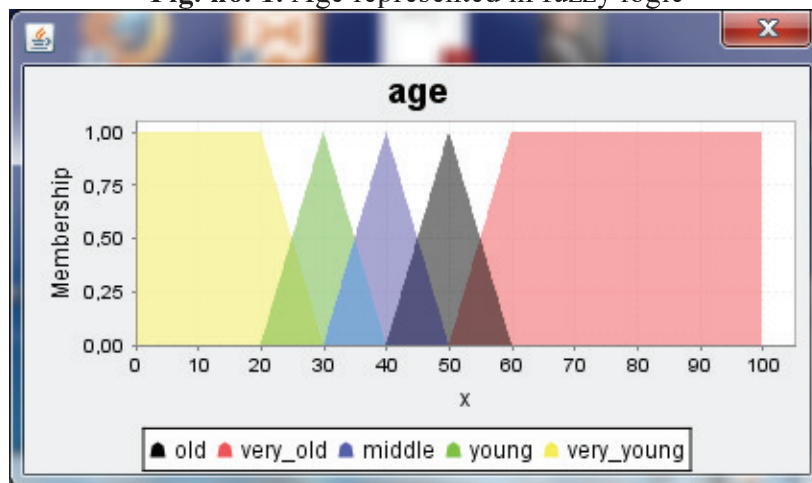**Fig. no. 1.** Age represented in fuzzy logic

Fig. no. 1 presents the *membership functions* for the *age* factor in our and in the SCARLED research (Fritzsh-Möllers-Bruchenrieder 2010). Instead of the Matlab™ and the fuzzy package from that software, we use the JFuzzyLogic package in Java language developed by Cingolani and Alcala-Fdez (2012). Figures 1, 3-12 are also performed by that package output.

The output of the fuzzy computation could be also a class with fuzzy membership, like our diversification potential in figure 3, or a crisp value. As we see on figure 10, the *potential* output is made with a method called Center of Gravity, that is one method to make mappings from a lot of inputs formulated in fuzzy mode and one fuzzy output.

First level of our fuzzy system contains ten attributes with values, that are fuzzyfied crisp values or fuzzy values itselfs. *Dependecy ratio* reflects how many not active (old and youth) people are related to total members of the family involved) and was measured as the share of persons older than 64 years and younger than 20 years as a proportion of the household members between 20-64 years old (economically active age). Households without economically active members, i.e. pensioner households, were assigned the value 3.0 to keep them in the sample.

Fig. no. 2. The two level fuzzy system (from Fritzsh-Möllers-Bruchenrieder 2010)
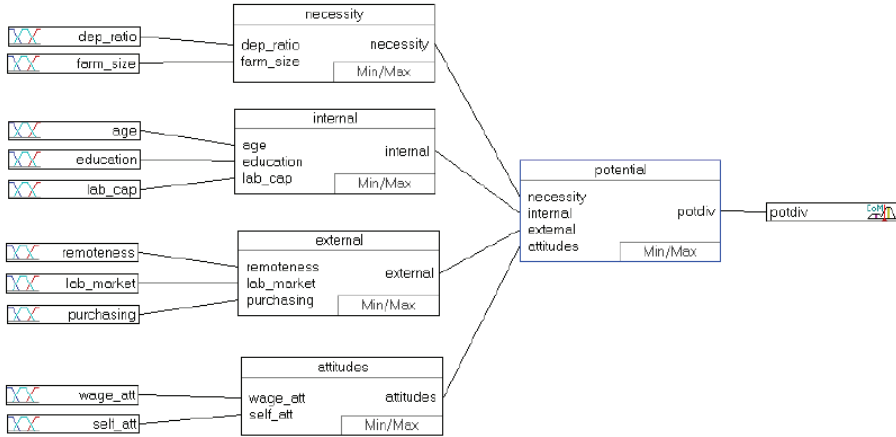

Fig. no. 3. Membership function for dependency ratio and farm size
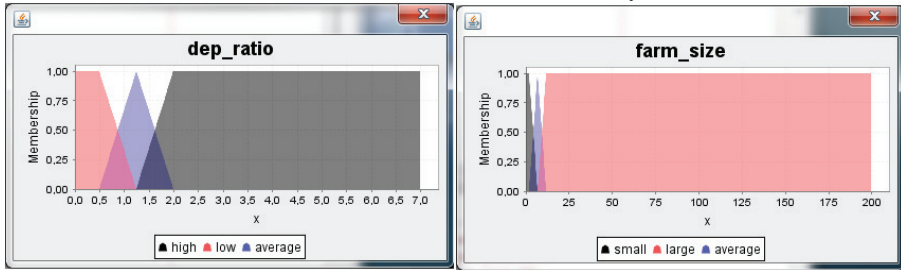
Farm size was measured in total available area of agricultural land, which includes permanently fallow land. We can see that upper 12 ha land are considered large.

Age is the age of the had of the family. The age attribute was considered in figure no.1.

**Fig. no. 4.** Membership function of education and labor capacity
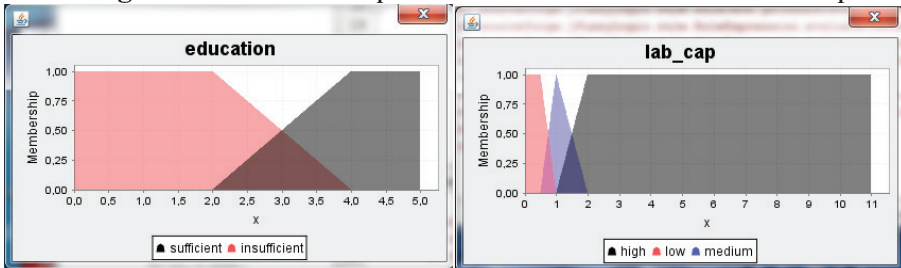
Education is the education of the head of the family. This attribute could have seven different values, from no school to faculty. "*Labor capacity* was measured in person equivalents that is the sum of all household members of an economically active age plus the number of pensioners up to 69 years old multiplied with 0.5, plus the number of pensioners between 70 and 74 years old multiplied with 0.25 to account for their reduced, but still existent labour capacity." (Fritzsh, J., Möllers, J., Buchenrieder, G.)

Fig. no. 5. *Remoteness* uses the distance of the nearest city
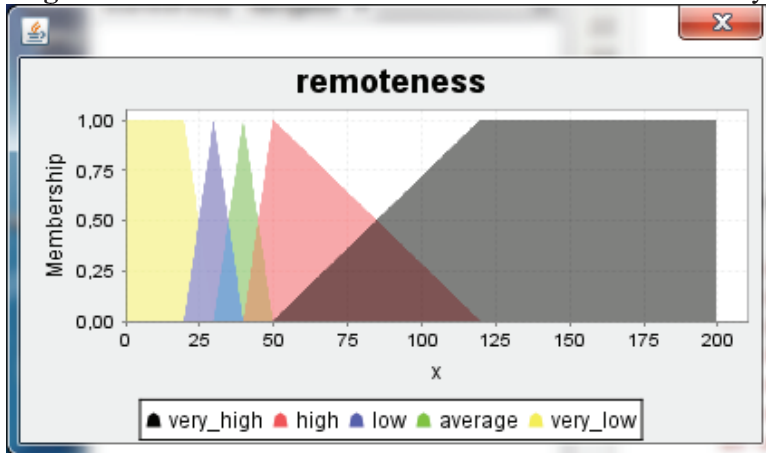
"Household members older than 19 years were asked for an assessment of the local labour market (lab_market). The question was how they rated their chance of finding a job on the local labour market. For each household, the maximum rating of all answers was entered in the calculation."(Fritzsh-Möllers-Bruchenrieder, 2010)
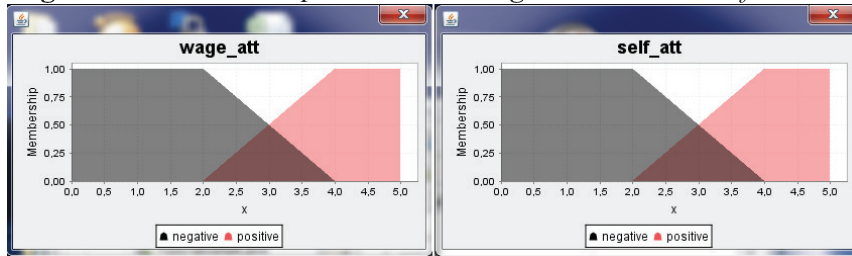
Fig. no. 6. Labor market and purchasing potential in fuzzy manner
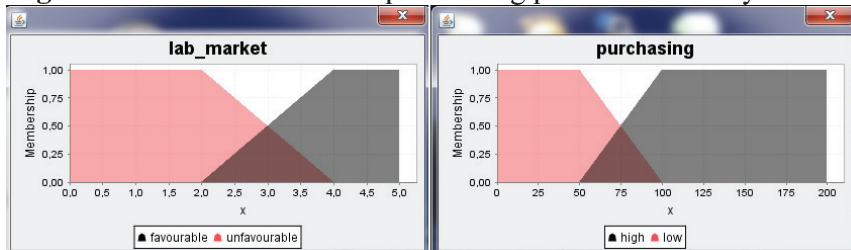
The purchasing power of the region was measured relative to the country average. This was computed in correspondence of GDP per capita.

Fig. no. 7. Membership function of *wage attitude* and *self attitude*

"The attitudes towards wage employment (wage_att) and self-employment (self_att) were assessed among all household members older than 19 years and the maximum rating was included in the model. In general, households have more positive attitudes towards waged jobs than towards self-employed activities." (Fritzsh-Möllers-Bruchenrieder, 2010)

One output of a fuzzy subsystem can be an input for another fuzzy subsystem. In our case, we have two levels of the fuzzy system We can see this in figure 2 where the diversification potential of households are computed in two steps. The inputs *farm size* and *dependency* ratio generate an output named (1) *necessity*. Inputs *education*, *age*, *labour capacity* maps in output named (2) *internal conditions*, the memberships of *labour market*, *purchasing potential*, *remoteness* generate the (3) *external conditions* membership and the *self attitude* and *wage attitude* goes to (4) *attitude* membership. In the next level, these four output factors become inputs and with their fuzzy memberships get through a Center of Gravity processing and result in a *diversification potential*, as we can see in figure 10. The Scarled authors (Fritzsh-Möllers-Bruchenrieder, 2010) define the IF-THEN rules we also use, from where we pick some:

"RULE 1: IF necessity IS unnecessary AND internal IS low AND external IS low AND attitudes IS negative THEN potential IS low"

"RULE 37: IF dep_ratio IS low AND farm_size IS small THEN necessity IS necessary"

"RULE 46: IF age IS very_young AND education IS insufficient AND lab_cap IS low THEN internal IS low"

"RULE 76: IF remoteness IS very_low AND lab_market IS unfavourable AND purchasing IS low THEN external IS low"
"RULE 96: IF wage_att IS negative AND self_att IS negative THEN attitudes IS negative"

Fig. no. 8. The necessity and internal conditions membership functions at the 2nd level
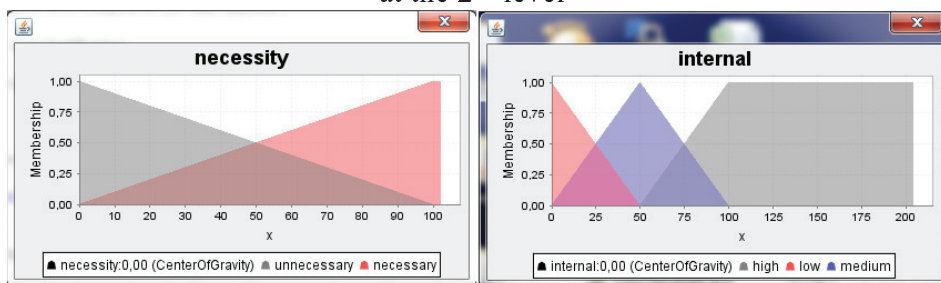
Fig. no. 9. The external conditions and attitude membership functions at the 2nd level
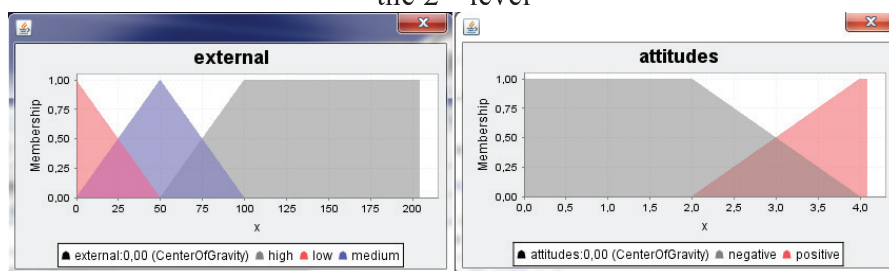
       The factors in the IF conditions are the inputs of the system, the factor after the THEN keyword represents the output. As we can observe, the first level rules are rules 37, 46, 76 and 96. The second level rule (RULE 1) has inputs from the output of the first level.

Fig. no. 10. The final output of the fuzzy system

Data collected through questionnairing have been used for the characterization of farms of the given regions and of the farm-owning households. Beyond this, however, we also performed modelling th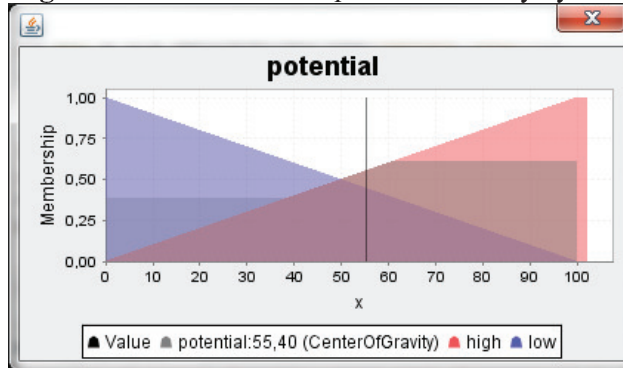rough using the fuzzy theory. In our case the sample served to estimate the diversification potential of households. For our estimate we have used the fuzzy application that an international research developed exactly for this problem. (Fritzsh - Buchenrider - Möllers, 2010.)

The essence of the sample consists in the fact that it arranges variables in four factors in the database of households.

Factor 1: need for diversification
Factor 2: preconditions of internal diversification
Factor 3: preconditions of external diversification
Factor 4: attitudes.

With variables belonging to the first factor we measure the incentive/coercive (compressive) effect on achieving income outside of agriculture. The second and third factors measure suction forces. The fourth factor measures whether a household is characterized by employer mentality or rather "one's own boss" one occasionally even in case of modest income. Through sampling with these four factors we may estimate to what extent the given households are prone to diversification.

Results of the study

As mentioned before, one of the most important features of agriculture in Szeklerland is the relative small size of estates. Within this, of course, there is also differentiation. While conducting the interviews, we tried to visit both farmers of larger as well as smaller

farms. In the interviews conducted with specialists we specifically focused on the differences in the situation of farms and households of different sizes and production structures.

It is true that generally the larger farms are the winners of EU accession, but the economic crisis has affected those involved in livestock breeding, more specifically: cattle breeders, and especially dairy farms. Their majority managed to meet the acceptance requirements increased by the EU accession, but they were shocked by the drastic decline of milk prices in the spring of 2009. Thus, they have tried to survive by transiting to meat cattle breeding, or by switching at least part of the livestock to meat cattle, or by some other type of enterprise (forestry, woodwork, tourism, food processing). Standing on multiple feet has always been characteristic of the region, while now it has become even more appreciated, which means that even larger farms are forced to the diversification of their activities.

Middle size farms are almost all part-time farms. It is very rare to find even one working age family member, who would not have some other source of income. This is the typical situation, even if the main source of income is the farm. The reason for this consists in the aspiration to safety, social security and pension. These people tend, however, to get external employment rather than starting an enterprise outside agriculture. They mainly look for employment that would fit their tasks on their own farm and its contact system: flexible work time, education and information useful both on their own farms and at their workplace.

This farms are quite stable, both from the point of view of family background and from that of rentability. One of the most important pillars of stability consists in subsidies. Many of the interviewees said that in fact the subsidies constituted the profit of farming, a profit that they received in a lump sum and thus they could use for investment. The rest of the continuous revenue (either milk-money or selling potatoes) is rather merged with the household and is used for the operating expenses of the farm or for household targets.

A few years ago livestock breeders were still working with 3 to 8 animals, but by today they have lowered this number to the minimum number required for the state subsidy (3). Thus former commodity producing dairy farms (producing for the market) have been replaced by production for own production (maybe for supplying dairy products for the neighborhood). The complete elimination of livestock is not

characteristic in the case of middle sized farms, they have rather become partially self-sufficient. This process seems to have two reasons: on the one hand, maintaining the state subsidy, on the other, they are still hoping for better times to come.

A good crop to be sold by farmers are potatoes. Crop rotation also depends on it. Livestock breeding also partially serves the purpose of producing organic fertilizers for the maintenance of the land's fertility. Produced grain is fed to the animals, while the excess is sold. Farms are relatively well-equipped, even if not with the most modern machinery. It is typical for two-three farms to "work together": they purchase machinery together (complementing each other), they perform the most important works together, they hire a shepherd together, etc. More extensive cooperation can be found only in connection with the two most important commodity products: potatoes and milk.

The smallest, mainly self-sufficient farms (or those turned into such in the previous couple of years) are also characterized by stability rather than the intent of liquidation, at least what regards the near future. What is interesting is that this is not only due to the fact that these people do not have enough money to switch from self-grown food to food purchased on the market, but also because of the fact that if you consume your own product, you "know what you are eating." There is obvious mistrust towards food sold in supermarkets. A further element belonging to this line of argument is the quite frequent use of food home-grown by acquaintances as well as direct selling. A further consideration supporting self-sufficiency: household tools (land, stables, skills, fraction of labor force) must be exploited. At the same time: uncultivated land will become weedy, will lose from its value, etc.

In the case of almost all types of farms we found the existence of informal relations to be typical, without which they would experience considerable difficulties in their functioning. Transforming these into regulated relations would pose serious challenges to everyone. For example, land use is often based on favors. Besides the members of the household, the registered farmer and his family members' wider kinship also participates in farm works and receive their share from the profits. A system of mutual favors has been formed that is operational even today. We have even noticed as an element of this informality that in the case of smaller, more remote villages authorities do not care whether machinery, tractors have their registration papers in order or whether drivers have licenses. Of course, machinery may be taken to the fields

also on "side roads", but they may just as well pass a couple of hundred meters on public roads, as well. Making such specifications more stringent or taking them more seriously would rather restrict the market presence and subsidy application of partially self-sufficient farms, rather than result in their total liquidation. The decisive majority of village households produce the most important foods for their own use themselves, regardless of the size of their farm.

Farming has a very strong social embeddedness and restrains. You are more than certain to fail if you remain outside the informal social network. This also hinders the participation of external investors as well as the development of larger local farms as a larger farm obviously cannot work without (full-time or seasonal) employees. This, however, also has limitations arising from the specificities of the local society consisting in the fact that the owner himself has to give directions to the employees, distribute work and check whether it has been done. So-called delegated authority is not considered legitimate. The owner may appoint someone to act as manager on his behalf on one of the worksites, but the other employees will not expect tasks and neither rewards from this person. The "boss" (farmer) has to be aware of everything, has to be present everywhere, if he wants things to go well. This means that hierarchical relations are also more personal than formal.

Discussion

Originally we were planning to interview 100 households in each of the microregions. Following the cleaning of data we dispose of 384 questionnaires, in the Hegyalja and the Kézdivásárhely microregion 100 each, in the Alcsík microregion 99 and in the Nyárádmente 85.

The size of the interviewed farms may well be characterized by the land that they use. These data with reference to the years preceding the interviewing are:

Table no. 1. Land use of farms (ha, 2009)

Region	Miniumum	Maximum	Average	Standard deviation
Alcsík	0,20	45	3,92	5,44
Hegyalja	0,04	100	6,55	11,86
Kézdiszék	0,03	34	5,06	6,54
Nyárádmente	0,10	70	5,95	10,93
Total	0,04	100	5,37	9,22

Based on the size of farms we could even be shocked by the large percentage of labor time spent with farmwork by the members of the household. Table no. 2 presents these data.

Table no. 2. Labor time spend with farming (%)

Region	Minimum	Maximum	Average	Standard deviation
Alcsík	12,07	100	72,54	28.49
Hegyalja	0,04	100	78,37	24.21
Kézdiszék	0,03	34	73,98	25.94
Nyárádmente	0,10	70	82,90	23.75
Total	0,04	100	76,95	26,04

The following tables (no. 3 and no. 4) offer some explanation to the phenomenon. Despite the large standard deviation, we can state that in all these microregions the average of self-sufficiency production is higher than three quarters of total production. This percentage is especially prominent in Hegyalja and Nyárádmente. What is even more, such high average may be experiences also in the case of lower standard deviation such as in Alcsík or Kézdiszék.

Table no. 3. Rate of self-sufficiency in production (%)

Region	Minimum	Maximum	Average	Standard deviation
Alcsík	0	100	77,11	36,18
Hegyalja	0	100	92,32	22,70
Kézdiszék	0	100	77,76	35,00
Nyárádmente	0	100	89,22	27,65
Total	0	100	84,78	43,96

What is also remarkable is the fact that in all these microregions on average at least half of the food consume of these households comes from their own products. It is not surprising that the average of Hegyalja and Nyárádmente while standard deviation is also lower here. That is, in these two microregions self-sufficiency production and consuming self-grown food is not only very frequent but low dispersion proves its overall prevalence.

Table no. 4. Rate of self-sufficiency in consumption (%)

Region	Minimum	Maximum	Average	Standard deviation
Alcsík	0	100	50,63	42.54
Hegyalja	0	100	61,08	42.63
Kézdiszék	0	100	53,28	46.24
Nyárádmente	0	100	64,38	41.60
Total	0	100	56,78	31,06

Social statistical data of these households also illustrate the consequence of these data and phenomena. In all the microregions the heads of the households are over 50 years old, dispersion being relatively low (12-15 years). The most frequent highest level of education is vocational school, we can find heads of households with higher education degrees almost only in the case of large farms. Due to the method of sample selection all of them live in rural settlements. However, given the small-town settlement structure of Szeklerland they live close to towns, the distance being less than 15 km.

Despite the proximity of towns and the small size of farms diversified households that dispose of non agricultural income are rare: this number is lower than one quarter of the interviewed households. Fully consistent with former data, data with reference to Hegyalja and Nyárádmente are also very low.

Table no. 5. Number and rate of diversified households

Region	No of house-holds	Out of wich diversified household	%
Alcsík	99	34	34,44
Hegyalja	99	19	19,19
Kézdiszék	86	22	25,58
Nyárádmente	91	18	19,78
Total	375	93	24,80

Diversification potential (Table no. 6) calculated by applying the fuzzy method is much higher than actual diversification. This numbers illustrate the difference between available jobs and needs. At the same time they also draw attention to the fact that living conditions of the

studied microregions' population should be improved through measures aiming the creation of possibilities to attain income outside of agriculture (job creation, development of small enterprises).

Table no. 6. Number and rate of households with diversification potential

Region	No of house-holds	Out of wich diversified household	%
Alcsík	99	55	55,55
Hegyalja	99	61	61,61
Kézdiszék	86	53	61,63
Nyárádmente	91	49	53,85
Total	375	218	58,13

Conclusion

Literature as well as our empirical study show that Szeklerland's agriculture is characterized by family farms. As a result of our research we may also assume that present ownership structures will not undergo fundamental change in the upcoming years. We may assert this both on the basis of the conducted interviews and founded on the model drawn up on the databasis of our questionnairing.

During the research we realized that not all the rules from the fuzzy model were useful for our data sets. We can change these rules by giving them weights and evolving these weights with genetic or evolutionary algorithms to fit the analysed data better.

Our empirical study show that those who have profited from the EU accession are the larger (family) farms; however, their growth is limited (lack of land, "the farmer needs to be present everywhere"). At the same time, middle-size almost entirely part time farms have also proven stable: the interviewees consider this activity to be rational use of the resources (workforce, land, other tools), while the social embeddedness of this type of farming is also strong, it is appreciated by local communities, social capital can be used efficiently. Production (also) for self-sufficiency characterizes almost every farm, but - of course - its rate is the highest in the case of the smallest farms. This is not only due to the fact that these small farms have the most difficulty to get to the market, but also because here we find the highest level of subsistence constraint to produce the greatest possible part of their

family's food demand. Beyond this one also has to take into account the consumer demand to "know what I'm eating," as well as the tradition and practice of processing one's own food.

Thus it seems that the agricultural structure of Szeklerland is quite „crisis resistant." This is partially due to social determinants, partially to economic incentives and constraints (increasing food prices, lack of jobs, low income, etc.). At the same time, we can presume that diversification in the field of income possibilities outside agriculture would lead to decrease in the role of self-sufficiency. This fact is also suggested by the gap between the diversification potential and actual diversification of households.

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