SZENT ISTVÁN UIVERSITY, GÖDÖLLŐ

Management and Business Administration PhD School

PH.D. THESIS

COMPLEX ECONOMIC EVALUATION OF ARABLE LANDS IN HUNGARY

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Gödöllő

2009.

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1. INTRODUCTION

1.1. The actuality of the subject

The liberalization of the Hungarian land market, which is due by 2011, will bring some changes which cannot be followed by the currently applied land evalution methods based on the outdated Gold Crown[1] land quality assessment system.

The gold crown (GC) values of land cannot be compared in national terms and often give distorted picture about the farming conditions of land areas even in case of smaller regional units. The gold crown system does not refer to the environmental conditions of production and the seasonal risk factors are not considered. [GAÁL et al. 2003].

In addition to this, the gold crown value, as land quality index „does not express the ratio represented by land, as national treasure, in the national assets" [KOVÁCS 1999]. The application of outdated land qualifying indices, which do not reflect the real quality differences, cannot be maintained because – according to the estimations of some professionals [ÁNGYÁN-MENYHÉRT 1998, NÉMETH 1998] – significant part (20-23%) of the total national assets of Hungary is given by the value of land. In Hungary 63% of the total land area consists of agricultural area, in contrast to the 43% of EU-25 countries [KAPRONCZAI et al. 2005].

BÓDAY et al [2008] determined the value of 4,5 million ha Hungarian arable land in 1 268 Mrd HUF on the basis of General Agricultural Inventory of 2000. According to their calculations, the value of land is 43%, the arable land is 26% out of the estimated assets of agriculture. As a comparison: the value of land in the United States of America made up 70-80% of the asset value of agriculture between 1965-1995 [OLTMANS 1995]. This ratio has not probably changed significantly by today. According to PUSKÁS [1993, 8. p.], the land capital gives 47,8% on average of the capital value of Western European agricultural companies.

In order to fulfill the important tasks related to the optimisation of land use system - which is necessary due to the responsible management of land, the observance of environmental protection aspects and the fiercening competition – it is inevitable to determine the economic value of land, as factor of production.

[1] The Hungarian land quality assessment system used presently, the „Gold Crown" system has become old-fashioned. In order to improve the sustainability of the land use and to facilitate the land valuation, a new intelligent land evaluating system was developed by the consortium of 9 institutions with the leading of Veszprem's University, and the support of the National Research and Development Program [GAÁL et al. 2003]. The new system is based on the D-*e*-Meter land quality index (it is more than the bonitation number!) which is calculated on-line with the help of a complex Geographical Information System of soil and other maps.

In Hungary the land market has not been set up yet. The lack of reliable, exact and public statistical data is the main problem on the Hungarian land market. The land market actors have serious difficulties because they do not have appropriate information about land market processes and related figures.

Considering the above, the land evaluation has – among others – an important task: that is to convey the value towards the land market actors, which can be the starting point in decision-making and around which the actual market price can be formed.
My research focuses on the theoretical, methodological and practical aspects of economic land evaluation.

I have started to process the subject of land evaluation during my graduate studies. At that time I analysed the factors influencing land value with multi-variable mathematical methods as well as the possibilities of land-based mortgage credits. I have dealt a lot with the activities and land evaluation methods of FHB Land Credit and Mortgage Bank. It was confirmed during my graduate research already that the land value estimating processes applied in Hungary have a lot of methodological deficiencies, that's why I have picked this subject for my PhD thesis.

In the research project No. NKFP-2004-4/015 titled „Land quality, land value and sustainable land use under the conditions of the European Union" I participated as the member of the research team in the elaboration of a new land evaluation method. The actuality of the topic was also justified by the sustainable strategy of the EU: the load on the environment has drastically increased owing to the expansion and extension of the production activities performed by people, which evokes the need for maintaining the environment. The necessary financial sources can be ensured by imposing taxes on arable land. The differentiation of land according to its quality is not enough for the fair taxation, it is also inevitable to make value estimation in economic terms, exploring the quality differences which also consider the external economic impacts, externalities, recognized by the society.

1.2. Objective and scope of examination

The thesis has three larger units. The **first** begins with the discussion of concepts connected with land evaluation, then the results of processing references are introduced. The main objective of processing references is to give a review of the practice of economic evaluation of arable land in Hungary and in some countries of EU with special regard to the methodological questions of economic land evaluation. The first part of the thesis ends with the introduction of ALES (Automated Land Evaluation System) developed at Cornell University and the land evaluation method based on D-*e*-Meter system of land quality assessment which was made in the frames of NKFP research-development project.

In the **second** part of my thesis I describe those databases and methods which served my research objectives. The **third** part starts with the comparative analysis of American ALES and Hungarian D-*e*-Meter land evaluation systems, which is followed by the comparison of two official land value estimation methods applied in Hungary. The unit is closed with the outcomes of analysis of factors influencing land value and the conclusions which can be drawn.

Although complex land evaluation means for me the joint evaluation of ecological (physical, biological and chemical features of soil, configuration of the terrain, climatic conditions) and economic factors affecting land value, my empirical research covered only the examination of economic conditions. The result of evaluation of ecological factors, the land quality assessment was put among the examined factors as a complex land quality index, the D-*e*-Meter score, and in the form of the gold crown value, in exogenous way.

The evaluation of farm management factors was an important part of my examinations. I do not deal with company-value determination aspects concerning land value.

Since each cultivation line requires different evaluation method, I deal exclusively with the questions connected with the economic evaluation of arable land.

My first research objective was the comparative analysis of D-*e*-Meter land quality index and the gold crown value regarding their usability in economic evaluation of arable land. The tasks connected with this were outlined as follows:

1. to examine the geographical differentiation of D-*e*-Meter scores at regional and natural macro-region level,
2. to compare the „value stability" of the two land quality indices (the constancy of land price per one D-*e*-Meter score and one gold crown, as well as the constancy of land rental fee and net added value) at county and regional level,
3. to examine the impact of land quality on arable land prices, by introducing the two quality indices one by one into the multivariable regression model,
4. to reveal the relation of the two competing land quality indices with the other factors which can be regarded important in arable land pricing in order to examine the possible indirect effects (e.g. if the profitability of field crop production has significant impact on land prices, it can be rightly presumed that the indirect effect of land quality appears in this relation).

The second objective is the examination of specific impacts of factors influencing the arable land pricing.

My research objectives do not include the revision of D-*e*-Meter land quality assessment index. One of the main objectives of developing the D-*e*-Meter system was to replace the outdated gold crown system. According to the system architects [GAÁL et al. 2006, GAÁL et al. 2007.] the new system could eliminate the main deficiencies of gold crown system. Examining the practical usability of land quality assessment in D-*e*-Meter system, HERMANN and co-authors [2007, 37. p.] state that the implementation of the system „puts both the assessment of environmental condition and the value estimation on an objective and exact basis which is in complete harmony with the greatest pursuit of our age that is sustainable, ecologically conscious farming, correct execution of land transactions and the system-oriented approach of information technology." Based on these statements I presume that the D-*e*-Meter score is more appropriate to demonstrate the quality differences of different land areas than the gold crown value.

On the basis of processing the references, I have drawn up the following research hypotheses:

1. the D-*e*-Meter land quality indices divided by macroregions show smaller differentation than at regional level,
2. the relation between land quality measured by gold crown value and the land price on the market is statistically proved but can be regarded as weak which can partly be due to the fact that gold crown values do not reflect accurately the differences resulted by the different natural qualities,
3. the D-*e*-Meter land quality index – since it expresses the production potential of the land part more exactly than gold crown value – shows stronger correlation with land price on the market,
4. the specific land prices and the land rental fees show smaller differences among counties and regions when a D-*e*-Meter score is a base of comparison than the gold-crown-based comparison,
5. presuming the significant role of land quality in returns on land, the net added values per one D-*e*-Meter score have smaller dispersion within the regions,
6. the land quality has significant impact on the size of land rental fees,
7. the size of land rental fees slightly depends on the values of farm management indices (intensity and profitability of production).

As the elements of hedonic pricing model I used social economic situation characterized by population density index, migration differences and the unemployment rate, as well as the accessibility represented by Accessibility and Transport Index in my examinations. The eighth hypthesis was formed according to this:

8. the social-economic state of the concerned region and the accessibility of the area significantly determines its market price of.

2. MATERIALS AND METHODS

2.1. Databases used for the examinations

The data required for the research and the gold crown land quality indices were provided by the Entreprise Analysis Department (operator of Test Farm System – FADN) of Agri-Business Research Institute (AKI).

I picked the **net value added** defined in FADN [KESZTHELYI-PESTI 2008, 7-8. p.] as an appropriate index for the evaluation of profitability situation of farms dealing with field crop production. The net value added (NVA) is the difference of output (production value) produced by the farms and the value of products and services used for production – current production input – increased by amortization.

The intensity of crop production was examined on the basis of total size of sowing seed, fertilizer, pesticide and fuel costs.

The farming data and the gold crown values were available in micro-region division. The farming data of years from 2004 to 2007 were averaged in the form of simple mathematical average for the analysis.

The land prices and land rental fees for 2007 were also taken from the Test Farm System.

The D-*e*-Meter land quality indices were determined for the Hungarian geographical microregions [TÓTH et al. 2007].

The determination of land quality indices is based on the procedure of D-*e*-Meter system [GAÁL et al., 2003]. The D-*e*-Meter system gives two indices: an 'extensive' index (for the low fertilizer doses) and an 'intensive' index (for fertilizer doses – which can be different by different soil types - required for optimal nutrient supply in order to reach maximum yield).

The 'extensive' D-*e*-Meter scores – regarding all the Hungarian farm fields – are placed on a scale of 1-100, where '1' is the relative productivity index of the least fertile land, while '100' is the index of the most fertile one. The 'intensive' D-*e*-Meter scores can be above 100 (and can be changed in the future by the improving agrotechnical level).

The available D-*e*-Meter scores (Figure 1) reflect the land quality of arable land – calculated with intensive cultivation.

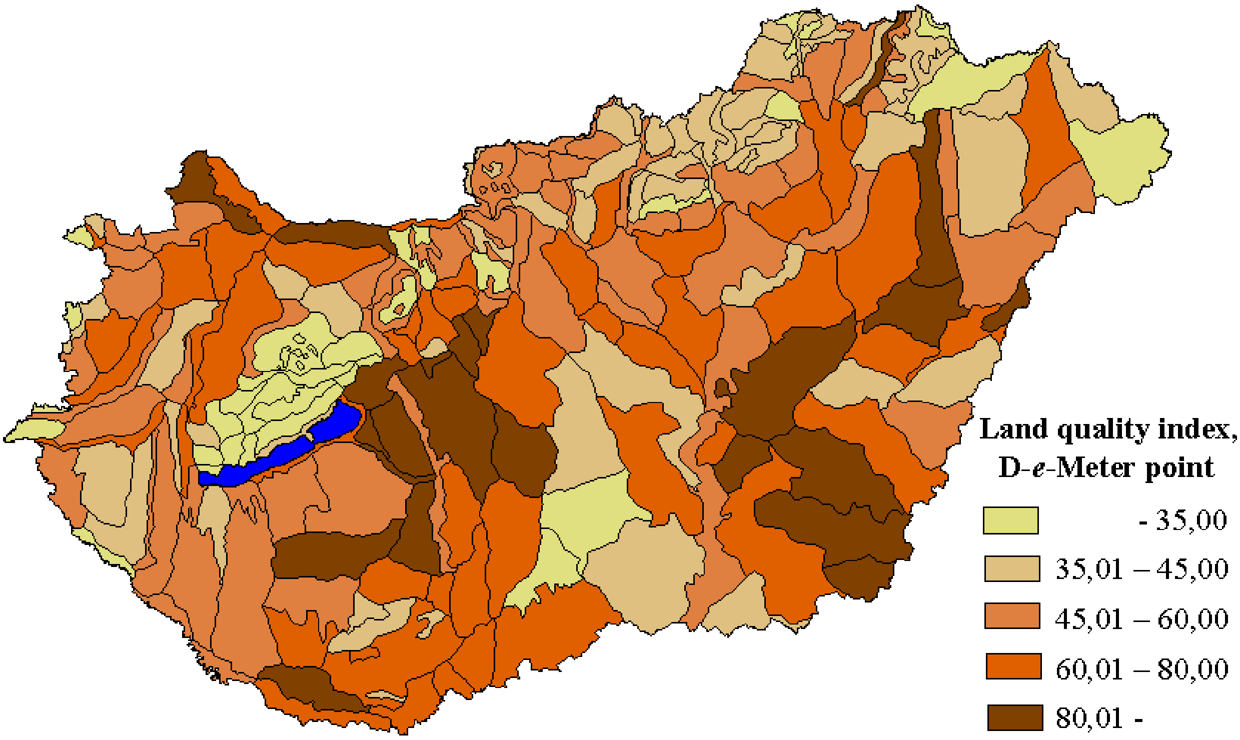

Figure 1. Classification of microregions of Hungary into five groups based on the average values of D-*e*-Meter score land quality index
Source: own construction on the basis of TÓTH et al. [2007]

As we can see, it is difficult to separate the geographical units with relatively similar natural conditions on the basis of land quality categories, not to mention the fact that individual values can have significant dispersion behind the categories.

The demographic situation of geographical units was evaluated by the **population density** index (number of inhabitants per one square kilometer), the social-economic situation by **migration balance** (difference of numbers of constant immigration and emigration per permanent inhabitants, calculated per thousand and the **unemployment rate** (percentage rate of the unemployed within population aged from 18 to 59). The single settlement basic data required for the calculation of the above listed derived data are from the Settlement Statistical Database System (T-Star) of KSH (Central Statistical Office).

The accessibility of geographical units was evaluated by **Access** index, while the extension and quality of public road network was evaluated by **Transport index**. The idea of Access index was given by the work of FALUVÉGI [2004] in which the author analysed the accessibility of microregions by reviewing the factors which affect the settlement of foreign capital. The basic data used for deriving the indices came from the Digital Topographic Database in the form of map objects.

The treatment of geographical information data and the construction of maps was solved by the use of **ArcView GIS 3.2a** program of ESRI (Enviromental System Research Institute).

When forming the Transport index – by weighted averaging of values of partial indices – I put the distance to railway with 30%, the distance to main road with 30% and the distance to motorway with 40% weight. The Transport index evaluates the transportation conditions of examined geographical objects (microregions, micro-landscapes) on a scale from 0 to 100%. The value of the index near 0% refers to the underdeveloped road network, while the near 100% value means developed transportation infrastructure.

The analysis of traffic conditions shows that the transportation infrastructure of two Southern regions – Southern Transdanubia and Southern Great Plain – is less developed compared to the other parts of the country, and their microregions show greater heterogeneity.

In the construction of Access index, I put the distance to the closest county town with 20%, the distance to Budapest with 35%, while the distance to the Western border (Hegyeshalom) with 45% weight. The near 100% value of Access index refers to the more favourable, while the value near 0% to the less favourable economic-geographical location.

The result of grouping the microregions according to Access Index clearly shows those microregions east of the River Tisza, the accessibility of which is the worst, while the economic-geographical situation of the two Transdanubian regions and Central Hungary is the most advantageous.

The analysis of accessibility and traffic conditions is very important from the aspect of foreign capital attraction: those microregions where the value of both indices is low cannot really be considered when speaking about the increasing demand of foreigners on land after 2011 (2014).

As it was introduced above, the available data sources have not provided a uniform level of data collection for me. I have considered more aspects in the construction of integrated database.

Hungarian researchers usually rely on natural macro-regions, within them the middle regions and microregions in their economic geographical and agro-ecological examinations. These „regions" reflecting clear natural and natural-geographical qualities are restrictedly suitable for fulfilling the function of the basic unit in economic analyses because they disregard the settlement, transport and economic qualities. Of course, it could be solved technically to reflect the population, infrastructural and farming data at microregion level, but I have not found it reasonable because the overlapping of microregion and microlandscape areas would result too many, 922 sections, and the weighing according to their sizes could not ensure representativity in the averaging of data.

Since part of the data were available at micro-region level and the other part could be easily aggregated to this level (e.g. single settlement data, traffic data), I chose microregion as observation unit.

2.2. The applied data analysis methods

The data processing and statistical analyses were made with the help of *SPSS 15.0 for Windows* statistical software package.

The regional differentiation was analysed on the basis of *one-way analysis of variance (ANOVA).*

The relations among indices involved in the examination were analysed with *multiple regression analysis* and *correlation calculation*. The results of applying these methods were verified with *principal component analysis* within multivariate methods and hierarchic *cluster analysis* (centre of mass method) made on the variables. The multivariate analyses – in contrast to regression analysis - do not highlight any of the examined variables but they enable the exploration of relation system between variables in case of variable groups. Here we could examine, for exapmple, whether the indices describing the social-economic infrastructure of a region form a coherent variable group with land market categories (price or rental fee of arable land, land quality indices). The mathematical background of multivariate methods chosen for the examinations were provided by the statistical methodological books of SZELÉNYI [1993, 2004], FÜSTÖS-KOVÁCS [1989], SVÁB [1979], and PODANI [1997].

During my examinations, I paid special attention to the preliminary examination and correction of data because the implementation of a statistical method or test is subject to strict conditions. For example, the *t-test* presumes normal dispersion of variables.

In case of regional-level analyses, the normal dispersion of numeric variables were examined with *Kolmogorov-Szmirnov test* - since the samples had appropriately large empirical sizes.

In case of *regression analysis*, the outstanding values may cause significant distortion in the slope of the line, and may significantly increase variance in *variance analysis*, therefore I preferred to determine and exclude the outstanding values, for which I used *Boxplot diagram.*

The identity of variances per groups was verified by *Levene* test [LEVENE, 1960]. According to LINDMAN [1974, 33. p.], the F statistics is resistant to the violation of this condition. I still needed the trial for choosing *post-hoc* test (in order to determine the groups with significant deviation). *Scheffe test* was used in case of identical variances and *Games-Howell test* in case of different variances. The selection of these tests was justified by the different empirical size of partial samples [FIELD 2005, 387. p.].

3. RESULTS

3.1. Incorporation of D-*e*-Meter system and the economic land evaluation into a unified system (based on author's research results)

As a member of research and development program No. 4/015/2004 "Land quality, land value and sustainable land use in conditions of European Union" I participated in the development of the new complex economic land evaluation system based on models of land quality.

Complex evaluation means an organic systematization of ecological and economical factors. The ecological evaluation signifies the elaboration of the D-*e*-Meter point system, while the economical evaluation systematizes the effects of economical factors in conformity with structure of D-*e*-Meter system.

The basis of the unified system is the D-*e*-Meter point, establishing the equivalence between specific yield and Gross Margin. The logic of the system can be interpreted as shown on the following figure (Figure 2.).

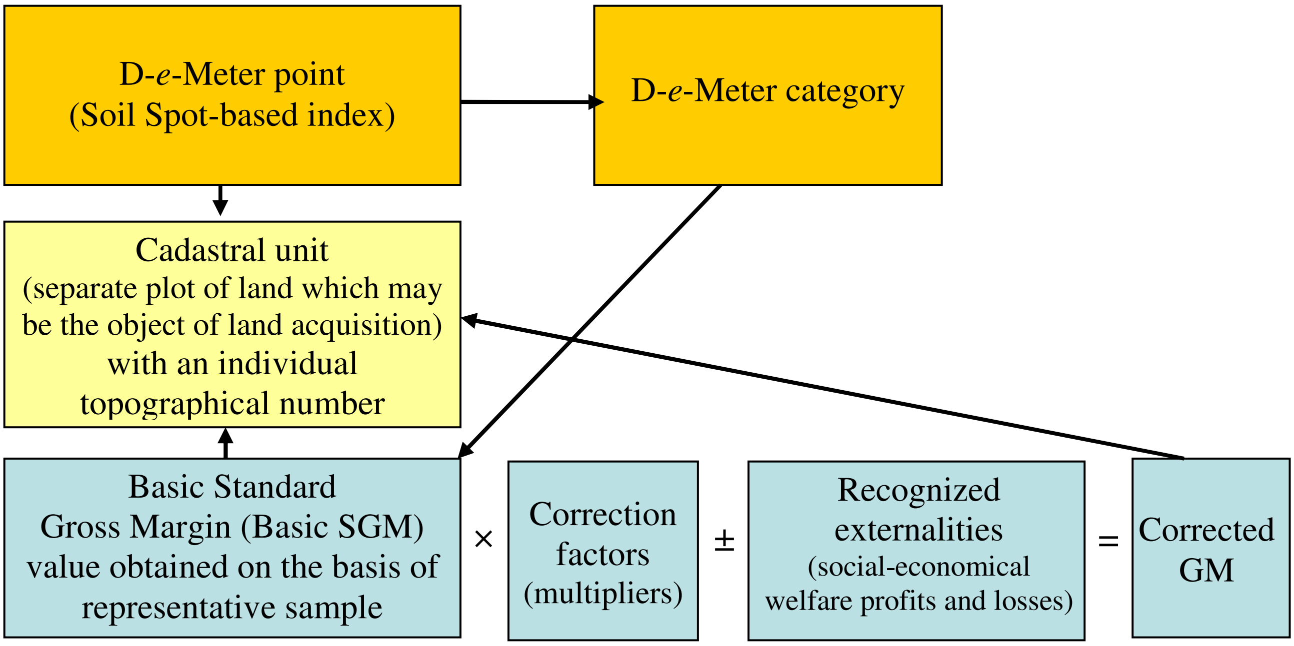

Figure 2. Determination of Corrected Gross Margin value of cadastral unit
Source: SZŰCS et al. 2006

The precondition to practical application of the land evaluation method, we elaborated, is to assign to ecah D-*e*-Meter category a weighted – so called standard – Basic Gross Margin value.

The computation of Gross Margin is carried out by sampling. The responding units are the enterprises dealing with production of arable-land crops in the given region.

Information can be read off from digital maps, whereby we ensure the automatic character of the valuation system. Following the recording of the necessary input data and data retrieval from maps, the model system **automatically** computes the D-*e*-Meter point value of the plot or land area with given topographical site number.

The connection and incorporation into a specific system of economy, ecology, as well as of scientific results of mathematics and information technology make possible the elaboration of an automated land valuation procedure.

The logical process of automation is as follows:

- The D-*e*-Meter points will be determined in ecologic block of the system on land plot level [TÓTH et al. 2006].
- The basic returns of lands (Basic Gross Margin) will be incorporated into the input data of the system in exogenous way after separated representative sampling.
- The stratification levels of map (land plot, parcel, topographical plot number) will be arranged on the level of topographical plot numbers. Thus, it will be the level, where the complex Euro-returns value appears. (It is also in conformity with practical applications, since all the land-estate questions are arranged according to topographical plot numbers or their fractions.)
- The basic land returns will be determined separately by regional levels, since there are big differences in infrastructural environment influencing the economic values, and they have to be taken into consideration during the construction of the system.
- The externalities are treated as corrections of basic net margin by means of mathematical formulae and incorporated into input data in exogenous way [FARKASNÉ-SZŰCS 2005].
- The basic returns value will be corrected by correction factors (after having red off the maps by means of mathematical formulae).

From economic point of view a certain difficulty arises, because the returns of land as of production factor are not separated from net margin, so the capitalization in classical sense (land price = capitalized land rent) cannot be carried out.

The research team have applied such an estimation method what deduces the share (γ-value) of land rent within total income from the conditions of real land market.

In case of necessary number of selling transactions of land estates, the extent of Land rent can be determined in knowledge of land prices and real interest rate:

$$\text{Land rent} = \text{Land market value} \times \text{real interest rate}$$

By means of this formula, the percentage of Land rent within the corrected Gross Margin can be determined:

$$\gamma = \frac{\text{Land rent}}{\text{Corrected GM}}$$

From this:

$$\text{Income value of land} = \frac{\gamma \cdot \text{Corrected GM}}{\text{interest rate}}$$

By employing this method (Figure 3.) we have practically combined the land prices calculated on return (income) basis with those current on the land market, whereby an up-to-date economic land value is obtained that not only respects the ecological quality of arable lands but also reflects the demand/supply conditions for land price.

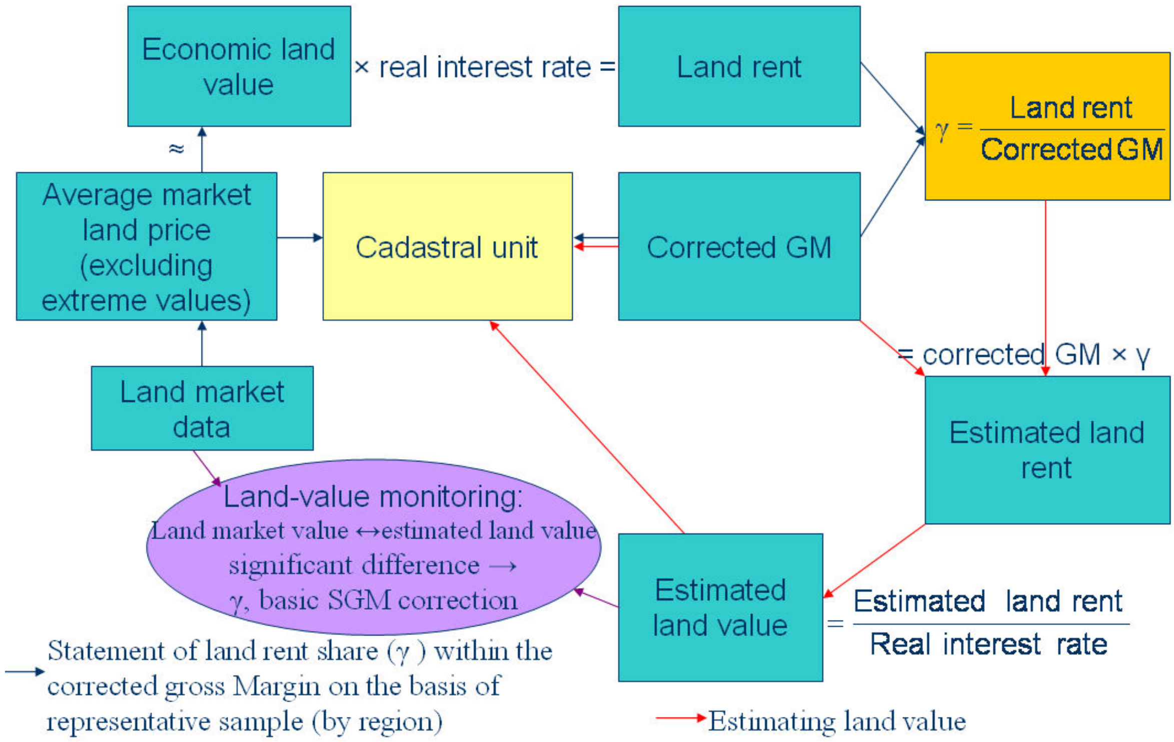

Figure 3. Estimation of land value
Source: SZŰCS et al. 2008., 82. p.

3.2. Comparative analysis of ALES and D-*e*-Meter land evaluation systems

By reviewing the international references on the subject, I have learnt that there are no uniform land evaluation system within the European Union. Moreover, the French example shows that the methods applied in the land value estimation practice may differ even within one member country. The experts in the field land evaluation seriously demanded the development of a unified land evaluation system within the European Union. The elaboration of the bases of unified land evaluation system is to be enhanced by the project initiated by the EU Committee, the primary object of which is the examination of suitability of arable lands in the Union for crop production purposes. The evaluation system is developed by the implementation of internationally recognized Automated Land Evaluation System (ALES) built up on FAO principles.

By finishing the general comparison of ALES and the economic land evaluation method based on the Hungarian D-*e*-Meter land quality assessment system, first I would underline that ALES is only a computer program which provides a framework for setting up individual land evaluation systems. We cannot speak about ready-to-use land evaluation model like in case of D-*e*-Meter. Compiling the lists of land use types, setting the requirements connected with each land use and constructing databases of the land mapping units to be evaluated and the data desribing their qualities: all these tasks belong to the model builder in ALES. When fulfilling the above listed tasks, the land evaluator should consider the individual demands of client who orders land evaluation. The results of the previous evaluation cannot be used at the next case of evaluation, because both the demands of customer and the databases are changing. Therefore the results of land evaluations made in ALES can be limitedly compared.

In contrast to ALES, the D-*e*-Meter system is an automatized complex land evaluation system which could be reached by the user (land owner, agricultural producer, bank, etc.) through Internet on his own computer.

ALES is not a geographical information program, thus it is unable to handle map-form data. The export of map data, however, is possible through some means of geographical information system, like e.g. IDRISI or Arc/Info. Contrary to this, the D-*e*-Meter system has full range of geographical information system support, the automatic downloading of data from digitalized maps is ensured. The objects of evaluation in both systems are map objects (land mapping units) but these are put in ALES as a table, while it is on-line in D-e-Meter by marking on the digital map.

Both methods of land quality assessment are indirect, the physical evaluation is based on the examination of cultivability of field crops. The evaluation in ALES is made along *decision trees*. The production of decision trees requires a multidisciplinary approach because it should be known exactly what are the environmental needs and conditions (land use requirements) of cultivating the given field crop, and how these requirements are met in the land qualities expressed in the combinations of land attributes.

The fundamental structure of D-e-Meter land quality assessment system is different: here the qualification of crop production conditions is made on the basis of yield. Those land qualities and their combinations are selected with the classification process which affect the fluctuation of yield to the greatest extent. The determination of cultivability of each field crop is made in the size of potential yield expressed on a scale from 0 to 100.

The economic evaluation of land units in ALES (Table 1) is made on the basis of farming data. The land quality is built in the model through the yields. The economic evaluation does not use the results of physical evaluation. The economic evaluation gives the economic suitability of the land unit concerning the realization of the given type of land use, separately on the basis of the four economic indices (gross margin, net present value, benefit/cost ratio, internal rate of return). The aggregation of the results into a general economic index or suitability degree is not solved. The algorhythm of evaluation does not give an exact estimation about the economic value of the land unit.

Table 1.
Comparison of economic land evaluation moduls of ALES and D-e-Meter

Aspect	**ALES**	**D-*e*-Meter**
economic index	gross margin, net present value (NPV), benefit/cost ratio (B/CR), internal rate of return (IRR)	gross margin
relation of land quality assessment and economic land evaluation	not created	determining the basic starting value of gross margin on the basis of general land quality (D-e-Meter score) which is corrected later according to the economic conditions
output	determining the grade of suitability as four economic indices[2]	value of gross margin corrected according to the quality of economic environment, estimated value of returns on land estimated land value (of returns)

Source: own construction

[2] S1 = absolutely suitable, S2 = conditionally suitable, S3 = marginally suitable, N1 = unsuitable for economic reasons.

Since the primary objective of ALES is to help the work of professionals dealing with land use planning, the output appears on the level of land use type (field crop) both in case of physical and economic moduls and it is not aggregated. Of course, the demands coming on behalf of land-use planning can be totally fulfilled, but as regards land value modelling I consider it necessary to set up general suitability classes and determine their land return content more exactly. „More exact determination” means that further division of gross margin and net farm income is needed for the quantification of returns on production factors – including land. The gross margin, in my opinion, cannot be regarded equal – not even in broader sense – with returns on land.

The economic evaluation in D-*e*-Meter system fully utilises the outcomes of land quality assessment, thus meeting the requirements towards complex land evaluation methods. The basis of economic evaluation is given by the estimation of returns on land but the method also presumes the analysis of land market data. By combining the two approaches – land evalution based on returns and on market - a totally new method has been developed which enables the elimination of specific errors of the two above mentioned evaluation processes.

I regard D-*e*-Meter automatized complex land evaluation system - even in international terms concerning its methodology - a modern and interesting solution of economic land evaluation based on land quality assessment.

3.3. Comparative analysis of two official land value estimation methods applied in Hungary

By the comparative analysis of the two official land value estimation methods – one is the land value estimating method of MNV (Hungarian National Asset Management Co.) (NFA - Hungarian National Land Fund), while the other is the method prescribed for implementing by credit banks in the FM (Ministry of Agriculture) decree No. 54 of 1997 – both applied in the Hungarian land evaluation practice, I intended to explore which of the two can give a value closer to land price on the market.

In Table 2 those estimated values are indicated bold which are below market value by more than 30%. The values in italic refer to the fact that the estimated value is more than 30% above the price approved by the market.
Out of the six regions, each represented with three counties, it was only in the Northern Great Plain region that both of the estimated values were lower by more than 30% than the market price in two of the three counties. It is interesting that the arable land areas of Borsod-Abaúj-Zemplén county were also overestimated by the market compared to their „internal” value.

The data of the table reveals that the arable land values estimated on the basis of FM decree No. 54 of 1997 are lower than the market values – with some exceptions. The result of two-sample t-test for the comparison of averages of the two belonging samples has confirmed that the values estimated on the basis of the given method are *significantly* lower ($p<0,01$) than the market prices.

The difference between the land price on the market and the values estimated by NFA methods has not been proved to be significant on the basis of two-sample t-test ($p=0,743$).

Table 2.
The actual arable land prices and those estimated on the basis of the two decrees by Hungarian counties

Region	**County**	**Arable land price of 2008[(1)], 1000 HUF/ha**	**Arable land value estimated on the basis of FM decree No. 54 of 1997[(2)], 1000 HUF/ha**	**Arable land value estimated on the basis of MNV (NFA) method[(2)], 1000 HUF/ha**
Central Hungary	Pest	523	**211**	**304**
Central Transdanubia	Fejér	421	399	*575*
	Komárom-Esztergom	398	319	458
	Veszprém	334	**243**	350
Western Transdanubia	Győr-Moson-Sopron	420	401	*578*
	Vas	415	**292**	421
	Zala	403	**161**	**232**
Southern Transdanubia	Baranya	380	386	*556*
	Somogy	420	**310**	446
	Tolna	648	**487**	701
Northern Hungary	Borsod-Abaúj-Zemplén	491	**202**	**290**
	Heves	253	252	*362*
	Nógrád	177	188	*271*
Northern Great Plain	Hajdú-Bihar	601	**301**	**433**
	Szabolcs-Szatmár-Bereg	307	**86**	**123**
	Jász-Nagykun-Szolnok	273	300	*432*
Southern Great Plain	Bács-Kiskun	376	**244**	351
	Békés	403	379	*545*
	Csongrád	335	**241**	347
National average		410	**278**	400

Source: [(1)]AKI test farm system, [(2)]own calculation

Summarizing the results of empirical analysis I can say that under the same economic conditions (capitalization rate of interest, normative land income, land quality measured in GC value) the application of MNV (NFA) land value estimating method gives price closer to market than the arable land value estimated on the basis of FM decree No. 54 of 1997. The values calculated on the basis of land evaluation methods used by credit banks are statistically provably lower than market prices. It is mainly due to the underevaluated size of rental fees.

3.4. Geographical differentiation of land quality indices

I have examined the geographical differentiation of quality of arable land measured in D-*e*-Meter score at the level of natural macroregions and statistical regions. The reason for the examination was that I wanted to choose an examination level at which the basic data show smaller dispersion, in order to make the economic analysis more precise and the outcomes more reliable.

The land quality measured in D-*e*-Meter score reveals strong differences within macroregions. The greatest dispersion could be explored in case of D-*e*-Meter scores of arable land units of the Transdanubian mountain range where the land quality of some areas deviates by 41,47% on average from the average 43 scores which is typical for macroregions. The quality of arable land on Small Plain (Kisalföld) is characterized by the highest (66,28) D-*e*-Meter score with the smallest (19,34%) relative dispersion.

On the basis of the result (p<0,01) of *one-way analysis of variance* (ANOVA) there are huge differences among the macroregions, too, as regards the qualities of their arable land units expressed in D-*e*-Meter scores.

I used *Games-Howell* post hoc test in order to analyse which macroregions have arable land units where the qualities expressed in D-*e*-Meter score show statistically significant differences. I picked *Games-Howell* test because the result of test - *Levene* test - examining the identity of variances of groups was significant (p<0,01) which refers to the different variances of D-*e*-Meter scores in groups formed according to macroregions. On the basis of *Games-Howell* test, the land quality of Western Hungarian borders, the mountain range of Transdanubia and the Northern Hungarian mountain range is significantly lower compared to the other natural macroregions.

The relative dispersion of land quality measured in D-*e*-Meter score exceeds 25% in case of four regions. The greatest deviation can be observed in the land qualities of arable land units of the Central Transdanubian region (the relative dispersion is 45,50%). The average quality of Southern Transdanubian land units is the highest: 66,90 D-*e*-Meter scores with 22,13% relative dispersion.

On the basis of statistical analyses (ANOVA: p<0,01), the regional differentiation of land quality is significant. The *Games-Howell* test proves that the arable land in Southern Transdanubia received higher D-*e*-Meter scores on average than the arable land in Central Hungary, Northern Hungary or Western Transdanubia. The quality of arable land in Northern Hungary is lower compared to the land quality of Southern Transdanubia, Northern Great Plain and Southern Great Plain regions.

The land quality measured with D-*e*-Meter score shows significant geographical differentiation both in case of macroregions and regions. The common conclusion of empirical tests is that the average agro-ecological potential of arable land in the Northern part of Hungary (mountain range in Northern Hungary, Northern Hungarian region) is lower than on the Great Plain.

My first hypothesis – according to which the D-*e*-Meter land quality indices show smaller differentiation divided by macroregions than by regions – proved wrong. The analyses based on land quality should not be made at macroregion level. The significant variability of natural attributes of crop production within the region indicates that the land-quality-based economic analyses – here in my opinion the representativity level of the data that counts - should be made for a geographical unit smaller than a region, like e.g. a county.

3.5. Value stability of land quality indices

Analysing the value stability of GC values and D-*e*-Meter scores, I saw great dispersion within the regions both in case of land prices and rental fees, for both land quality indices.

On the basis of aposteriori comparison of regional averages – with the help of *Games-Howell* test – I have statistically proved that the average „land price value" of one D-*e*-Meter score is significantly higher in Central Hungary and Western Transdanubia than in the Southern Great Plain region.

The arable land units in the Southern Great Plain – considering their prices per one GC – are undervalued compared to the arable land in Southern Transdanubia.

In case of rental fees per on D-*e*-Meter score I could not confirm differences between regions due to the great extent of dispersion within the regions (ANOVA: p=0,142).

On the basis of the result of ANOVA (p=0,006) the specific rental fees per one GC are significantly different in the regions. The *Levene* test (p=0,025) has not proved the identity of variances of groups. The *Games-Howell* test used for post-hoc analysis demonstrated that the agricultural producers in the Southern Transdanubia paid significantly higher fee for the use of one hectare of arable land than the crop producers in Central Hungary.

My hypothesis, according to which the „value stability" of D-*e*-Meter score is higher than the GC value, has not been proved. The value content of both land quality indices measured on the basis of both the land prices and the rental fees is very different within the regions.

Since either the GC value or the D-*e*-Meter score has no economic value stability at the level of statistical regions, there is serious professional demand for conducting county-level examinations. These examinations have outstanding significance in the evaluation of applicability of the indices at issue in economic analyses.

The results of examinations made at county level also demonstrated a great degree of dispersion in case of specific land prices and land rental fees made on the basis of both land quality indices.

In case of specific land prices, the post-hoc tests performed in the frames of ANOVA have revealed that both land quality indices are undervalued in Nógrád, Jász-Nagykun-Szolnok and Békés counties. The situation is the opposite in Borsod-Abaúj-Zemplén county, where the „rates" of gold crown and D-*e*-Meter score are significantly higher.

Analysing the average size of specific land rental fees I could state that the average rental fee per GC value is lower in Vas, Pest and Jász-Nagykun-Szolnok counties than the average value in Tolna county. The farmers pay considerably lower rent per one D-*e*-Meter score in Nógrád, Jász-Nagykun-Szolnok, Pest and Zala counties than in Szabolcs-Szatmár-Bereg and Tolna counties.

Besides the analysis of the two land quality indices on the basis of land market data I also consider important to involve the net value added (NVA) index which expresses the profitability of agricultural production. The variability of return on land can be concluded from the dispersion of income per one unit of land quality because relatively permanent ratio can be presumed within the net value added in case of a given region or county.

The values of specific profitability index demonstrate great dispersion in case of the two quality indices both within regions and counties. According to this, on the basis of ANOVA outcomes, not any statistically significant deviation can be proved among the regional[3], or the county-level[4] average values of specific profitability index.

The outcomes indicate that the profitability of crop production activity performed on arable land units with similar land quality can be very different. It also allows to make another conclusion: the ratio of quality land within the supplementary land rent can be smaller than the local rent.

[3] p=0,385 received for net value added per one gold crown, p=0,693 per one D-e-Meter score.
[4] p=0,080 received for net value added per one gold crown, p=0,056 per one D-e-Meter score.

3.6. Arable land prices and rental fees in relation to farm management, social-economic and infrastructural indices

3.6.1. Examinations at national level

My first examination aimed the survey of factors which significantly influence arable land prices, on the basis of farm management, social-economic and infrastructural indices. I paid special attention to the relations of the two land quality indices, the D-*e*-Meter score and the gold crown value with each other and with other indices. The joint evaluation of linear correlation co-efficients demonstrated that the two land quality indices have moderately strong positive relation (r=0,63) with each other. Their relation with land price is positive and weak and there is moderately close positive relation with rental fee. The relation between land quality measured in D-*e*-Meter score and net value added is weak (r=0,23) while with gold-crown value of land and its profitability it is weak-moderate (r=0,43). Indirectly it allows to conclude that the ratio of returns on land has decreased within the income of crop production. By analysing the competitiveness of agricultural and food industry production, MÓDOS et al. [2004, 13. p.] came to the same conclusion, that is the weight of advantages from natural qualities diminishes very much compared to other factors.

On the basis of values of linear correlation co-efficients we cannot speak about statistically proved relation between land prices, land rental fees as well as infrastructural (indices of transport, accessibility), social-economic (migration difference, unemployment rate) indices and population density.

The arable land price of 2007 was put as a target variable in the first regression model[5]. Out of the explanatory variables only one index, the rental fee had significant impact. The explanatory force of the model, however, is small: the rental fees contribute to the explanation of dispersion of land prices to a degree of 15,8%. A land rental fee higher by thousand HUF corresponds to an arable land price higher by six thousand HUF on average. I would draw the attention to the fact that the direction of causal relation found between the two examined indices can be turned round: it is not only that the higher land rental fees are built in the higher arable land prices but also the opposite side of this process, when the value increase of arable land prices resulted by the changing market conditions evokes the strong growth of rental fees.

In Hungary, the permanently high ratio of rental fees compared to the arable land prices in my opinion is the result of sharp separation of land ownership and land use. MOLNÁR [2000, 30. p.] declares that the utilisation of arable land in leasing system is typical in the developed countries. Out of the factors inspiring the strenghtening of leasing system he underlines the economic force of modern techniques, technologies

[5] I used the *Forward* method for my examinations based on multiple linear regression model..

for increasing the size, the market and economic policy impacts (subsidies, legal regulations in favour of the tenant).

The impact of land quality, the profitability of farming as well as the social-economic and social indices have not been proved significant.

The outcomes of my examination have been confirmed by the similar results reached by NAÁRNÉ [2006] from the examinations made on the basis of her own database: she could not reveal strong relation between GC and market arable land price either. Research in Latvia [BASTIENE-SAULYS 2005] has proved that the arable land price on the market is in weak-moderate relation (r=0,35) with fertility scores. The relation, however, between standard arable land price and fertility is stronger.

The results led to the drafting of another hypothesis, which says that the national-level research revealed the common features of geographical units only as regards the factors influencing arable land prices, because these prices are formed in relation to local conditions. As regards plougland price modeling, however, different factors can be brought into the foreground by each geographical unit. Therefore I considered it appropriate to extend my examinations onto regional level.

Examining rental fees, I put D-*e*-Meter score first into the model out of the explanatory variables, then in the second run, I involved gold crown value, too.

In case of both runnings, first the land quality index was put in the model. The land quality measured in D-*e*-Meter score contributed to the explanation of variability of rental fees to a greater extent (R^2=37,1%), compared to that expressed in GC value (R^2=34,9%).

In both runnings, the starting standard error of estimation was around 7 thousand HUF, which corresponds to 35% relative error.

In the first running, besides the impact of land quality measured in D-*e*-Meter score, the profitability of crop production expressed in net value added and the plougland price proved to be significant for the land rental fees. The explanatory force of the three-factor model is 51,8%. On the basis of values of regression coefficients, the higher-by-one value of D-*e*-Meter index was paired with higher rental fee by 291 HUF per hectare on average. The new value added higher by one thousand HUF can be related to higher rental fee by 96 HUF, presuming an average situation. The higher arable land price by one thousand HUF corresponds to higher rental fee by 13 HUF on average.

The output of the second running is a four-factor model, in which the land quality measured in GC value has the strongest impact on the land rental fees. The impact of plougland price and profitability of crop production is almost the same, the accessibility index is the last significant explanatory variable of the model, its impact is the weakest.

It is interesting that the relation between the accessibility index and the rental fee is opposite: a rental fee lower by 75 HUF on average belongs to an index value higher by 1%. I have to note, however, that this conclusion cannot be extended to company level because the observation units were statistical microregions.

The arable land of higher quality by one gold crown costs the tenant more by 679 HUF per hectare on average.

The results of other research [SZŰCS 1999] also reveal that close correlation between land quality and rental fee cannot be demonstrated in every case. In my opinion, it can also be due to the fact that not the profitability of farming is stressed in land rental fees but the bargaining position of the landlord and the tenant: big land users of the locality can join forces against the many land-owners in order to keep the rental fees low. The rental fees are greatly influenced by the direct land-based subsidies, too: the landlords want to have more and more share in the subsidies going to the land user, and – last but not least – the size of the rental fee depends on the accessibility, irrigation possibilities of the area, etc.

As regards the prices of arable land, on the basis of results of national-level research my hypothesis has been proved only partly acceptable. This hypothesis said that the land quality has only a moderate impact on arable land prices because the impact of land quality measured either in gold crown or in D-*e*-Meter score has not been proved statistically significant.

The development level of infrastructural environment and the social-economic situation has no significance regarding the arable land prices.

Out of the factors influencing land rental fees, the impact of land quality (measured by both land quality indices) has proved to be the strongest. The impact of profitability of crop production is weaker, but statistically traceable.

On the basis of results achieved by implementing the multivariable methods I have drawn the following conclusion: corresponding to the results of regression research made at national level, the significant impact of infrastructural, social, economic and demographical indices on arable land prices and land rental fees cannot be proved. Although the arable land price was put in the same group with land rental fee as well as land quality and net value added, in case of regression examinations only its relation with land rental fee has proved to be significant which can also mean that the profitability of land quality and crop production is built in the arable land price indirectly, through the land rental.

All the above lead to the conclusion that the local demand-supply conditions, the individual attributes of the given land unit – which are not expressed either in gold crown value, or in D-*e*-Meter score - have considerable impact on arable land prices. These factors include the accessibility of the area (not the general traffic infrastructure), its structure, irrigation possibilities, etc. E.g. BIRO [2009, 97. p.] has found significant positive relation between the plot size and the plougland price per hectare. In D-*e*-Meter economic land evaluation modul these factors are built in the eonomic value of arable land in the form of corrections, which is already close to market land price.

3.6.2. Regional-level examinations

The results of examinations made at regional level are „multi-colored". As regards arable land prices, different factors are put in the foreground by each region. The effect of land quality on arable land price can be clearly observed only in the Southern Great Plain region. In case of Central Transdanubia, only the impact of gold crown is significant out of the two land quality indices. The technical level of crop production is important arable land price forming factor in the Central Hungarian region. In the Southern Transdanubia, the profitability measured in net value added of crop production has proved to be considerable arable land price factor. As regards the Northern Great Plain region, the arable land price is explained by only one important factor in almost 53% – identically to the result of the national-level research – that is the land rental fee.

The size of land rental fees is significantly determined by the land quality (on the basis of both land quality indices) in the Central Transdanubian, Southern Transdanubian and Southern Great Plain regions, that is in those regions where the quality of arable land is better than the average. In the Central Hungarian region, while the impact of land quality measured in gold crown proved to be significant regarding land rental fees (the involvement of land quality in the explanatory model consisting of migration difference included as the first explanatory variable increased the explanatory force of the regression model by almost 30%), till instead of land quality expressed in D-*e*-Meter score, the population density was put in the model as the second explanatory variable. It can be due to the fact that in this region the determination of rental fees per one gold crown is especially widespread.

Regarding the Western Transdanubian region, the key factors influencing land rental fees are the unemployment rate and the traffic index. These indices explain the rental fees of arable land in 72,2%. It follows logically that the rental fee is higher in those microregions where unemployment rate is lower and the traffic conditions are better (when the Traffic index is higher by one percentage point, the land rental fee is raised by 258 HUF on average).

3.7. Results and new scientific achievements

My new research results are summarised in the following::

1. As the participant of research project registered under No. NKFP–2004-4/015. entitled: „Land quality, land value and sustainable land use under the conditions of the European Union" I have developed the theoretical basis of economic land evaluation based on D-*e*-Meter land quality index and unified systematization of economic land evaluation. I made suggestions for the calculation of value added which better support land evaluation objectives and developed the computer-based calculation algorhythm of it.

2. I have proved statistically that under the same economic conditions (capitalization rate of interest, standard land income, land quality measured in GC value) the implementation of land value estimation method of MNV (NFA) gives closer value to the market price than the arable land value estimated on the basis of FM decree No. 54 of 1997.
   In the FM decree No. 54 of 1997, the values calculated on the basis of land evaluation method prescribed for the implementation by credit banks are statistically proved to be lower than market prices.

3. I tried to specify the new land evaluation method by empirical examinations:

   a) In case of land quality measured by D-*e*-Meter scores I have found significant geographical differentiation both in case of macroregions and regions.

   b) I have proved that the ratio of No. I differentiated – **quality –** land rent is very varied in the prices of arable lands, land rental fees and profitability of field crop production, both in case of regions and counties.

   c) I have stated that regarding the arable land prices, the impact of land quality on national level is not significant in case of either indices.

   d) I have proved that the infrastructural, social-economic and demographic situation of the microregion has no significant impact on arable land prices or land rental fees on national level.

   e) I have found that the arable land prices are influenced by different factors in each region. The impact of land quality on arable land prices has been clearly observed only in the Southern Great Plain region.

   f) I have proved that the size of land rental fees in Central Transdanubian, Southern Transdanubian and Southern Great Plain regions are considerably determined by the land quality expressed by both indices – gold crown value and D-*e*-Meter score.

4. CONCLUSIONS AND SUGGESTIONS

Conclusions and suggestions which can be made on the basis of processing references:

1. The countries in the European Union have no unified and modern economic land evaluation system, which could be the basis of a unified land registry. Some European countries (Germany, France and Denmark) operate the national registry land evaluation systems in order to impose land taxes but the values provided by these registries are much lower than the land prices on the market.

2. The ALES land evaluation system in its present form is not suitable for registry land evaluation based on land returns estimation.

3. The economic evaluation built on D-*e*-Meter land quality assessment system fully utilises the results of physical land valuation, thus it meets the requirements set to complex economic land evaluation. The complex economic land evaluation means the joint evaluation of ecological and economic factors which express the natural and economic productivity of arable land, its value and utility. The basis of the economic evaluation is given by the estimation of returns on land, and the analysis of land market data is also presumed by the method. By combining the two kinds of approaches – land evaluation on the basis of returns and market – a completely new method has been developed which enabled the elimination of specific errors of the two evaluation processes.

4. I see the possibility of improving D-e-Meter system in the determination of crop-specific and general suitability classes, on the basis of FAO methodology.

5. The automatized complex land evaluation system built on D-*e*-Meter can be the basis of registry land evaluation. The results of evaluation can be carried over to the official real estate registry, thus easing the work of land evaluators and real estate experts. Following the Hungarian introduction of this unique system – which combines the return-based and market-based land value estimation - I suggest to implement it in the European land evaluation practice and to apply it as an integrated and unified land evaluation method. In order to introduce the system at national level, it is inevitable to construct largescale genetical soil maps for those agricultural areas where these are not available yet and the digitalization of the currently used maps.

Conclusions and suggestions belonging to the new research results:

1. Temporary – until the introduction of D-*e*-Meter complex economic land evaluation method – I suggest to use the land value estimation method of MNV (NFA) as a unified land evaluation method based on returns.

2. The analyses built on land quality are not proposed to perform at macroregion level. The significant variability of natural conditions of crop production within the regions mean that the economic analyses based on land quality should be made for geographical units smaller than a region, e.g. counties.

3. The huge geographical dispersion of arable land prices per one gold crown or one D-*e*-Meter score refers to the fact that there have been significant changes in the factors influencing the arable land prices. The weight of land quality has become smaller and the factors forming the local supply-demand conditions, like e.g. the accessibility of land unit, its structure, size, etc., have been put in the foreground.

4. My hypothesis which says that the „value stability" of D-*e*-Meter score is higher than the GC value, has not been proved. The value content of both land quality indices measured on the basis of arable land prices and rental fees is very varied within the regions.

5. The price of arable land on the basis of multivariable methods (principal component analysis, cluster analysis) has been put in the same group with the land rental fee, land quality and net value added. In contrary to this, in case of regression analysis, only the relation with land rental fee has proved to be significant, which can also mean that the land quality and profitability of crop production is built in the arable land price indirectly, through the land rental fee. It leads to the conclusion that the local supply-demand conditions, the specific features of the given land unit have considerable impact on arable land prices, although these are not expressed either in gold crown value or in D-*e*-Meter score. These features are the accessibility of the area, its size, structure, irrigation possibilities, etc. In D-*e*-Meter economic land evaluation modul these factors are built in the economic value of arable land in the form of corrections and thus it is already close to the market land price.

6. In spite of the fact that in our days the rental fees are still determined on the basis of gold crown values in wide range among landowners, the rental fees asked for one gold crown of arable land show great differences in each statistical region and in 10 counties out of the total 19. On the one hand, it refers to the fact that the gold crown values do not offer objective basis for comparison and, on the other hand, to the other fact, that not the quality parameters of the given land unit are decisive in fixing land rental fees, but more the bargaining position of landlord and tenant.

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