Application of decision support methods in preparation for a Hungarian bio-fuel programme

Lakner, Zoltán – Vizvári, Béla

Keywords: agro-ecological potential, land usage, linear programming, deterministic modelling, multi-issue actor analysis.

Summary findings, conclusions, recommendations

Under current market circumstances and those predictable in the near future, further increasing agricultural production seems to be rather groundless. By utilising agro-ecological conditions more efficiently, one eighth of Hungary's gasoline demand could be satisfied from maize production, without considerably decreasing current agricultural production for human and animal consumption. For realisation of biofuel programmes a relatively stable socio-economic environment is essential. There is considerable pressure on government from different stakeholders to shift the risks of large-scale investments to the state budget. In the long-run, under the conditions of a liberalised world market the feasibility of biofuel-programmes based on European raw materials, are highly questionable. To build up "shock-resistant" projects, well-founded, simulation-based risk analysis is essential.

Introduction

The utilisation of agricultural row materials for energy production – like an intermittent stream – is a regularly recurring issue. In Hungary between 1924 and 1942 a gasohol-ethanol brand-called Motalkohad been used. After the system-transition, in nineties of the last century the non-food use of agricultural material got a new attention *(Lakner – Kóbor, 1992),* because this possibility seemed an adequate answer to that-time problems of food economy: overcapacity and collapse of former export-markets. At this time the lack of financial resources hindered the development work. Around the millennium the domestic and international attention has increased rapidly towards the renewable energy resources. Renaissance of renewable energy in the world can be explained by (1) economic (2) environmental (3) social and (4) national security considerations *(Ryan et al., 2006).*

EU-accession of Hungary has enhanced the importance of this question. During the last decades the EU tried to promote the energy-production from renewable materials, but the goals seem not to be fulfilled.

In 1997, the EU set itself the target of generating 12% of gross domestic energy consumption from renewable sources by 2010. This target will not be met. In accordance with Directive 2001/77/EC, all Member States have adopted national targets for the proportion of electricity consumption from renewable energy sources. If all Member States meet their national targets, 21% of total electricity consumption in the EU will be produced from renewable energy sources by 2010. According to the latest estimations EU will only manage to produce 19% of its electricity from renewable sources by 2010 *(EC, 2006)*.

The 5.75% target for the contribution of biofuels to total fuel consumption by 2010, set on the basis of Directive 2003/30/EC , will probably not be met either unless current policies are strengthened. Only two Member States met the intermediate target of 2% for the contribution of biofuels by 2005. In 2005, biodiesel accounted for 81.5% of total biofuel production in the EU, while bioethanol accounted for 18.5%.

These fact highlight the practical problems of achievement of – even moderately ambitious – goals in the most developed states of the world.

Under these conditions a through social-economic analysis is needed. The current article is structured as follows: in first part an analysis of Hungarian agro-ecological potential is offered from point of view of renewable energy resource production. Put it in another way: the "supply" side of bio-energy production will be offered. In second part of the work the actors and their strategies on biofuel-issue will be analysed by a multi-issue actor analysis approach. In this way it becomes possible to understand the forces, shaping the socio-economic environment of biofuel production. This analysis gives information of "demand" side of the issue.

The Hungarinan agroecological potential and its application for renewable-energy production

The globalisation of the word economy highlights the importance of the optimal use of resources of each country *(Tamusné, 1997)*. For Hungarian food economy one of the most important natural resource is the abundance of arable land with high production potential *(Domján – Tamusné, 2002)*. Table 1 shows that the arable land endowment in Hungary is one of the highest in Europe, and the highest among the EU countries.

Based on this fact, it would be rather a simple strategy to increase the agricultural production for human nutrition, but this is not supported by the current state of the world market. On example of two basic arable-land products of Hungarian agriculture: maize and wheat it is obvious, that however there is some increasing of nominal price of the products, in real terms (recalculated in this case to prices in 2005- USD value), there is a decreasing tendency in product prices *(Figure 1)*. As a consequence of the increasing world production of these products, a reverse trend of this price-tendency seems to be an unreal scenario, that's why the most important question is not that: "how to produce more products?" but the question: "how can we satisfy the current food and feed demands in the most efficient way, allowing space enough for energy production?" This question has a great and practical importance. E.g. in opinion of *Steenberghen and Lopez (2008)* "The main risk for the deployment of liquid biofuel technology across Europe is the uncertainty surrounding feedstock availability. If farmers were restricted from growing food crops, then the land could be suitably used for other applications… competition for land use will continue to be a problem, and as such, farmers will be reluctant to enter into long-term supply contracts for crops whose return may fall in comparison to other crops." According to prognoses of *OECD-FAO workgroup (2007)*: "… structural changes such as increased feedstock demand for biofuel production, and the reduction of surpluses due to past policy reforms, may keep prices above historic equilibrium levels during the next 10 years". That's why it is a question of great importance: whether the increasing of non-fuel use of cereals in Hungary is a real threat for competitiveness of Hungarian agricultural and food industrial products, or not.

Metodology

Arable land of Hungary is used to a wide variety of crops. From these crops seven: barley, maize, potato, rye, sugar beet and sunflower seed occupy two-third of arable land has been chosen for investigations.

The basic unit of public administration and statistical data collection in Hungary is the county. There are 19 counties in Hungary. The data of production of the crops investigated were available on county-level. According to the classification system of the EU, these are the Nomenclature of Territorial Units for Statistics (NUTS) NUTS 4-level data. The counties of Hungary are geographically different and therefore they have different agricultural production potential. An optimal plan for the usage of the arable land must take into consideration of these differences.

The first problem to solve is that how could be determined the production-potential of different counties. It is obvious, that the yields of the last one and half decade (after beginning of the land privatisation) cannot be used, because there were considerable erratic fluctuations in yields. These fluctuations can be explained partly by a series of extremely unfavourable (e.g. draught in 1993, 2000, 2003) and favourable (all-time high yields in 2004 and 2005) conditions, but mainly by the declining technological level, e.g. drastic decreasing of the use of artificial fertilizers, manure and pesticides, growing age of the machinery park.

The most reliable way to determine the expectable yield is to take the averages of the years 1984-89. In case of sugar beet and sunflower a rather increasing trend of yield can be detected. That is why in case of these two industrial crops the yield data from 1999-2005 have been used.

The demand-side of model has been calculated on base of facts 1999-2004. By this way we could eliminate the effects of extremely high yields in 2005 and 2006.

There are many possible ways to gain energy from agricultural products. In framework of our investigations we have analysed only one aspect: the energy-gain from maize, by way of bioconversion of maize-corn to ethyl alcohol. To have a conservative approach of calculation it is supposed that by processing of one ton maize 317.5 l pure (water content less than 0.01%) ethyl alcohol can be produced *(Wright et al.*, 2006). The energy-density of ethanol is lower (23.5 MJ/l) than that of the regular gasoline (34.8 MJ/l), but this difference can be considerably compensated by higher octane-number of ethanol. According to the data of gasoline engine full throttle power output using ethanol fuel blends (10% ethanon-90% gasoline) is practically the same, as in case of using pure gasolone *(Johnson – Melendez, 2006)*. From one million ton maize 317 thousand m3 pure ethanol could be gained. In an average, the gasoline consumption in Hungary in period 1990-2005 has been 1430k ton *(HCSO, 2007)*, average density of gasoline is 737.22 kg/m3, that's why the average volume of gasohol consumption is 1980 thousand m3. It means that an increase of maize production by 1 million t and the biotechnological conversion of this row material into pure ethyl alcohol is equivalent of nearly one sixths of fuel demand of transportation. Of course, the bioconversion of maize into ethanol is only one of possible methods of biofuel-production. Production of biodiesel seems to be another prospective way of biofuel, production. However the comparative analysis of these two methods goes beyond the scope of current article.

The basic tool for the optimisation has been the simplex algorithm of linear programming. The objective is to minimize the total arable land to be used. Two types of constraints are applied: the total arable land area in each county, and the land area, used for production of the crops investigated in period 1999-2005.

The complete mathematical model is a stochastic programming problem as all yields are random variables. To describe the problem the following are used:

x_{ij}	the arable land used in county j for plant i
ξ_{ij}	the yield of plant i in county j
b_i	the minimal supply required from plant i
c_j	the total arable land used for the seven plants in county j
d_{ij}	the individual upper bound of the arable land used for plant i in county j

The first set of conditions are the supply constraints:

$$\sum_{j=1}^{19} x_{ij}\xi_{ij} \geq b_i \qquad i=1,\ldots,7 \qquad \text{(Eq. 1)}$$

In each county the total used arable land cannot be larger than of the upper bound:

$$\sum_{i=1}^{7} x_{ij} \leq c_j \qquad j=1,\ldots,19. \qquad \text{(Eq. 2)}$$

The arable land used for plant i in county j cannot be larger than the individual upper bound:

$$x_{ij} \leq d_{ij} \qquad i=1,\ldots,7;\ j=1,\ldots,19. \qquad \text{(Eq. 3)}$$

Finally, all variables are non-negative:

$$x_{ij} \geq 0 \qquad i=1,\ldots,7;\ j=1,\ldots,19. \qquad \text{(Eq. 4)}$$

As the coefficients of the variables xij in inequalities (1) are random variables, one cannot claim the satisfaction of these inequalities for sure. Instead, it can't be claimed that they are satisfied with a fixed probability p, i.e. the correct form of (1) is:

$$P\left(\sum_{j=1}^{19} x_{ij}\xi_{ij} \geq b_i \,\middle|\, i=1,\ldots,7\right) \geq p. \qquad \text{(Eq. 5)}$$

The objective is to minimize the total used arable land, i.e.

$$\min \sum_{i=1}^{7}\sum_{j=1}^{19} x_{ij}. \qquad \text{(Eq. 6)}$$

The Problem (2)-(6) is a stochastic programming problem. Although there are algorithms for many stochastic programming problems, this type is too complicated, and no algorithm is known. Therefore only a linear approximation of it has been solved. Let aij be the expected yield of plant i in county j. Then, (5) is substituted by

$$\sum_{j=1}^{19} a_{ij}x_{ij} \geq b_i \qquad i=1,\ldots,7. \qquad \text{(Eq. 5')}$$

Then the Problem (2)-(4), (5'), (6) is an usual linear programming problem solvable by any LP package.

Results and discussion

Results of the basic model (taking into consideration of the production-area for different counties in average of 1999-2005) are presented in Table 2. The "relaxed" version of basic model by increasing the county-level constraints by 15% are presented in Table 3.

If the current use of land in counties is disregarded and only the total arable land is restricted in the counties then an extremely small land is required (Table 3).

Of course, this scenario goes against the practice of agricultural production, not taking into consideration the crop-rotation and other adverse consequences of exaggerated specialization. The limits of the scope for action and the "shock-resistance" of the Hungarian agriculture under the assumptions of a stability of agro-ecologic potential can be proven by forbidding of the plantation of the crops in the counties, which were evaluated as best places for the production of a given crop in previous model. If these counties are excluded from production of crops, the another counties are able to take over the production, with a relatively low level of change.

The effect of the additional maize-demand for energy production was tested on base of the model, not taking into consideration of the constraints on county-level (Table 4).

According to the optimal solution of the basic model the demands could be satisfied on 2,685 thousand ha (Table 3). This is only 88% of the territory used for production of these crops in average of years 1999-2005. If the individual upper bounds for all crops in all counties are increased by 5%, 10%, and 15% then the optimal value of the objective function, i.e. the total of the used territory is strictly decreasing. At the same time the counties become more specialized, i.e. they produce less number of different crops.

If we negligee the constraints on county-level, the 83% of the current territory used for production of these crops would be enough. In this case more than half million ha land would become free for another use. The results of this extreme case are useful to determine an appropriate lower bound of the territory necessary territory to satisfy the current demand. The main drawback of this plan is that the production structure of counties has a monocultural character in most of the cases. In case of capacity of biodiesel-production a similar method could be applied but it should be taken into consideration that the integration of sunflower into crop-rotation systems is extremely difficult *(Frank, 1999).*

The calculations highlight the potential role of Hungarian agriculture in the energy-production. Analysing the results, it is obvious, that the production of an extra, one million ton production would not cause a considerable change in the production structure. This means, that the realisation of a biofuel-program does not means a considerable threat on competitive position of Hungarian agricultural and food industrial sector by inducing the price-increasing.

Multi-issue actoranalysis of biofuel producion

The biofulel production is a highly complex problem, that's why it is extremely important to determine exactly the stake holders, and their position towards different issues, jointing to renewable fuel production and consumption.

For analysis of this problem we have applied the MACTOR® method and software, developed by Lipsor institute *(Godet, 2001).*

In first phase we have determined the most important actors, that has a stake in the system under study and plays a role in its evolution by mobilizing the resources at their disposal to influence the issue outcome directly (i.e. using its „clout") or indirectly by influencing other actors (Table 5).

Using an expert-interview method *(Hajduné, 1982),* involving five specialists into the interviews, we have determined the matrix of influences (MID). Influence represents the power that the influential actor has over the influenced actor, measured on a scale ranging from 0 to 4, respectively meaning no influence to very high influence *(Bendahan et al., 2004).* This matrix is summarised in Table 6.

In constructing of this table we have taken into consideration of some asymmetries. E. g. the European public opinion is more susceptible to ecological issues than the Brazilian one, that's why the influence of these organisations is more successful.

In next phase of investigations we have determined the different goals of each relevant actor. These goals are summarised in Table 7.

The positions of different actors to different issues were summarised in position matrix. The cells of this matrix represent how important each issue is to an actor, evaluated on a scale ranging from -4 (extremaly important and against the issue), via 0 (unimportant) to 4 (extremely important, and supporting the issue) (Table 8).

Analysing the table it can be seen, that the development of biofuel products is a rather controversial issue, because there are considerable divergences from point of view of different goals.

To better understand these relations, we have calculated the matrix of direct and indirect influences. According to this approach, the influence of a on c, is the sum of the direct influence it has on c and of all indirect influences it gains through all the other third actors (e. g. b and d)

Based on these information the relative dependences and independences of different actors can be determined (Figure 2).

This graph highlights the decisive influence of extern effects on Hungarian biofuel system. Analysing the independence-dependence relationships it is obvious, that the highest level of dependence with an extremely low level of independence have the agricultural producers. That's why each decision concerning the biofuel-production has profound effects of this part of the society, which has in Hungary a relatively low level of bargaining power. The consumers' have a relatively high level on infulence on decision-makers. That's why the scientific analysis of consumer attitudes and behaviour has a high importance *(Dinya et al., 2006).*

Using the direct and indirect influence of different actors as weights, the relative position of different goals can be determined. The multidimensional scaling offers a favourable possibility to visualise these relationships (Figure 3).

Analysing the two-dimensional picture of different goals it is obvious, that the position of goals, joining to decreasing of energy-dependence, maintenance of agricultural production in less favoured areas, stabilisation of revenues of agricultural producers, as well as cluster-building have from each other a relatively low geometric distance. This supports the opinion of *Dinya (2005)* that these should be the basic arguments for the biofuel programs. At the same time, it is obvious, that there is an important distance between the goals, joining to development of biofuel-programmes and decreasing of budget deficit as well as minimising the tax-burden. This fact highlight the relatively high level of vulnerability of biofuel projects in Central-Europe. Analysing this Figure it is obvious, that there is a high social pressure from side of some stakeholder-groups to government. This is an especially difficult field, because in the European Union there are numerous possibilities for incentives of biofuel-use (Table 9), but in Hungary only one small part is utilised. On the other hand, numerous authors emphasize the threat of increasing role of the state-subsidies. E.g. in opinion of *Steenblink (2007):* "Governments should also ... industry pressure to mandate biofuel production or consumption. While mandates create certainty for investors, they simply transfer market risks to other sectors and economic agents.....The current emphasis on supporting biofuels risks crowding out investment in other technologies that may be much more sustainable, both commercially and environmentally.

Some issues to the research agenda

In last months of 2007 it became obvious, that the Hungarian ethanol-production is rather vulnerable from economic point of view, that's why numerous potential investors quit the sector. This fact highlights the carrying out a sensitivity analysis of biofuel programs, taking into consideration the possibilities of changes in economic and technological environment *(Popp – Potori, 2007)*. The basic logic of this analysis is summarised in Figure 4.

A further, specific question is the integration of biofuels into the future perspectives of Hungarian agriculture. Majority of perspective plans in Hungary, but also in Europe mention the biofuel-problem assuming a "ceteris paribus" situation in development of socio-economic conditions. That's why they assume a linear and continuous change, however numerous factors are unknown, that's why this, over-simplified future perspective is hardly supported.

In our opinion in strategic planning of Hungarian agricultural systems, and within this framework at least two factors should be taken into consideration. These are summarised in Table 9. Of course the lowest probability can be attributed to the "optimal" combination, and to the best our knowledge the only realistic scenario seems to be the parallel energy and climatic crises (Figure 5). This new conditions involve a need for re-thinking all older paradigms, joining to economic development of societies.

Acknowledgement

The research has been supported by OTKA T049396 project.

Authors are grateful to Mr Jozsef Popp for his comments.

References

(1) Bendahan, S. – Camponovo, G. – Pigneur, Y. (2004): Multi-issue actor analysis: tools and models for assessing technology environments. Journal on Decisiom Systems 13(4) pp. 871-892. – (2) Dinya L. (2006): Innovációs klaszterek az agrárgazdaság szerkezetváltásában [Innovation clusters in structural change of agricultural economy] 10th International Scientific Days of Agricultural Economics, CD publication – (3) Dinya L. – Domán Sz. – Fodor M. – Tamus A.-né (2006): Az alternatív energiaforrások lakossági megítélése [Consumers' opinion on alternative energy resources] Marketing és Menedzsment, 34(4) pp. 37-48 – (4) Dinya L. (2005): Regionális versenyképesség a hálózati gazdaságban [Regional competitiveness in network economy] Gazdálkodás, 49, (13), 22-30. – (5) Domán Sz. – Tamus A.-né (2002): Marketing alapismeret. Jegyzet, SZIE GMFK Gyöngyös, 261 p. – (6) EC (1996): Commission Green Paper of 20 November 1996 on renewable sources of energy [COM (96) 576] – (7) EC (1997): Commission Communication of 26 November 1997 on energy for the future: renewable sources of energy – White Paper for a Community strategy and action plan [COM(97) 599] – (8) EC (2004): Commission Communication of 26 May 2004 on the share of renewable energy in the EU. Commission Report in accordance with Article 3 of Directive 2001/77/EC – evaluation of the effect of legislative instruments and other Community policies on the development of the contribution of renewable energy sources in the EU and proposals for concrete actions [COM(2004) 366] – (9) EC (2006): Commission Communication of 10 January 2007: „Renewable Energy Road Map. Renewable energies in the 21st century: building a more sustainable future" [COM(2006) 848] – (10) Einschenk, G. (1986): Der ökonomische oder der ökologische weg? Agrarwirtschaft, 11(3), pp. 321-327 – (10) Faostat data http://faostat.fao.org – (11) Frank J. (1999): A napraforgó biológiája, termesztése. [Biology and growin of Sunflower] (Ed.: Frank J.) Mezőgazda Kiadó, Budapest, p. 422. – (12) Godet, M. (2001): Manuel de prospective stratégique. Paris, Dunod – (13) Johnson, C. – Melendez, M. (2007): E85 Retail Business Case: When and Why to Sell E85, Report, US Department of Energy, Alternative Fuels and Advanced Vehicles Data Center p. 97. – (14) Hajdu I.-né (1982): Vezetési ismeretek [Managemnet methods], Kertészeti Egyetem, Budapest, p. 150. – (15) Lak-

ner, Z. – Kóbor, K. (1993): „The possibilities and chances of a Hungarian bioethanol program" Acta Agronomica Hung., 42 (3), 419-31. – (16) Di Lucia, Lorenzo – Nilsson, Lars J.: Transport biofuels in the European Union: The state of play: Transport Policy 14 (6) 533–543 – (17) OECD-FAO: Agricultural outlook, 2007-2016; Rome-Paris, p.190. – (18) Popp, J. – Potori, N. (2007): A GM növények (elsősorban a kukorica) termesztésének és ipari felhasználásának közgazdasági kérdései Magyarországon. [Economic problems of production and indusrial use of GM plants in Hungary, with special emphasis on maise], Magyar tudomány, 59 (4) p. 451-462. – (19) Ryan, L. – Convery, F. – Ferreira, S. (2006): Stimulating the use of biofuels in the European Union: Implications for climate change policy, Energy Policy, 34(17) pp. 3184-3194 – (20) Steenberghen, T. – Lopez, E. (2008): Overcoming barriers to the implementation of alternative fuels for road transport in Europe Journal of Cleaner Production 16(4). p. 577-590. – (21) Steenblink, R.: Government support for ethanol and biodiesel in selected OECD countries A synthesis of reports addressing subsidies for biofuels in Australia, Canada, the European Union, Switzerland and the United States, International Institute for Sustainable Development, Global Support Initiative 2007 September Winnipeg, Manitoba p. 98. – (22) Tamus A.-né. (2000): Termékpolitika [Product policy], SZIE GMFK, Gyöngyös, 48 p. – (23) Word Bank (2006) World development indicators, Washington D.C.

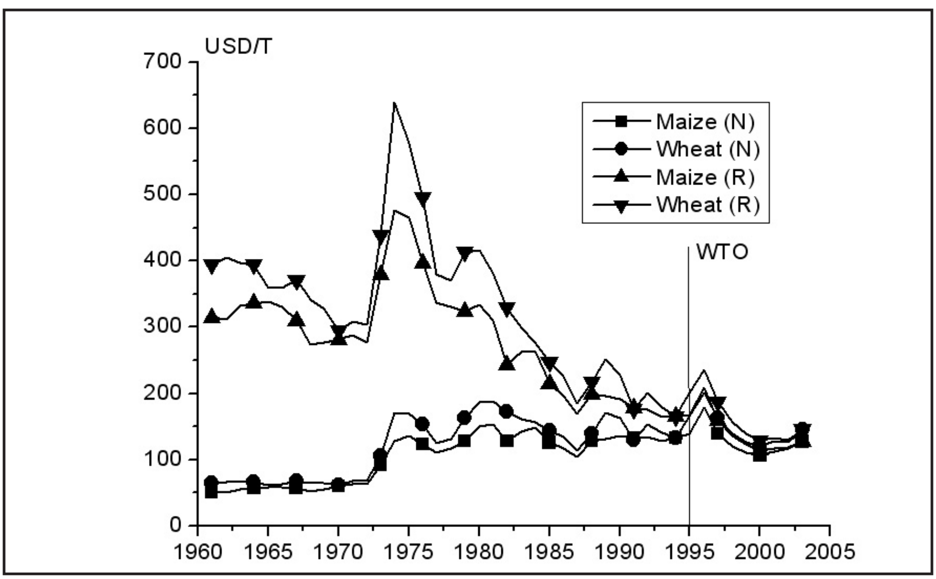
Address:

Lakner Zoltán, egyetemi docens, Budapesti Corvinus Egyetem, Élelmiszertudományi Kar Élelmiszeripari Gazdaságtan Tanszék, 1118 Budapest, Villányi út 35-43., Tel.: 1/209-0961, Fax: 1/209-0961, E-mail: zoltan.lakner@uni-corvinus.hu

Vizvári Béla, egyetemi docens, Eötvös Lóránd Tudományegyetem, Természettudományi Kar Operációkutatási Tanszék, 1117 Budapest, Pázmány Péter sétány 1/c., Tel.: 1/209-0555/8575, Fax: 1/209-0555/8056, E-mail: vizvari@cs.elte.hu

Figure 1

Nominal (N) and real (R) world-market prices of maize and wheat



Source: own calculations, based on FAO integrated database www.fao.org and Word Bank database

Table 1

The land-endowment in some European states

Country	Arable land (ha) per capita	Country	Arable land (ha) per capita
Ukraine	0.665	France	0.308
Belarus	0.564	Czech Republic	0.300
Hungary	**0.465**	Ireland	0.287
Denmark	0.425	Slovakia	0.265
Bulgaria	0.421	Greece	0.248
Romania	0.420	Austria	0.171
Poland	0.360	Italy	0.144
Ukraine	0.665	Germany	0.143
Spain	0.335	United Kingdom	0.097

Source: own calculations, based on FAO integrated database www.fao.org

Table 2

The structure of land-use according to the basic model (ha)

Counties	Potato	Wheat	Maize	Barley	Rye	Sugar beet	Sunflower seed
Baranya	801	35645	85592	20024	0	1557	11401
Borsod-Abauj-Zemplén	1,413	64120	31766	28744	955	1685	48915
Békés	332	119,959.8	94,620	25,600	100	4,705	18,756.23
Bács-Kiskun	2,634	81,858	91,240	24,970	8,373	5,856	40,378
Csongrád	4,810	68,616	57,789	12,020	6,205	2,523	21,929
Fejér	339	77,835	38,609	17,934	425	0	35,851
Győr-Sopron-Moson	1,849	41,320	54,359	32,837	1,576	8,506	14,236
Hajdú-Bihar	2,001	78,118	114,508	0	2,640	11,533	14,766
Heves	0	46,353	0	10,750	165	0	33,350
Komárom-Esztergom	540	30,405	27,311	1,732	690	1,605	7,880
Nógrád	850	16,323	0	5,409	451	0	7,853
Pest	5,748	62,515	6,214.38	0	7,043	2,922	34,650
Somogy	1,064	0	102,919	14,425	1,380	609	12,287
Szolnok	1,210	86,257	48,200	24,112	269	4,167	78,021
Szabolcs-Szatmár	3,146	0	99,648	0	10,152	2,010	0
Tolna	518	35,803	94,133	11,974	579	1,768	0
Vas	633	0	28,596	25,186	1,400	3,392	6,200
Veszprém	1,087	0	26,320	12,875	1,630	235.2	7,040
Zala	1,582	0	43,993	0	0	0	4,576
Total	30,557	845,127	1,045,818	268,592	44,033	53,074	398,090

Source: own calculations, based on 1-6 equations

Table 3

The optimal structure of land usage without the individual constraints of crops by counties (ha)

Counties	Potato	Wheat	Maize	Barley	Rye	Sugar beet	Sunflower seed
Baranya	0	0	155,020	0	0	0	0
Borsod-Abauj-Zemplén	0	177,599	0	0	0	0	0
Békés	0	174,076	61,718	0	28,279	0	0
Bács-Kiskun	0	255,311	0	0	0	0	0
Csongrád	0	0	0	0	0	0	173,892
Fejér	0	65,879	0	105,115	0	0	0
Győr-Sopron-Moson	23431	0	0	131,252	0	0	0
Hajdú-Bihar	0	0	175,949	0	0	47,617	0
Heves	0	0	0	0	0	0	0
Komárom-Esztergom	0	0	70,163	0	0	0	0
Nógrád	0	0	0	0	0	0	54,190
Pest	0	167,136	0	0	0	0	0
Somogy	0	0	171,803	0	0	0	0
Szolnok	0	0	0	0	0	0	154,370
Szabolcs-Szatmár	0	0	0	0	0	0	0
Tolna	0	0	144,775	0	0	0	0
Vas	0	0	102,785	0	0	0	0
Veszprém	0	0	0	0	0	0	0
Zala	0	0	85,800	0	0	0	0
Total	23431	840,000	968,013	236,367	28,279	47,617	382,452

Source: own calculations, based on 1-6 equations

Table 4

The basic model with assumption of one million ton of additional demand for maize, not taking into account county-constraints

Counties	Potato	Wheat	Maize	Barley	Rye	Sugar beet	Sunflower seed
Baranya	0	0	155,020	0	0	0	0
Borsod-Abauj-Zemplén	0	177,599	0	0	0	0	0
Békés	0	64,748	171,045.2	0	28,278.86	0	0
Bács-Kiskun	0	255,311	0	0	0	0	0
Csongrád	0	0	0	0	0	0	173,892
Fejér	0	88,467.67	0	82526.33	0	0	0
Győr-Sopron-Moson	0	0	0	154,683	0	0	0
Hajdú-Bihar	0	0	223,566	0	0	0	0
Heves	0	0	0	0	0	0	0
Komárom-Esztergom	0	0	70,163	0	0	0	0
Nógrád	0	54,190	0	0	0	0	0
Pest	0	201,930	0	0	0	0	0
Somogy	0	0	171,803	0	0	0	0
Szolnok	0	2,003.845	0	0	0	0	209,088
Szabolcs-Szatmár	0	0	0	0	0	55970	0
Tolna	0	0	144,775	0	0	0	0
Vas	0	0	102,785	0	0	0	0
Veszprém	0	0	0	0	0	0	0
Zala	26,923	0	85,800	0	0	0	0

Source: own calculations, based on 1-6 equations

Table 5

The key actors of biofuel-program

Name	Abbreviation	Remark
European Union	EU	
Non-european biofuel producers	Brazil	Some producers of the (first of all, but not exclusively: Brazil) are highly cost competitive. According to the data of Ryan et al. (2005) the price of bioethanol from Brazilian sugar cane at the filling station 294€/1000 l, in case of other products between 1171-1448 €/l.
Hungarian agricultural producers	Agric	
Hungarian Ministry of Finance	MF	In our model this institute embodies of the organs of public administration (centre of force) whose main mission is the maintenance of central budget
Average consumer	Avcon	Put it in another words: the voter, the citizen
Global environmental organisations and treaties	GEO	Governmental or non-governmental organisations and inter-governmental treaties
Hungarian environmental protection agencies	HUEN	Governmental or non-governmental organisations

Source: own compilations

Table 6

Matrix of direct influences of actors (the cells represent the intensity of influence of actor in the row to the actor in the respective column on a 0-4 scale)

	EU	BRASIL	AGRIC	MF	AVCON	GEO	HUEN
EU	0	2	3	3	1	1	1
BRASIL	2	0	1	0	1	1	1
AGRIC	0	0	0	0	1	0	0
MF	0	0	3	0	2	0	0
AVCON	1	0	0	1	0	0	1
GEO	3	2	0	0	0	0	0
HUEN	1	0	1	0	0	0	0

Source: expert-interview

Table 7

Set of goals of different participants

Name	Abbreviation
Decreasing of carbon-dioxide emission	CO2 min
Extensification of agricultural production	Extagr
Maintenance of revenue of agricultural producers	Agrrev
Decreasing of energy –dependence	Enindep
Maintenance of biodiversity	Biodiv
Maintenance of agricultural production, because this is the cheapest way of environmental protection (Weinschenck, 1986)	Agricprod
Import –liberalisation; WTO regulation	Implib
Workplace-creation	Work
Formation of clusters (Dinya, 2006)	Clusters
Cheep products	Cheep
Optimal utilisation of agro-ecologic potential	Agroec
Stabilisation of balance of payment of the state	Budget

Source: expert-interview

Table 8

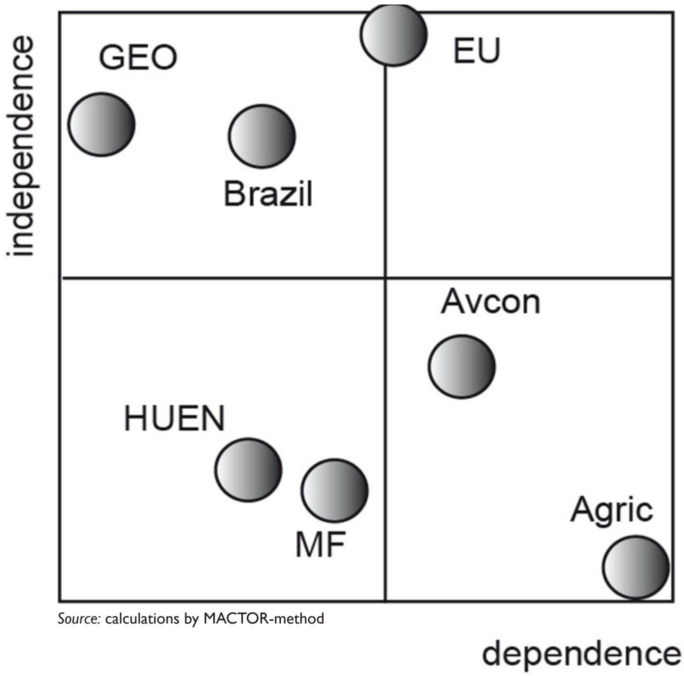
The valued position matrix of actors (explication in the text)

Actor	CO2 min	Extagr	Agrev	Enindep	Biodiv	Agricprod	Implib	Work	Clusters	Cheep	Agroec	Budg.
EU	4	2	4	4	1	1	3	2	1	0	0	1
BRASIL	3	0	0	0	0	0	4	0	0	0	0	0
AGRIC	0	0	3	4	0	1	-4	0	3	0	4	0
MF	0	4	0	-2	0	0	0	0	0	0	0	4
AVCON	0	0	0	0	1	0	1	1	0	4	0	0
GEO	4	0	0	0	0	0	4	0	0	0	0	0
HUEN	0	4	0	0	4	0	0	0	0	0	0	0

Source: own calculations, based on MACTOR-method

Figure 2

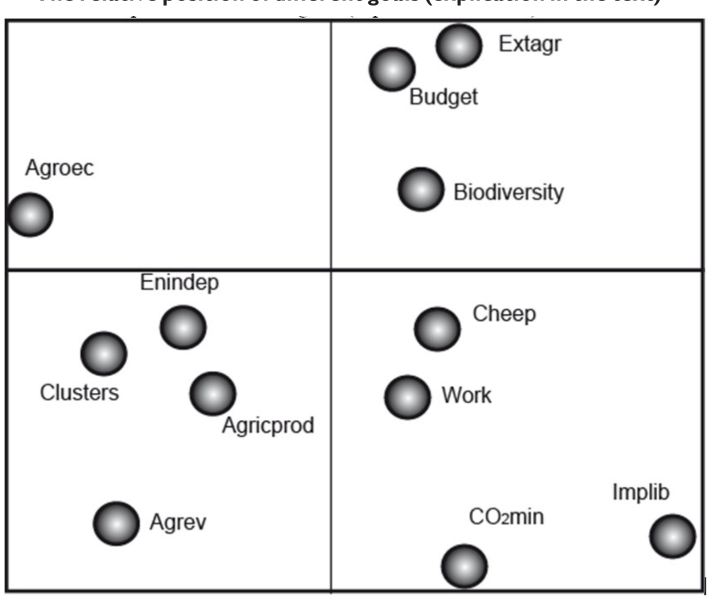
The dependence-independence matrix



Source: calculations by MACTOR-method

Figure 3

The relative position of different goals (explication in the text)



Source: calculations by MACTOR-method

Table 9

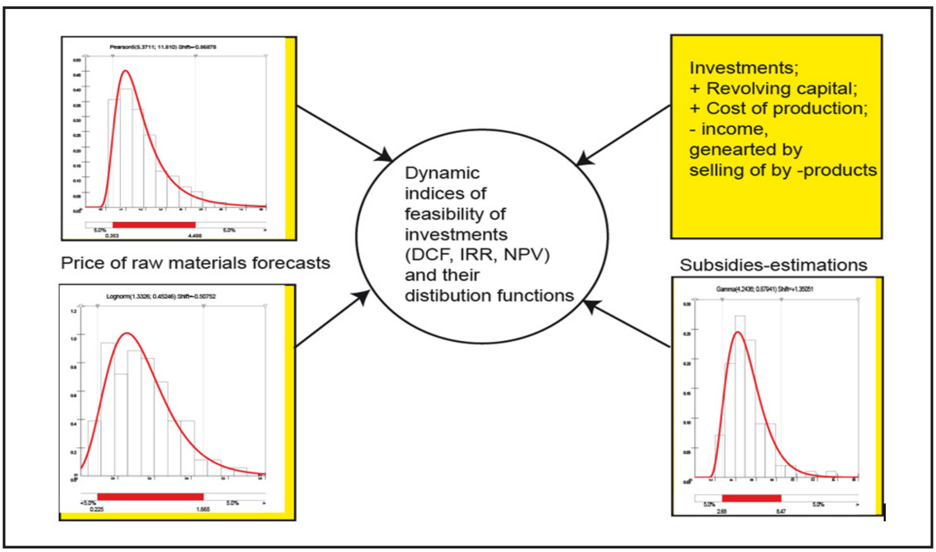
Policy instruments and their application in European Union for promotion of biofuel programs

Policy instruments	Member states applying the policy instrument
Tax incentives	21
Biofuels obligations	9
Production subsidies	6
Investment grants for conversion plants	4
Research and development	14
Biofuels quality standards	2
Biofuels use in public fleets	4
Congestion and parking fees reductions	1
Filling stations availability	1
Public relations activities	3

Source: Di Lucia – Nillson, 2007

Figure 4

Conceptual model for modelling of economic feasibility of biofuel-production investment



Source: own model

Figure 5

Simplified possible long-range scenarios of Hungarian agriculture

		Climate	
		Stability	Global warming
Balance of energy demand and supply	Energy demand increases linearly, parallel with resources available	The „optimal" situation main goal of agricultural policy: quality –oriented differentiating strategy	Increasing importance of traditional agricultural production. Main goal: satisfaction of increasing food and feed demand,
	Drastic increasing of energy demand	Increasing importance of energy –crop production	Global warming and energy crisis

Source: own model