Some economic aspects of the Hungarian biofuel programs

Lakner, Zoltán – Szabó-Burcsi, Dóra – Magó, László

Keywords: comparative analysis, simulation, return on investment, welfare economics..

SUMMARY FINDINGS, CONCLUSIONS, RECOMMENDATIONS

The use of renewable materials in energy production is gaining in importance all over the world. The production of bioethanol and biodiesel is an important element of the agricultural strategy of numerous countries, even though the economic and environmental impact of these projects is subject to significant debates. Our paper analyses the welfare effects of the Hungarian bioethanol programme, as well as the economic feasibility of the projects. It can be demonstrated that the Hungarian bioethanol programme will cause a rather marginal increase in agricultural prices.

The cost of bioethanol production is estimated between 470 and 630 €/m3, influenced by numerous factors. This estimate is in line with the average European values. The possibilities for reducing costs are rather limited, as the two most important components are raw material costs and energy costs. The return on investment indicators are most favourable in the case of small-scale, farm based ethanol plants, producing DSG as a by-product with a simple technology, and in case of extremely large-capacity plants.

INTRODUCTION

The climate change and energy supply are among the most important global challenges *(Blottnitz – Curran, 2006).* That's why all over the world there are intensive efforts to increase the share of renewable energy resources in energy portfolio. Governments of developed states are willing and able to mobilise considerable resources for enhancement of (supposedly) environmental–friendly energy-generating capacities. However, there are considerable debates on the environmental aspects of different renewable energy resources, the intensity of these efforts can be well demonstrated by the fact, that e.g. in Germany the investments for development and installation of renewable energy-generating capacities in 2008 were 160 €/capita, 2.22 times higher, than in Hungary the total per capita investments into the total energy sector (72 €/capita) in the same year (own calculations, based on *Linkohr et al., 2009* and *HCSO, 2006*).

The use of agricultural materials for fuel -like an undercurrent- has been present in the international and Hungarian professional public opinion for a long time (*DEFRA, 2003*). Roots of biofuel-use for internal combustion engine are as old as the engine-driving itself. It is well-documented, that ethanol as an alternative fuel was developed before the discovery of petroleum by *Edwin Drake* in 1859. Henry Ford envisioned automobiles that relied on ethanol as their fuel source. The term “biodiesel” is not a new one, too. The history of using vegetable oil extends back to the discovery of the diesel engine by *Ru-*

dolf Diesel. The first diesel–engine had been tested using peanut oil (*Songstad et al., 2009*).

There have been three important waves of use of bio-fuels as energy resources in last hundred years: (1) the war-periods, when the energy self-sufficiency became a strategic question, (2) the years of energy price increasing in the seventies resurrected interest in ethanol production all over the world. (3) from the middle of nineties of the last century, when the growing apperception of global warming, increasing international pressure to decrease the export-subsidy of agricultural products, and the sophistication of production technology further enhanced the public interest towards the biofuel production. In last years the biofuel production of the world has been increased in an extremely dynamic way (Fig. 1). As a consequence of technological development and the increasing of crude oil price the producer prices of gasohol and bio-ethanol during the present time are practically the same in the US (Fig. 2).

The professional public opinion is highly divided concerning the practical application of potential food and feed raw materials for energy production. Some years ago there has been an intensive debate on price-modifying effects of biofuel programs. The *Outlook Report for 2007-2016 of FAO-OECD* highlighted, that growth in the use of agricultural commodities as feedstock to a rapidly increasing biofuel industry is one of the main drivers in perspective and one of the reasons for international commodity prices to attain a significantly higher plateau over the outlook period. *Rosegart* (*2008*) argues, that the removal of policies in Europe promoting biofuels and the ethanol blending mandates and subsidies and ethanol import tariffs in the United States would contribute to lower food prices.

In our previous communication (*Lakner – Vizvári, 2007*) we have highlighted the importance of system-based approach, and the extreme high level of vulnerability of agricultural producers in biofuel-programs. That's why in our current article we focus on effects of biofuel programs of market equilibrium and on the microeconomic aspects of production.

The structure of this article is as follows: in the first part we analyse the welfare –effects of bio-fuel programs on the agricultural production sphere on example of bioethanol. In the second part the economic aspects of different production-technologies and capacities will be analysed.

METHODOLOGY

Estimation of potential effects of bioethanol-project on agricultural market

The basic paradigm of our research on effects of bioethanol–program on income –position of agricultural producers is the welfare economics. According to the fundamental principles of microeconomics, the demand function for a market is the relationship between the price of the commodity and the quantity of it demanded (*Wonnacott, 1978*). Likewise the supply function is the relationship between the price of the commodity and the quantity of it supplied. The demand and supply functions can be represented as curves in a graph. Let p_{eq} and the q_{eq} the price and quantity where the demand and supply curves intersect. Let D(p) be the demand function for the market and S(p) the supply function. The equilibrium under conditions of this model is depicted on Fig. 3. Suppose that the demand for the product will increase, causing a shift of demand function from D(p)to D(p)'. This process will increase the point of equilibrium q_e to point q'_e. The producer surplus will be the area p_e, E, E', p'_e.

The operalisation of the theory of supply-demand equilibrium was as follows: The basic raw material for bioethanol production is the corn in Hungary, that's why we have analysed this market. According to the basic microeconomic assumptions, to maximise profits, the firm chooses the output, where marginal costs equal with marginal revenues. For a firm (in our case a farm) in a perfectly competitive industry (for simplicity, we assumed the Hungarian corn-market as a competitive one), marginal revenue is equal the prices. Put in another way: a firm in a perfect competition produces, where the marginal costs are equal with marginal prices, and these are equal with market prices. The relatively high number of maize-producing firms offers to assume a perfect competitive market of agricultural farms. The supply function of raw materials has been based on data-base of *Hungarian Research Institute of Agricultural Economics* (aki.gov.hu; individual data supply). The *Hungarian Farm Accountancy Data Network* (FADN), is an integral part of statistical system of the European Union. The Hungarian FADN system consists of ca. 1900 sample farms and represents more than 87 thousand agricultural holdings over 2 European Size Unit. These farms cultivate ca. 93% of territory of Hungary. Data have been supplied for 30 size-categories of farms. The marginal costs of these farm-categories in 2008 served as inputs for determination of supply function.

The demand function has been determined on historical prices of last eighteen years. We have tested some more wider time-windows, but in our opinion the fitting of regression function was rather poor. This fact can be explained by the deep-rooted structural transition of Hungarian maize market in last decades. For comparability, the nominal prices have been re-calculated by consumer price-based index of inflation to the price level of 2008. Theoretically, the determination of comparable prices could be carried over by using another proxies of the changing value of money in time. A possible solution would be the application of core inflation index or the of the price index with constant tax-content. However the *Hungarian National Bank* calculates the core inflation index only from 1995. Between the consumer price index and the core inflation index a rather strong (r^2=0.9869) correlation could be determined, that's why the changing of index of inflation would not had caused a considerable change in the calculations. The intersection point of two curves has been considered as the theoretical market-equilibrium. A similar method of estimation has been applied by *Borbély (2007)* to estimate the welfare and redistributional effects of the sugar-market reform of the European Union.

Estimation of profit and risk of bioethanol plant investment

The most widely used method in evaluation of an investment proposal is to compute the net present value (NPV) at a chosen interest rate of all inflows expected form the investment and of all outlays required (*Hajdu I.né, 1980, 2010*). The excess of the present value of profits over the present value of investments is known as the net present value of the investment; this quantity may either positive or negative in sign. A positive net present value means that the investment will yield a return higher than the chosen rate; if the NPV is zero at the chosen discount rate indicates that the company could not achieve a positive return.

$$\mathrm{NPV} = \sum_{i=1}^{i=n} \mathrm{CF_i}(1+\mathrm{d})^{-i} \qquad (1)$$

where

CF – the cash flow (profit and amortisation) in th year

C- capital invested in jth year

d- discount rate

i- number of years

n- total duration of period investigated (in years)

It is evident that the choice of an appropriate rate of discount is crucial to the net present value method, since a given investment may have a positive or negative NPV depending on the interest rate used to discount cash flows. In general, the investment rate chosen should be the minimum rate of return that the company is willing to accept for an investment, given the degree of risk involved. At the margin, this minimum rate should be the cost of capital, which is defined as the cost (expressed as a yield rate) of obtaining the necessary investment funds, whether through borrowing additional equity investment, or retention of earnings.

The internal rate of return (IRR) is an alternative technique for use in making capital investment decisions, which also takes into account the time value of money. The internal rate of return is the investment rate when used to discount all cash flows resulting from an investment. It will equate the present value of the cash receipts to the present value of cash outlays. In other words, it is the discount rate which will cause the net present value of an investment to be zero.

In calculation of IRR we determine the value of d when the

$$\sum_{i=1}^{i=n} \mathrm{CF_i}(1+\mathrm{d})^{-i} = 0, \qquad (2)$$

Alternatively, the internal rate of return can be described as the maximum const of capital which can be applied to finance a project without causing harm to the shareholders. The specialists have different opinions on the preference of NPV or IRR methods. For example *Brailey and Mayers (1980)* prefer NPV, *Bálint (1988)* prefers IRR approaches. In broad sense, risk analysis is any method – quantitative and/or qualitative – for assessing the impacts of risk on decision situations. The risk in general is the quantifiable likelihood of loss or less-than-expected returns. In its broadest sense the expression "risk" means the possibility of suffering harm or loss: danger (*Podruzsik – Kasza, 2009*). Risk in such is an integral part of our lives in general and the agricultural enterprises in particular. The economic analysis of research of risk in agriculture has long traditions, and because it can only be estimated as a stochastic variable, simulations seem to be the only possibility of estimation of effects of different stochastic variables on profitability of the enterprise.

In practice the importance of risk is often under-estimated, however according to theorem of the reliability of future estimations are highly risk –sensitive. This can be expressed by equation as follows:

where

$N_t = N_o q^t$

where

N_t = the reliability of prognosis in t^{th} interval;

N_o = the initial biass of estimation;

q = factor, expressing the increasing of bias in time

t = number of time periods.

Based on this equation the reliability of estimations can be calculated. It is obvious, that this value decreases extremely rapidly even if we calculate with moderate initial un-reliability values.

To minimise the biases of estimation we have applied the method of triangulation in process of estimation of different technical and economic parameters. This is based on approach, when two or more independent methods are uses in a study with a view to double (or triple) checking results. This is also called cross examination. In line with this approach we have different data sources, and in case of contradiction we double-checked the results. We have considered the in-and output variables of estimations as stochastic ones. That's why we have been able to estimate not only the expected value of different indicators of capital investment, but also their distributions –functions, too. 100 simulations have been carried over, by software @Risk™˙.

Different models of bioethanol-production have been analysed on base of technical materials of Vogelbusch firm for industrial-size bioethanol-plants. This Austrian based engineering company has a wide experience in bioethanol industry. We have purposefully chosen this firm, because it can be considered as a forerunner of bioethanol technology in European market.

The economic indicators have been determined based on trend analysis and the comparative analysis of international costs and prices. Based on this resources some model estimations have been determined, which were shown to four Hungarian specialists. They have been asked-based on data of literature-to estimate five parameters: the type of distribution, estimated mean (μ) and standard deviation (σ); the possible minimal (I_{min}) and maximal (I_{max}) values.

For international comparability the experts' estimations have been re-calculated to Euro on base of official average-exchange rate in 2009: 1 HUF=275.54 Ft.

There are various technical and technological solutions for bioethanol production. The bioethanol-production systems can be classified on base of different attributes. The most important possibilities of csoportosít are as follows:

- type of the feedstock of production;
- type of the dehydration;
- technology of by-product processing;
- size of the bioethanol-plant.

There is a wide range of potential feedstock for bioethanol production. For practical purposes, it seemed to be only the processing of maize as a feasible alternative.

The technologies of dehydration show a high level of diversity. The most important technologies are: azeotropic distillation, extractive distillation, molecular sieves. In modern bio ethanol plants the application of molecular sieves are used (*Hahn-Hägerdal et al., 2006*). The most important advantage of this method is the considerable energy-saving, that's why we have used this method in each and every case.

There are two main solutions of by-product processing: the direct addition of by –products (distillers' grains and solubles, DGS) as a low –cost waste feedstocks or adjacent cattle feedlots that can utilise the stillage directly. In this case the bioethanol plants are built on a site –specific basis for conditions at hand. Another method of by-product processing is the production of distillers dried grains with solubles (DDGS). The DDGS production needs a considerable investment and energy, but the product has a relatively high (35%) crude protein content. Studies and experiences (especially from the USA) show that this kind of animal feed is well suited as feed for cattle, pigs and poultry (*Geiß, 2007*). Its market is relatively stable, but (due to the lack of generally accepted quality standards) the exact and comparable price-statistics is not available (*Popp, 2007*).

We have analysed two basic models of bioethanol-production: the farm-based, small-capacity alternative with direct utilisation of fermentation by products for animal feeding and the large-scale, industrial technology, with the condensing and drying at least three-fourths of the solids of the resultant whole stillage.

There are considerable differences between the capacities of industrial plants, that's why we have chosen four industrial-scale alternatives, ranging from 60 to 720 m^3/day.

The technology of bioethanol production in case of farm-based plant is much more simpler, because there is no need for treatment of by-products. The relatively small size of the production plant does not necessitate considerable additional investments. In this case the costs of raw-material transportation are marginal.

In case of industrial technologies the basic operations and technology parameters are the same, because in this size –category the basic characteristics of the operations do not change with the size of the processing units. The experts estimated a practically linear increasing of average transportation distance of raw material. In case of small-scale industry plant (60 m^3/day) the 10 km average distance means a circle with 314 km^2. Calculating with a 8 t/ha yield, only 71 km^2 would be enough for satisfaction of the feedstock demand of the plant, but there should be taken into consideration of the points of view of crop rotation, too. In case of extreme-large capacity production plant the assumption of a 40 km average distance can be modelled by a circle of 5064 km^2 as production area. The raw–material demand of this plant can be satisfied by corn production on 17% of this area. As a summary it can be stated, that this estimation of average transportation distances lives room for avoidance of monocultural production.

The determination of output-ethanol-price have been based on world-market trends. The DDGS price determination has been more difficult, because in lack of generally accepted quality standards the price of this products.

RESULTS

Welfare-effects of the Hungarian bioethanol-program from point of view of produces

It is obvious, that the supply function can be approximated by a simple linear equation (Fig. 4).

In case of demand-function there are two ways of approximation. The relatively simplest possibility is to apply a linear function, but in this case the fitting of regression is relatively poor (Fig. 5). Another possibility is the application of a more complicated function. In our case the best solution seeped to apply a logistic function (Fig. 6). The economic interpretation of this function is relatively simple and important: the price-elasticity of demand rapidly decreases with increasing of the quantity offered, that's why in zone of high production quantity the price –changing is minimal.

The equilibrium of the system is in the intersection point of the supply and demand functions (Fig. 7).

Applying the linear approximation for demand and supply function, we have to solve the model:

$15648+9.878\ 10^{-4}\ q_e = 63279.53-0.00424\ q_{e.}$

Under the above conditions we can calculate the (theoretical) equilibrium price (p_e) at the equilibrium quantity (q_e) which is ~24 660 Ft at q_e = 9 110 thousand t production.

If we try to determine the equilibrium, based on assumption of logistic function between the supply and market price, than the form of equation will be as follows:

$$15648+9.878\cdot 10^{-4} = 22411.14536+\frac{3903510-22411.145}{1+\left(\frac{q_e}{351191.4522}\right)^{2.02236}}$$

In this case the equilibrium will be at 10 650 thousand t maize and 25 420 Ft/t, respectively.

At an average the gasoline consumption in Hungary in period 1990-2007 has been 1430 kt. If we calculate with 5% of substitution of this gasoline, it will be equivalent with 71 500 t gasoline, not considering the differences in energy – content, the value of which is highly debated in literature. To produce this quantity we need a 258 kt plus maize production. If we use the linear approach of the supply function, than the new equilibrium will be at q'_e=9368 kT quantity and p_e =24 901 Ft price. It means that the bio bioethanol program would mean a 240 Ft/T price increasing. The producer-surplus is 240×9110+240× 258/2=2.217 billion HUF.

If we apply the logistic approach, than the market-price change will be much more smaller. These facts do not support the preliminary concerns over the drastic price-increasing effects of the Hungarian bio-ethanol program.

The costs and cost-structure of bioethanol-programs

The analysis of cost structures of different technological plants highlights the possibilities and limits of cost – decreasing of bioethanol-production under current Hungarian circumstances (Table 1). The most important part of costs is the raw material. Its share is at least half of the direct costs of production. The transportation costs in farm –based bioethanol plant are marginal, but their importance is increasing parallel with the capacity of bio-ethanol plant. In case of extra-large plants the share of transportation is nearly 6 per cent of total direct costs of production. Of course, theoretically this fact could be reduced, but in this case there is a danger of further increasing of formation of monocultural areas. There are only limited possibilities of decreasing the energy demand, because the Vogelbuch technology is in the cutting age of bioethanol production worldwide. In case of farm-scale plant, there is some extra-electric energy demand. This can be explained by economy-of scale effects. The decreasing of energy costs could be achieved by application of renewable materials for vapour production, this is only approximately 12-17 per cent of total direct costs.

If we take into consideration of price of by-products, the total costs of bio-ethanol approximately 470-650 €/m^{3}. With these values, the cost of Hungarian bio-ethanol production falls within the interval of costs of European bio-ethanol production programmes (Table 2). This means that Hungary is not able to show a specific cost-advantage in this field. as a consequence of similarities of row material price and the same technological solutions. That's why the vulnerability of Hungarian bio-ethanol projects is relatively high, because it heavily depends on market entry barriers of the European Union.

Economic feasibility and risk of bio-ethanol plants

Based on expert estimations the 550 €/m^3 bioethanol-priec seemed as an acceptable starting point for further investigations. Below these vaules only the farm-size and the large-scale capacity plants are able to generate a positive revenue.

The different indicators of economic feasibility of farm-scale bioethanol-plant are favourables (Fig. 8). This can be explained by the relatively tow investment-costs of these plants, the simple technology and the low costs of transportation. The DGS production is much more simpler than the DDGS processing. A necessary precondition of the practical realisation of such type construction is the presence of an animal breeding plant in the physical proximity of the production plant, because there is no possibility of transportation of DGS as a consequence of its relatively high water content. As we see the input-price and the by-product (DSG) price are not formed in a market-determined bargain, because the agricultural producer, the bioethanol-plant owner and the animal-breeder is the same person. This fact highlights the importance of real calculations. In lack of this the artificially formed prices can highly distort the economic feasibility of investment.

In case of larger (industry-scale) production capacities we see a rather high level of decreasing of costs as a function of the production capacities. This can be explained by technological properties. The cumulative density functions of investments show a practically predictable economic failure, but in case of bioethanol-plant, having a 180 m^3/day capacity. the investment is about the Hungarian average rate of return (Fig. 9). In case of large-scale (360 m^3/day) and extra-large (720 m^3/day) capacities these values are even more favourable. At the same time it should be emphasized. that the risk of larger-scale bioethanol-plant is much higher. This is expressed in fact. that the spread of the cumulative density function is much more wider than in former cases.

From factors influencing the economic feasibility of investments the most important ones are the price of ethanol and the DDGS (Table 3). The importance of transportation distance is increasing with size of the plants. As a consequence of high importance of investment costs on feasibility of bioethanol-plants the organisation of bioethanol-plant projects is crucial.

Table 1

Cost-structure and income models of bioethanol production

	Technology and plant-size alternatives				
	farm-based ethanol-plant	small-scale ethanol plant	middle-scale ethanol plant	large-scale ethanol plant	extra-large scale ethanol-plant
daily production capacity (m^3)	μ= 15; σ= 5; l_{max}= 25	μ= 60; σ= 10; l_{min}= ; l_{max}= 70	μ= 180; σ= 24; l_{min}= 80; l_{max}= 240	μ= 360; σ= 72; l_{min}= 300; l_{max}= 460	μ= 720; σ= 144; l_{min}= 300; l_{max}= 780
number of production-days (d)	μ= 333; σ= 10; l_{min}= 300; l_{max}= 350	μ= 333; σ= 10; l_{min}= 300; l_{max}= 350	μ= 333; σ= 10; l_{min}= 300; l_{max}= 350	μ= 333; σ= 10; l_{min}= 300; l_{max}= 350	μ= 333; σ= 10; l_{min}= 300; l_{max}= 350
total yearly production (thousand m^3)	4.99	20.0 0	μ= 59.90	119.88	239.76
costs of raw material (€/t feedstock)	μ= 80; σ= 14; l_{min}= 50; l_{max}=100	μ= 98; σ= 14; l_{min}= 70; l_{max}=150	μ= 98; σ= 14; l_{min}= 70; l_{max}=150	μ= 98; σ= 14; l_{min}= 70; l_{max}=150	μ= 98; σ= 14; l_{min}= 70; l_{max}=150
yield (t feedstock/m^3 ethanol)	μ= 2.85; σ= 0.29; l_{min}= 2.7; l_{max}=3.14	μ= 2.85; σ= 0.285; l_{min}= 2.7; l_{max}=3.14	μ= 2.85; σ= 0.285; l_{min}= 2.7; l_{max}=3.14	μ= 2.85; σ= 0.285; l_{min}= 2.7; l_{max}=3.14	μ= 2.85; σ= 0.285; l_{min}= 2.7; l_{max}=3.14
Distillery grain with solubles (DGS/DDGS yield t/m^3 ethanol)	μ= 1.80; σ= 0.16; l_{min}= 0.6; l_{max}= 0.94	μ= 0.78; σ= 0.156; l_{min}= 0.6; l_{max}= 0.95	μ= 0.78; σ= 0.156; l_{min}= 0.6; l_{max}= 0.95	μ= 0.78; σ= 0.156; l_{min}= 0.6; l_{max}= 0.95	μ= 0.78; σ= 0.156; l_{min}= 0.6; l_{max}= 0.95
raw material costs. calculated to bioethanol (€/m^3)	228.0	279.3	279.3	279.3	279.3

transportation (€/tkm)	μ= 0.25; σ= 0.3; l_{min} = 0.15; l_{max} = 0.38	μ= 0.25; σ= 0.3; l_{min} = 0.15; l_{max} = 0.38	μ= 0.25; σ= 0.3; l_{min} = 0.15; l_{max} = 0.38	μ= 0.25; σ= 0.3; l_{min} = 0.15; l_{max} = 0.38	μ= 0.25; σ= 0.3; l_{min} = 0.15; l_{max} = 0.38
average transportation distance (km)	μ= 10; σ= 3; l_{min} = 2; l_{max} = 12	μ= 10; σ= 4; l_{min} = 10; l_{max} = 30	μ= 20; σ= 8; l_{min} = 10; l_{max} = 40	μ= 30; σ= 10; l_{min} = 10; l_{max} = 50	μ= 40; σ= 20; l_{min} = 10; l_{max} = 100
total transportation costs (€/t)	2.5	2.5	5.0	7.5	10.0
transiportation costs on bioethanol (€/m³)	7.12	7.13	14.25	21.38	28.50
total row material costs (€/t)	82.5	100.5	103.1	105.5	108.0
Row material costs to bioethanol (€/m³)	235.21	286.50	293.50	300.68	307.80
vapour demand (t/m³)	μ= 5.45; σ= 0.55; l_{min} = 5; l_{max} = 6.5	μ= 5.45; σ= 0.545; l_{min} = 5; l_{max} = 6.5	μ= 5.45; σ= 0.545; l_{min} = 5; l_{max} = 6.5	μ= 5.45; σ= 0.545; l_{min} = 5; l_{max} = 6.5	μ= 5.45; σ= 0.545; l_{min} = 5; l_{max} = 6.5
vapour price ˙(€/t)	μ= ;12.8 σ=2.8 3.84 ; l_{min} = 6; l_{max} = 15	μ= ;12.8 σ= 84 ; l_{min} = 6; l_{max} = 15	μ= ;12.8 σ= 3.84 ; l_{min} = 6; l_{max} = 15	μ= ;12.8 σ= 3.84 ; l_{min} = 6; l_{max} = 15	μ= ;12.8 σ= 3.84 ; l_{min} = 6; l_{max} = 15
vapour costs (€)	69.76	69.76	69.76	69.76	69.76
electric energy demand (kWh/m³)	μ= 420; σ= 15; l_{min} = 270; l_{max} = 380	μ= 310; σ= 15; l_{min} = 270; l_{max} = 380	μ= 310; σ= 15; l_{min} = 270; l_{max} = 380	μ= 310; σ= 15; l_{min} = 270; l_{max} = 380	μ= 310; σ= 15; l_{min} = 270; l_{max} = 380

electric energy price (€/kWh)	μ= 0.13; σ= 0.03; l_{min} = 0.1; l_{max} = 0.28	μ= 0.13; σ= 0.026; l_{min} = 0.1; l_{max} = 0.28	μ= 0.13; σ= 0.026; l_{min} = 0.1; l_{max} = 0.28	μ= 0.13; σ= 0.026; l_{min} = 0.1; l_{max} = 0.28	μ= 0.13; σ= 0.026; l_{min} = 0.1; l_{max} = 0.28
electric energy costs (€/m³)	54.63	40.30	40.30	40.30	40.30
water demand (m³/ m³)	μ= 4; σ= 0.8; l_{min} = 3.2; l_{max} = 6	μ= 4; σ= 0.8; l_{min} = 3.2; l_{max} = 6	μ= 4; σ= 0.8; l_{min} = 3.2; l_{max} = 6	μ= 4; σ= 0.8; l_{min} = 3.2; l_{max} = 6	μ= 4; σ= 0.8; l_{min} = 3.2; l_{max} = 6
water and waste water costs (€/m³)	μ= 5; σ= 1; l_{min} = 4; l_{max} = 7	μ= 5; σ= 1; l_{min} = 4; l_{max} = 7	μ= 5; σ= 1; l_{min} = 4; l_{max} = 7	μ= 5; σ= 1; l_{min} = 4; l_{max} = 7	μ= 5; σ= 1; l_{min} = 4; l_{max} = 7
Total water costs (€/m³)	20	20	20	20	20
chemicals. yiests and other materials (€/m³)	μ= 26; σ= 7.8; l_{min} = 15; l_{max} =50	μ= 26; σ= 7.8; l_{min} = 15; l_{max} =50	μ= 26; σ= 7.8; l_{min} = 15; l_{max} =50	μ= 26; σ= 7.8; l_{min} = 15; l_{max} =50	μ= 26; σ= 7.8; l_{min} = 15; l_{max} =50
Proportional costs	407.49	444.85	μ=474.19	458.73	465.86
costs of material pre-finance as a percentage of raw material costs	μ= 5; σ= 2.5; l_{min} = ; l_{max} = 30	μ= 5; σ= 2.5; l_{min} = ; l_{max} = 30	μ= 5; σ= 2.5; l_{min} = ; l_{max} = 30	μ= 5; σ= 2.5; l_{min} = ; l_{max} = 30	μ= 5; σ= 2.5; l_{min} = ; l_{max} = 30
costs of revolving capital (€/m³)	20.37	22.22	22.58	22.94	23.29
total direct costs (€/m³)	427.86	466.70	474.19	481.67	489.15
share of maintenance costs as a percentage of investments costs	μ= 2; σ= 0.4; l_{min} = 1; l_{max} = 4	μ= 2; σ= 0.4; l_{min} = 1; l_{max} = 4	μ= 2; σ= 0.4; l_{min} = 1; l_{max} = 4	μ= 2; σ= 0.4; l_{min} = 1; l_{max} = 4	μ= 2; σ= 0.4; l_{min} = 1; l_{max} = 4

labour –demand (capita)	μ= 4; σ= 2;l_{min} = 5; l_{max} = 3	μ= 18; σ= 4;l_{min} = 10; l_{max} = 20	μ= 26; σ= 8 ;l_{min} = 20; l_{max} = 32	μ= 30;= 12 l_{min}10; l_{max} = 20	μ= 42;= 12 l_{min}38; l_{max} = 50
average wage (thousand €/cap/year)	μ= 24; σ= 6; l_{min} = 18; l_{max} = 30	μ= 24; σ= 6; l_{min} = 18; l_{max} = 30	μ= 24; σ= 6;l_{min} = 18; l_{max} = 30	μ= 24; σ= 6; l_{min} = 18; l_{max} = 30	μ= 24; σ= 6; l_{min} = 18; l_{max} = 30
fix living labour costs (thousand€/year)	96	432	624	720	1080
investment costs (10⁶ €)	μ= 1.785; σ= 0.150; l_{min} = 1.4; l_{max} = 2.5	μ= 31.63; σ= 6; l_{min} = 25; l_{max} = 45	μ= 48.49; σ= 18; l_{min} = 35; l_{max} = 60	μ= 31.63; σ= 6; l_{in} = 25; l_{max} = 45	μ= 105.63; σ= 6; l_{in} = 25; l_{max} = 45
rate of amortisation (%)	μ= 12; σ= 2.4;l_{min} = 10; l_{max} = 18	μ= 12; σ= 2.4;l_{min} = 10; l_{max} = 18	μ= 12; σ= 2.4;l_{min} = 10; l_{max} = 18	μ= 12; σ= 2.4;l_{min} = 10; l_{max} = 18	μ= 12; σ= 2.4;l_{min} = 10; l_{max} = 18
yearly amortisation (10^6 €)	0.21	3.79	5.81	8.34	12.66
total fixed costs (10^6 €)	0.35	4.86	7.41	10.32	15.79
ethanol unit price (€/m^3)	μ= 550; σ= 55; l_{min} = 400; l_{max} = 700	μ= 550; σ= 55; l_{min} = 400; l_{max} = 700	μ= 7.40; σ= 55; l_{min} = 400; l_{max} = 700	μ= 550; σ= 55; l_{min} = 400; l_{max} = 700	μ= 550; σ= 55; l_{min} = 400; l_{max} = 700
DDGS (in case of farm-based plant: DGS) price (€/m^3)	μ= 15; σ= 10; l_{min} = 5; l_{max} = 140	μ= 80; σ= 16; l_{min} = 60; l_{max} = 140	μ= 80; σ= 16; l_{min} = 60; l_{max} = 140	μ= 80; σ= 16; l_{min} = 60; l_{max} = 140	μ= 80; σ= 16; l_{min} = 60; l_{max} = 140
Income from ethanol (10^6 €)	2.75	10.99	32.97	65.93	131.86
Income from DGS/DDGS	0.13	1.25	3.74	7.48	14.96
Total income	2.88	12.24	36.70	73.41	146.82
Profit (10^6 €)	0.57	-1.29	0.87	5.32	13.75

Source: Expert estimations, based on current industrial technologies

Table 2

The different estimations of costs and producer price of bioethanol in Europe

Source	Definition	Cost or price (€/m³ pure ethanol)
Prévot et al. (2005)	France; costs	500
Klenk and Kunz (2008)	Germany; price	572
Heilmann (2006)	Germany; price	600
	price in US	750
Stark (2006)	Germany;break-even point in case of Sugar-been based bioethanol -production:	550
	estimated costs of production (original data in USD/l recalculated by authors on base 1€=1,3 USD)	
Henniges (2007)	Germany	424-514
Popp (2008)	Brazil	231-246
	USA	269-308
	China	308-423
	India	500-538
	EU	730-846
Popp-Somogyi (2007)	USD/l	231-246
	Brazil	230-308
	USA	461-477
	EU	461-677
	India, China	308-346
European Biomass Industry Association (2004)	European average	530

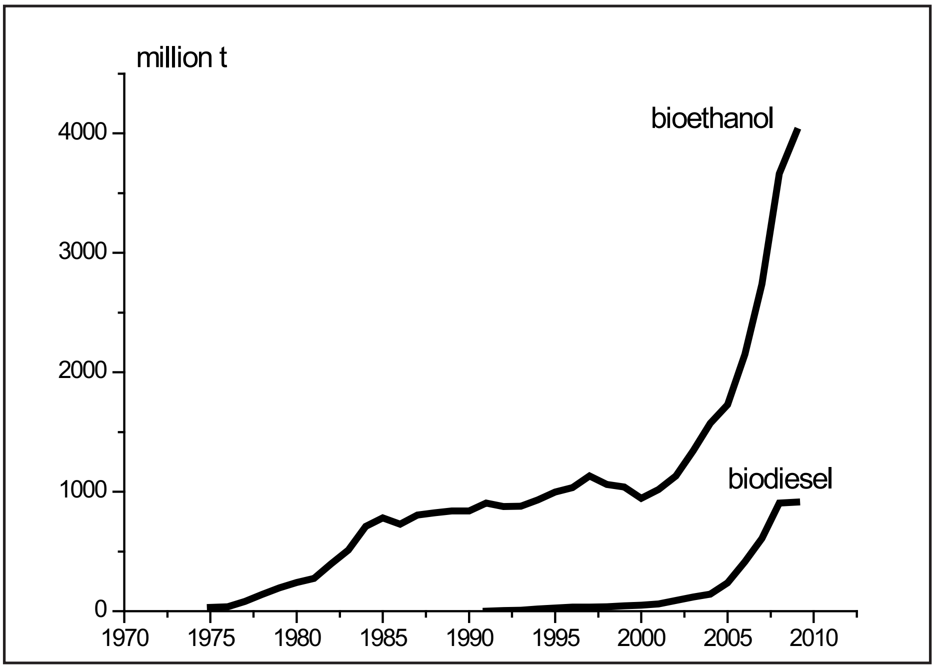
Table 3

Sensitivity analysis of different investments as a function of influencing Factors on net present value

Factors	Capacity (m³/day)			
	60	180	360	720
cost of investment	-0.948	-0.801	-0.742	-0.613
ethanol price	0.604	0.642	0.662	0.720
raw material cost	-0.448	-0.481	-0.434	-0.515
daily production	0.174	0.205	0.242	0.172
vapour price	-0.116	-0.071	-0.045	-0.025
yield	0.133	0.082	0.031	0.002
transportation cost	-0.092	-0.111	-0.164	-0.244
DDGS price	0.139	0.208	0.278	0.277
finance of revolving capital	-0.121	-0.121	-0.143	-0.293
average distance of transportation	-0.034	-0.064	-0.086	-0.143

Figure 1

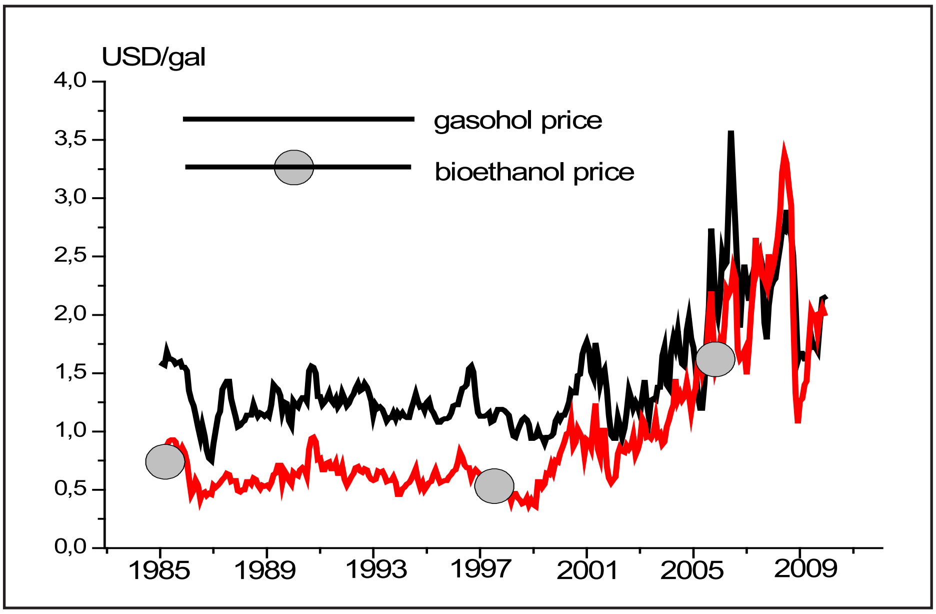
The bioethanol and biodiesel production of the world



Source: Earth policy institute; http://www.earth-policy.org/index.php?/data_center/C21/

Figure 2

The producer price of gasohol and bioethanol in the US



Source: own compilation, based on market information

Figure 3

Theoretical effect of biofuel-programs on market-equilibrium of agricultural raw materials

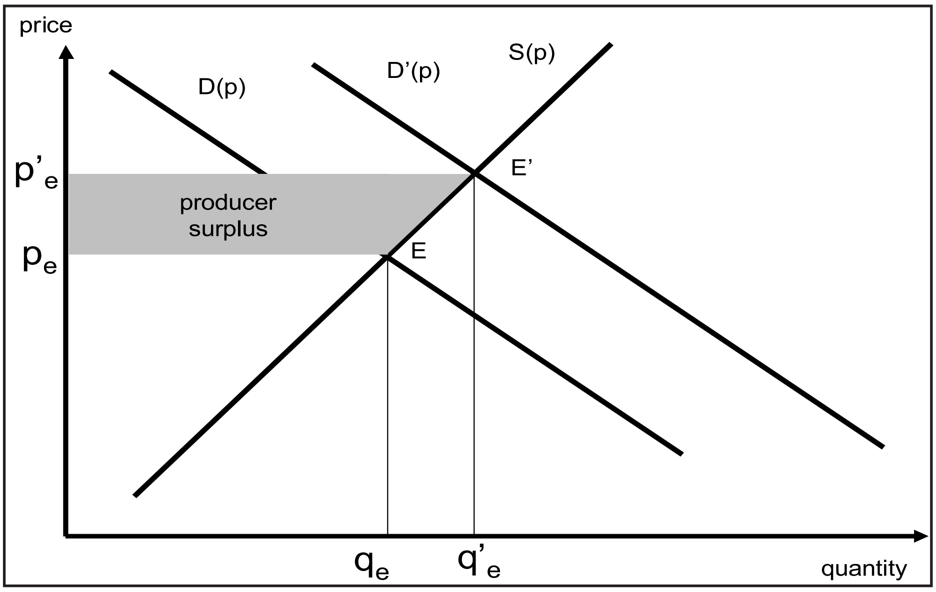
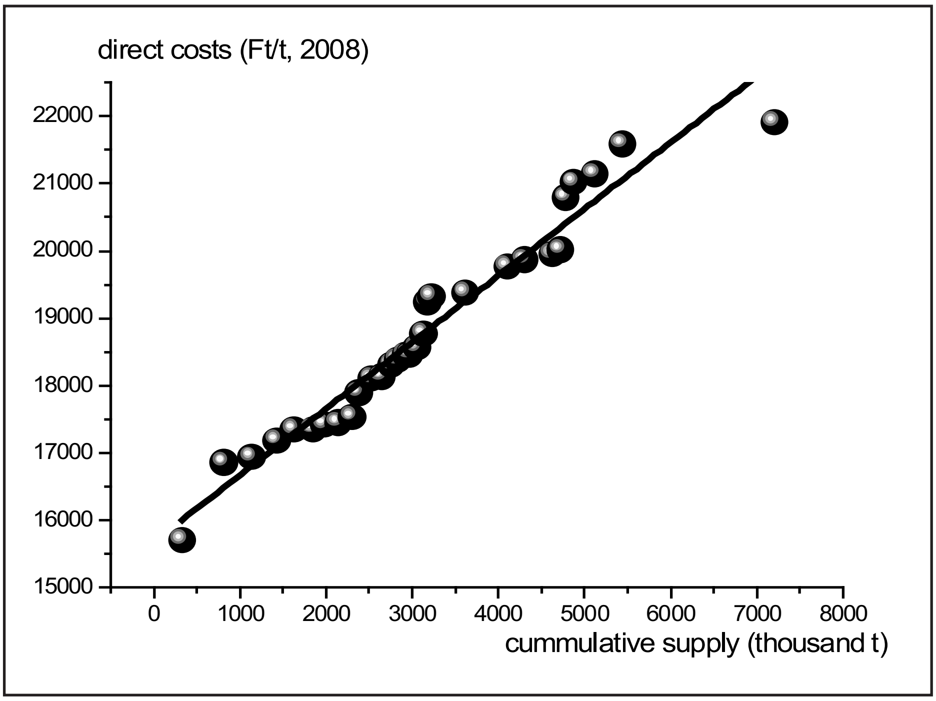


Figure 4

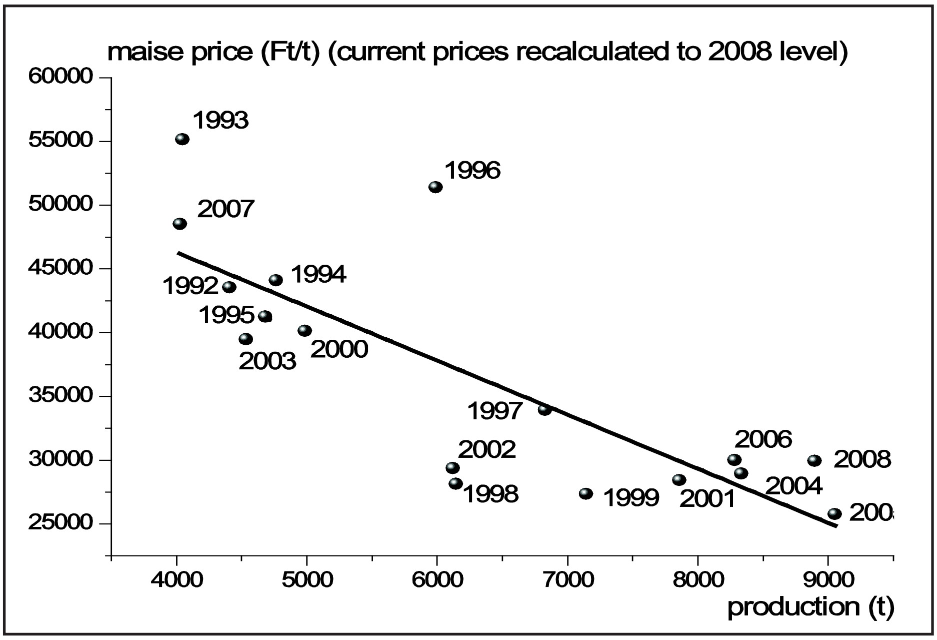
Estimation of demand function of maize in Hungary by linear funciton (r^2=0.94)



Source: own calculations, based on database of AKI

Figure 5

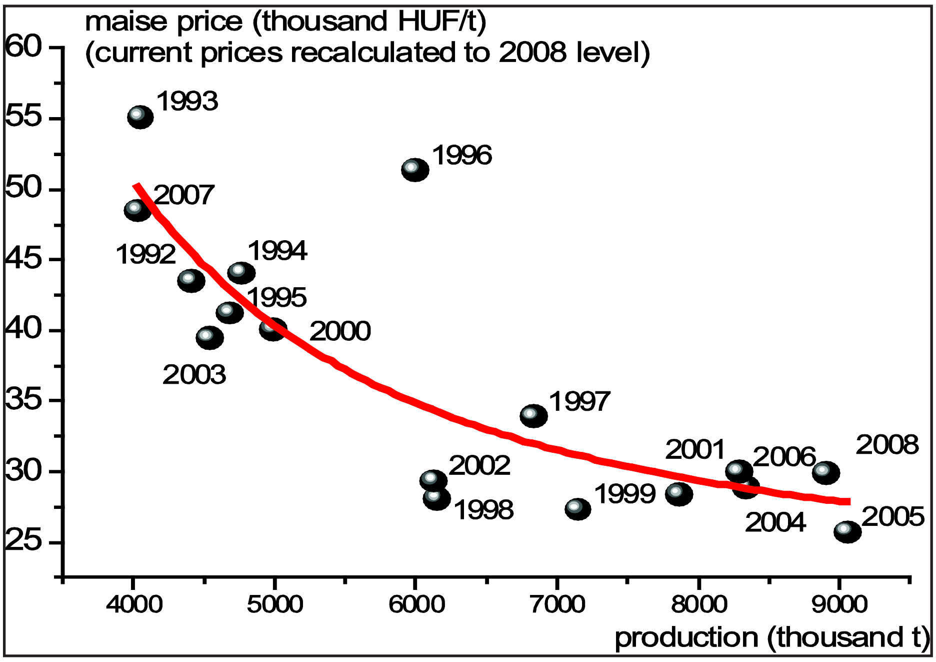
Estimation of demand function of maize in Hungary by linear function (r^2=0.62)



Source: own calculations, based on data of HCSO yearbooks 1991-2008

Figure 6

Estimation of demand function of maize in Hungary by logistic function (r^2=0.83)



Source: own calculations, based on data of HCSO yearbooks 1991-2008

Figure 7

Effect of different factors on net present value of small-scale. farm-based bioethanol plant

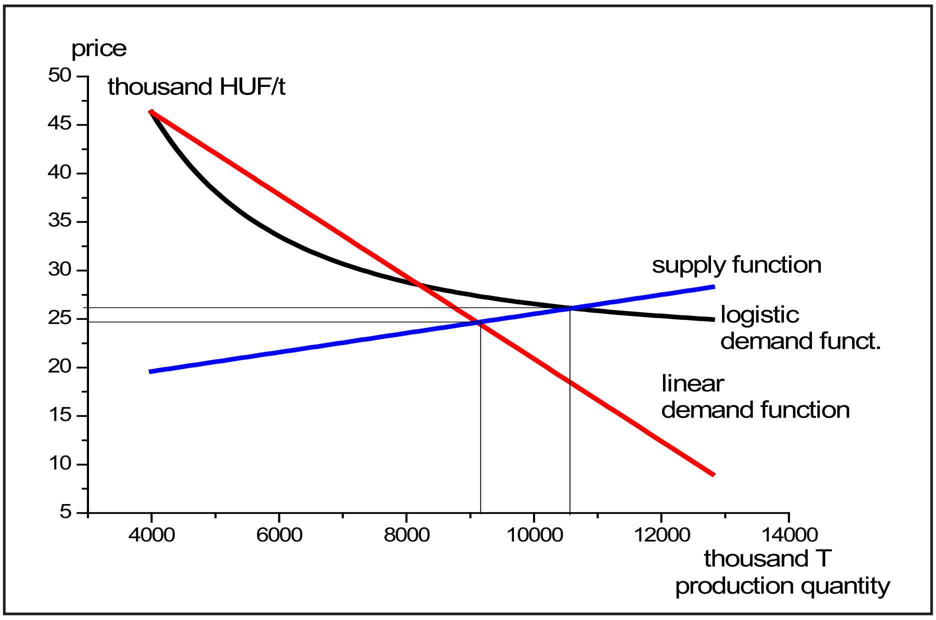


Figure 8

Results of economic feasibility analysis by simulations of farm-scale bioethanol-plants

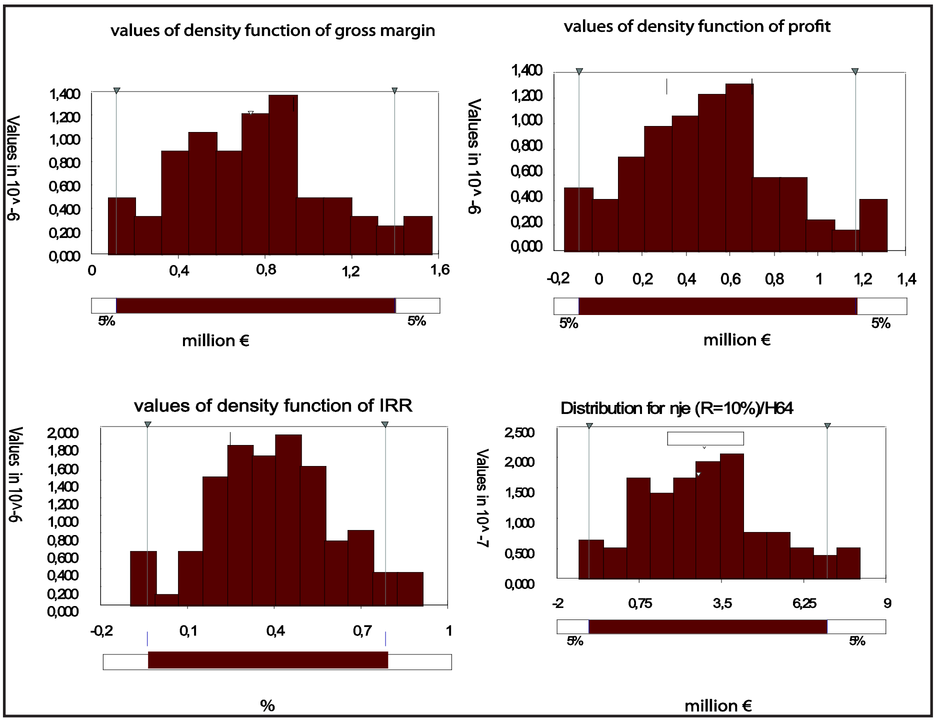
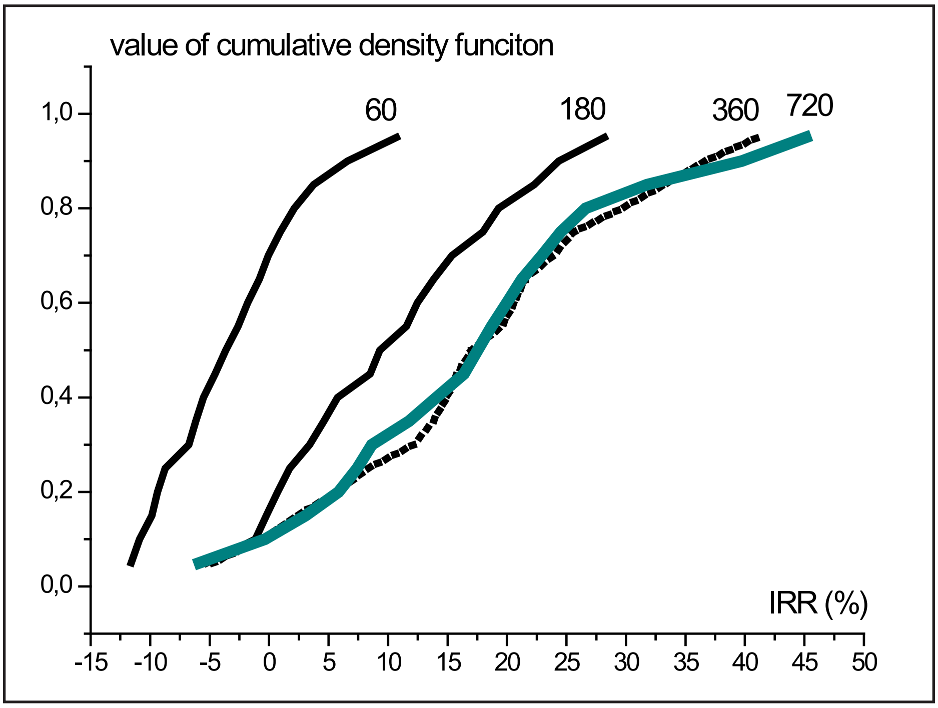


Figure 9

The value of cumulative density functions of bioethanol plants with different daily production capacity (in m³)



REFERENCES

(1) Bálint J. (1988): Korszerű üzemelemzési módszerek a kertészetben. [Modern entreprise-analysis methods in horticulture] CSc thesis, Budapest, 86. p. – (2) Blottnitz, H. V. – Curran, M. A. (2006): A review of assessments conducted on bio-ethanol as a transportation fuel from a net energy, greenhouse gas, and environmental life cycle perspective. Journal of Cleanaer Production, 15, 607-619. p. – (3) Borbély Á. (2007): Az Európai Unió cukorpiaci reformjának elosztási és strukturális hatásai. [Sugar-market reform of the European Union; its structural and welfare effects] Gazdálkodástani Doktori Iskola-Agrár Specializáció. Budapest Corvinus University, Budapest, 130. p. – (4) Brailey, M. – Mayers, V. (1990): Modern vállalati pénzügyek I. [Modern Corporate Finance] Bankárképző, Budapest, 530. p. – (5) Defra (2003): Liquid biofuels – industry support, cost of carbon davings and agricultural implications. Prepared for the Department for Environment, Food and Rural Affairs (defra). www.defra.gov.uk/farm/acu/research/reports/biofuels_industry.pdf. (last accessed: 11.04.2010) – (6) European Bioethanol Agency (EUBIA): Bioethanol http://www.eubia.org/212.0.html (Last accessed: 11.04.2010) – (7) FAO-OECD (2006): Agricultural Outlook 2007-2016, Paris-Rome – (8) Geiß, M. (2007): Wirtschaftlichkeit regenerativer Energien am Beispiel Bioethanol. Hamburg, Diplomatica Verlag GmbH. 151. p. – (9) Hahn-Hägerdal, B. – Galbe, M. – Gorwa-Grauslund, M. F. – Lidén, G. – Zacchi, G. (2006): Bio-ethanol – the fuel of tomorrow from the residues of today. Trends in Biotechnology, 24, 549-556. pp. – (10) Hajdu I.né (1980): Gazdasági elemzés. [Economic analysis] Kertészeti Egyetem, Budapest, 110. p. – (11) Hajdu I.né (2010): Borászati gazdaságtan. [Wine Economics] Alfadat-Press, Budapest, 324. p. – (12) Heilmann, H. (2006): Überlegungen zur bioethanol-Zuckerrübenproduktion. http://www.agrarnet-mv.de/var/plain_site/storage/original/application/f920a7d6424fc3ff7d7d400ca4df338f.pdf (last accessed: 11.04.2010) – (13) Henniges, O. (2007): Profitability of bioethanol-a national and international comparison of production and production costs. Agrarwirtschaft, 56 (5-6) 249-254. pp.

– (14) Klenk, I. – Kunz, M. (2008a): Europäisches Bioethanol aus Getreide und Zuckerrüben – eine ökologische und ökonomische Analyse. Sugar Industry 133, 625–635. pp. – (15) Lakner Z. – Vizvári B. (2007): Application of decision support methods in preparation for a Hungarian bio-fuel programme. Gazdálkodás, 52. spec. edition No. 22. 47-61. pp. – (16) Linkohr, C. – Musiol, F. – Ottmüller, M. – Zimmer, U. – Memmeler, M. – Mohrbach, E. – Moritz, S. – Schneider, S. (2009): Erneubare Energien in Zahlen. Bundesministerium für Umweltschutz, Naturschutz und Reaktorsicherheit, Berlin – (17) Podruzsik Sz.. – Kasza Gy. (2008): Alapelvek az élelmiszerbiztonsági kockázatok gazdasági értékeléséhez. [Principles to economic valuation of foodborne risks] Élelmezési Ipar 2. , 41-44. pp. – (18) Popp J. (2007): Bioetanol és biodízel: áldás vagy átok? [Bioethanol and biodiesel: blessing or curse] (I.). = Agrofórum. Extra 18. Bioenergia. 2. 1. 5-13. pp. – (19) Popp J. (2008): Bioüzemanyag-gyártás – a piaci folyamatok tükrében. (Bio-energy production in mirror of market-processes) Fiatal gazda Konferencia, Budapest, www.szilberhorn.com/bio-uzemanyag.../bio-uzemanyagok.ppt (Last accessed: 11.04.2010) – (20) Popp J. – Somogyi A. (2008): Bioetanol és biodízel az EU-ban: áldás vagy átok? [Bioethanol and biodiesel in the EU: blessing or curse] Zöldtech www.zoldtech.hu/cikkek/20070425biouzemanyagok/.../biouzemanyagok.doc (Last accessed: 11.04.2010) – (21) *Prévot,* H. – *Hespel,* V. – *Dupré,* J-Y. – Baratin, F. – Gagey, D. (2005): Rapport sur l'optimisation du dispositif de soutien à la filière biocarburants. Conseil Général des Mines, Inspection générale des finances, Conseil general du Génie rural des eaux et forêts, Paris, 120 p. – (22) Rosegart, M. W. (2008): Biofuels and Grain Prices: Impacts and Policy Responses. International Food Policy Research Institute. Testimony for the U.S. Senate Committee on Homeland Security and Governmental Affairs, Washington D. C., 5. p. – (23) Songstad, D. D. – Lakshmanan, P. J. C. – Gibbons, W. – Hughes, S. – Nelson, R. (2009): Historical perspective of biofuels: learning from the past to rediscover the future. In Vitro Cellular & Developmental Biology-Plant, 45, 189-192. pp. – (24) Stark, G. (2006): Bioethanol aus zuckerrüben-überlegungen aus der Sicht des Marktes. http://www.lfl.bayern.de/iem/agrarmarktpolitik/20256/linkurl_0_20.pdf (last accessed: 11.04.2010) – (25) Wonnacott, P. – Wonnacott, R. (1976): Economics. New York, McGraw-Hill Book Co., 845. p.

ADDRESS:

Dr. Lakner Zoltán, egyetemi docens, Budapesti Corvinus Egyetem, Élelmiszertudományi Kar, Élelmiszeripari Gazdaságtan Tanszék

associate professor, Corvinus University of Budapest, Faculty of Food Sciences, Department of Food Economics

1118 Budapest, Villányi út 35-43., Tel.: +36-1-209-0961, Fax: +36-1-209-0961, E-mail: zoltan.lakner@uni-corvinus.hu

Szabó-Burcsi Dóra, PhD hallgató, Budapesti Corvinus Egyetem, Élelmiszertudományi Kar, Élelmiszeripari Gazdaságtan Tanszék

Ph.d. student, Corvinus University of Budapest, Faculty of Food Sciences, Department of Food Economics

1118 Budapest, Villányi út 35-43., Tel.: +36-1-209-0961, Fax: +36-1-209-0961, E-mail: dora.szabo2@uni-corvinus.hu

Magó László, osztályvezető, FVM Mezőgazdasági Gépesítési Intézet, Növénytermelés Gépesítése Főosztály

head of department, Hungarian Institute of Agricultural Engineering, Section of Mechanisation of Plant Production

2100 Gödöllő, Tessedik S. u. 4., Tel.: +36-28-511-601, Fax: +36-28-511-600, E-mail: laszlomago@fvmmi.hu