University doctoral (PhD) dissertation abstract

COMPLEX ANALYSIS OF THE HUNGARIAN BIODIESEL SECTOR

Péter Jobbágy

Supervisor:
Dr. habil Attila Bai
associate professor

UNIVERSITY OF DEBRECEN
Ihrig Károly Doctoral School of Management and Business Administration

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1. RESEARCH OBJECTIVES AND BACKGROUND

Biofuels have been commonly used in the European Union for about ten years, however, their widespread use can be observed merely in the last six years. Efforts of the EU for achieving the Kyoto goals can be mentioned as room for their headway on the one hand and for gaining more energetic independency on the other hand. Numerous oil- and transport companies (e.g. airplane companies) have started to take part in research and development activities, which gave an additional push for the development of this sector.

Naturally some changes have taken place in land use patterns, commerce and in industry as well similarly to the widespread use of biofuels, which lead to an on-going scientific and social debate about biological fuels. However, despite the fierce scientific, political and social controversies, the market of biofuels of the 1st generation displayed unbroken development; even the global economic crisis could not stop its boom. Biodiesel sector has attained 3.2-fold increase since 2006, thus its output was 18 500 thousand tonnes in the last year. The growth seemed to stumble in 2012 but this can be ascribed rather to the shortage of resources due to the bad agricultural year than to economic circumstances. This opinion is supported by the prognosis of the F.O. Licht (2013) and FAPRI (2012), which forecast further production growth in middle distance.

In Hungary biofuels - bioethanol and biodiesel of the first generation - have been produced in major quantity for about five years. In the commerce of bioethanol (E85) was almost eight times increase in 2010, however, this growth has stopped and broken after the introduction (2011) and later the increase of excise duty for bioethanol, leading to a drastic fall in 2012. Pure biodiesel (B-100) has not been sold at Hungarian fuel stations; biodiesel has been sold only mixed with regular diesel fuel, thus the commerce of biodiesel can be considered significantly well-balanced, it has been mostly around 140-160 thousand t/a.

The Hungarian bioethanol sector was analysed deeply and comprehensively in the last time, but the analysis of the biodiesel branch in Hungary with similar thoroughness has not been carried out yet. However, the importance of this sector cannot be questioned. The Hungarian biodiesel output was 162 thousand t in the last year. Biodiesel factories worked with overall maximal capacity utilization, which is a remarkable result considering the average capacity utilization of the European biodiesel factories that was lower than 34% in the same period. Taking all of these into account, the complex economic analysis of the Hungarian biodiesel sector with some social aspects was set as the main objective of this Ph.D. thesis. The following hypothesis were taken in connection with the main objective:

H_1: The Hungarian biodiesel product line has only a few agents and the current market situation does not really allow the access of new agents, except for the market niche including the collection of residential used cooking oil.
H_2: Significant added value is produced on the biodiesel product line, but its distribution among the agents is not consistent.
H_3: The income generating capacity of certain processes of the product line is similar to the added value, however supports result in distorted high cost-related profitability in the case of the cultivation of oleaginous plants.
H_4: Job creation potential of transesterification is irrelevant (few persons) in itself, however considering the other agents of the product line – especially the agricultural raw material producers - as well as the indirect effects, it can provide livelihood for about 1000 persons.
H_5: Hungarian drivers basiacally relate to biofuels – within that to biodiesel - in a positive way, but their knowledge is incomplete in connection with them and they mostly have practical experience only in relation to E-85 fuel.

In the course of this dissertation I strove to adapt the latest and most relevant literature sources, thus my calculations are predominantly based upon data of 2012. In those cases when data of 2012 were not available (e.g. financial accounts, profit and loss accounts), I calculated on the basis of factual data of 2011.

The results of this thesis provide a comprehensive view on biodiesel sector. The future prospects of the sector are also genuinely outlined on the basis of in-depth interviews carried out with the employees in top positions of the factories. I expect that in terms of practical adaptability this work can be also useful over the restricted professional audience to the ordinary man inquiring after this topic. Moreover I hope it can help to make political and legal decisions, which have fundamental influence on the future of the sector.

2. MATERIALS AND METHODS

In the course of model constructions (added value, profitability, job creation) I relied on primary and secondary databases. Data originating from the conversations and in-depth interviews with the sectoral agents served as a basis for primary database. In conformity with my research objectives I visited the biodiesel factory of Inter-Tram Kft. in Mátészalka, the factory of Rossi Biofuel Zrt. in Komárom, the vegetable plant factory of Ökoil Material Production and Trading Co., Kft. as well as an enterprise – wished to remain anonymous - dealing with the collection of used cooking oil. The questionnaire composing the guide of the in-depth interviews in the course of factory visits included questions not only for objective data (capacity, utilisation, number of employees, raw materials), but also for the subjective opinion and future prospects of the employees in top positions.

2.1. Determination of added value

Definition of the Hungarian Central Statistical Office was taken for the basis of the determination of gross added value in biodiesel sector, in compliance with it *gross added value= gross output – intermediate consumption*. I composed models to calculate added value with regard to each agent of the sector. The parameters of the models were the following:

Oleaginous plant cultivation

- cultivation technology: planning model for crop cultivation developed in the Agronomy School of University of Debrecen Centre for Agricultural and Applied Economic Sciences and its predecessor institutions and the recommendations of hand book on arable technologies by KITE Zrt..
- nutrient requirements: during the determination of the quantity of required artificial fertilizer I considered the specific nutrient requirements indicated by KITE Zrt. as a normative quantity.
- rent of land: its measure was defined on the basis of the factual data of 2011 given by the Farm Accountancy Data Network of AKI.

- machinery costs: based on the study of VM GKI detailing agricultural machinery costs converting into II. area category.
- cost of input materials: were determined on the basis of prices of 2012 by KITE Zrt.
- general cost: I calculated with 12% general cost ratio on the basis of the Farm Accountancy Data Network of AKI, taking into consideration 7.2% general cost ratio, i.e. the 60% of it as intermediate consumption in the course of the determination of added value.
- average yield: the average yields of oleaginous plants were determined by averaging the national average yields of the period between 2007-2012 resting on the database of AKI.
- selling price: the price of oil seeds was determined as the mean of the market reports of AKI.

The basic model is based upon the semi-intensive cultivation technology being characteristic in Hungary. In sensitivity analysis I analysed ceteris paribus the development of added value in that case if farmers complied with the recommendations of KITE relating to cultivation technology.

Plant oil production

- selling price of plant oils: in case of sunflower oil the average market price based on the market reports of AKI, in case of rape seed oil the mean of market prices recorded in EUR by the UFOP expressed in HUF owing to the incompletion of AKI databases.
- selling price of oil grits: the average market price calculated by the market reports of AKI.
- selling price of sunflower seed shell: average selling price indicated by Ökoil Kft.
- selling price of mucilage: average selling price indicated by Ökoil Kft.
- purchase price of oil seeds: average market price calculated by the market reports of AKI.
- public utility costs: based on the annual report for 2011 of Ökoil Kft. (utilised services).
- cost of other input materials: from the annual report for 2011 of Ökoil Kft. all material inputs and calculated material costs minus public utility costs.

The basic model is based upon the real achievement of the enterprise producing biodiesel raw material. However, considering that the activity is losing on the basis of both the financial report and the model calculation, in sensitivity analyses I made an attempt at developing a more competitive model resting on close integration, in case of which the enterprise can buy oil seeds on a favourable price.

Collection of used cooking oil

- selling price of refined cooking oil: I calculated with a price of 900 EUR/t for 2012 based on the data collection in the biodiesel factory.
- selling price of watery fat: average price given by the enterprise dealing with the collection of used cooking oil.
- purchase price of used cooking oil: a sum determined by expert judgement on the basis of price range given by the enterprise dealing with the collection of used cooking oil.
- cost of other input materials: cost ratio per main activity from other material consumption based on the sales revenue from the annual report of the enterprise.
- public utility costs: cost ratio per main activity from public utility costs (utilised services) based on the sales revenue from the annual report of the enterprise.

As the Hungarian used cooking oil market is tightly oligopolistic in structure, purchase prices are unanimously determined by enterprises dealing with collection, thus the changes in prices are not worth being examined, since they are formed in compliance with the interests of the enterprises concerned. Therefore the effect of the change in oil quality was examined in sensitivity analyses.

Biodiesel production

As the agents of the sector typically register their costs in EUR, I constructed the model of added value in EUR as well and I expressed only the results in HUF on behalf of the mean of EUR-HUF exchange rate for 2012 by MNB.

- selling price of biodiesel: based on the mean of market prices being recorded in EUR by UFOP.
- selling price of glyceric stage: it was 60 thousand HUF on the basis of the data collected in the course of in-depth interviews.

- purchase price of plant oils: in case of sunflower oil the average market price based on the market reports of AKI was expressed in EUR, in case of rape seed oil the mean of market prices recorded in EUR by the UFOP owing to the incompletion of the AKI databases.
- purchase price of used cooking oil: I calculated with a price of 900 EUR/t based on the data collection in the biodiesel factory.
- purchase price of other input materials: the average purchase price of other input materials used in production was determined on the basis of purchase prices I managed to obtain during personal data collection in plants.
- public utility costs: on the basis of data I managed to obtain during personal data collection in plants.

In the course of sensitivity analyses I tried to quantify how the change in the selling price of biodiesel ceteris paribus influences added value. Primarily it seems to be practical to examine higher selling price, since biodiesel producers do not sell biodiesel on market price, but on price determined by a favourable price formula, thus the real added value is slightly also higher than one calculated by market prices.

2.2. Determination of cost, yield and income relations in the sector

Similarly to added value, production value, production cost, average cost, net income as well as cost-related profitability were determined separately to each sectoral agent. In the course of the calculation of the above-mentioned indicators I expanded models - developed for calculating added value, introduced in chapter 2.1. - with other costs to be taken into consideration (e.g. labour costs, amortization). In determination of average cost of oleaginous plant cultivation I did not consider the value of plant residues and I calculated with 8% general cost ratio. In case of plant oil production, purification of used cooking oil as well as biodiesel production I reckoned up the value of by-products during the determination of net production cost. Net income was calculated as the difference between production value and production cost based on the method of agronomy.

During the sensitivity analyses I considered the same aspects as during the sensitivity analyses of added value calculation, these are the following: complete compliance with the technology recommended by

KITE in oleaginous plant cultivation, possibility for price reduction in plant oil production by closer integration, the effect of oil quality in case of used cooking oil collection, the effect of the higher purchase price in the sensitivity analysis of the average cost of biodiesel production.

2.3. Quantification of the job creation potential

The model of NEUWAHL et al., 2008 further improved by BAI, 2009 was taken for the basis of the determination of the job creation potential of biodiesel sector. I tried to eliminate the incompletion of the model, i.e. the results mainly based on theoretical calculations as well as its limited adaptability for domestic conditions. Adaptation of this model without any review would leave out of consideration that biofuel plants in Hungary typically operate with foreign technology, i.e. the job creation effect of mechanical engineering is mostly realized outside of our boundaries on the one hand. On the other hand, reduction in transportation represents a significantly smaller extent, since inland logistics comes to the front instead of export- in which foreign carriers are also concerned.

In order to obtain results mostly complying with the real situation, direct job creation potential was determined on the basis of data from production. In the course of factory visits I collected real employment data as well as the effect of possible expansion potential on employment. Determination of job creation potential of used cooking oil collection per biodiesel production capacity unit caused some problem, since the current production in the Hungarian used cooking oil sector is about 10 000 t/a (solely based on restaurants, public institutions). However, if residential collection developed to a maximum level, output would be only 30 000 t/a in this case as well, so there would be need significant import quantity of used cooking oil, which does not create domestic workplaces. Therefore I did not consider the quantity of 30% (about 50 000 t/a) that can be theoretically incorporated, but the quantity (6%) collected from domestic sources in determination of job creation per biodiesel production capacity unit.

The job creation potential of oleaginous plant cultivation was determined by the transformed and simplified version of the planning model for crop cultivation in compliance with my objectives, developed in the Agronomy School of University of Debrecen Centre for Agricultural and Applied Economic Sciences and its predecessor institutions. The labour demand of each technological operation was calculated by data concerned to the mechanical work performance by VM GKI supposing further 20% unskilled labour use (loading, filling) and 10% general activity (office work, recording, plant protection engineer). Workplaces can be possibly realized or retained in animal production are disregarded in determination of agricultural workplaces owing to the limited usability of by-products as forage on the one hand and to the advantageous marketability of them (it is not at all sure that they will be utilised in Hungary) on the other hand. Furthermore difficult estimation would have made the results of the job creation model considerably uncertain.

2.4. Study on the knowledge and attitudes of Hungarian drivers related to biofuels

In February 2012 the knowledge of Hungarian drivers on biofuels, the origin of this knowledge, their practical experience and satisfaction as well as their attitude related to biofuels were analysed by an internet questionnaire. The objective of this questionnaire was to survey the knowledge and opinion of those drivers, who continually improve their knowledge by following the drivers' press, hereby they probably have more knowledge related to biofuels, thus they can deliver a more established opinion and they are more opened for the novelties. Considering these aspects the readers of drivers' professional pages/journals were marked out for the subjects of my survey. Finally I chose the readers of the portal www.totalcar.hu, as this is one of the largest car magazines (about 100 000 clicks per day) which was several times concerned with the domestic situation of biofuels.

The questionnaire contained overall 27 questions and it consisted of 3 main parts. The first part investigated the knowledge related to biofuels, the origin of this knowledge as well as the possible practical experience. The second part served for the analyses of opinion and attitude related to biofuels, while the third part was useful for the identification of the respondents (socio-demographical data). Only those respondents had to answer for questions referring to knowledge, who valued satisfactory their own knowledge related to biofuels on a five-phase scale, however every respondent was covered into the attitude analysis.

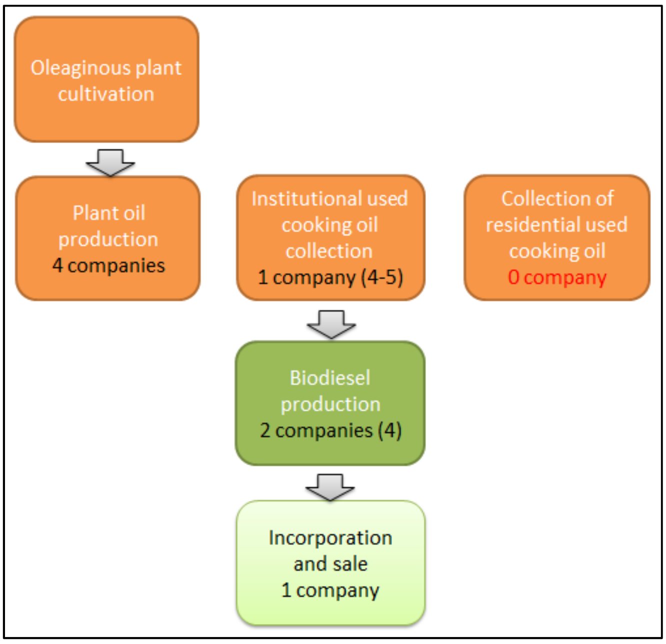
The reputation of each biofuel varietiy and raw materials was defined by descriptive methods. The attitude analysis contained 3 questions and 7 statements, which had to be valued on a five-phase Likert scale. The relation of the Hungarian drivers to biofuels was outlined from averaging the points of answers and valuations. I carried out cluster analysis in order to prove that respondents can be actually ranked into different groups on the basis of their attitude related to biofuels.

3. MAIN CONCLUSIONS OF THE DISSERTATION

3.1. Introduction of the Hungarian biodiesel sector

The Hungarian biodiesel sector can be considered small in international comparison. It gives only 0.7% of the capacities, but it is not at all unimportant, since it is among the first in Europe as regards its utilisation and at present it can completely satisfy domestic demands. This sector consists of a few agents and it is typically limited to production, i.e. devices being necessary for production predominantly derive from foreign manufacturer.

Figure 1.: The Hungarian biodiesel product line



Source: own data collection and construction

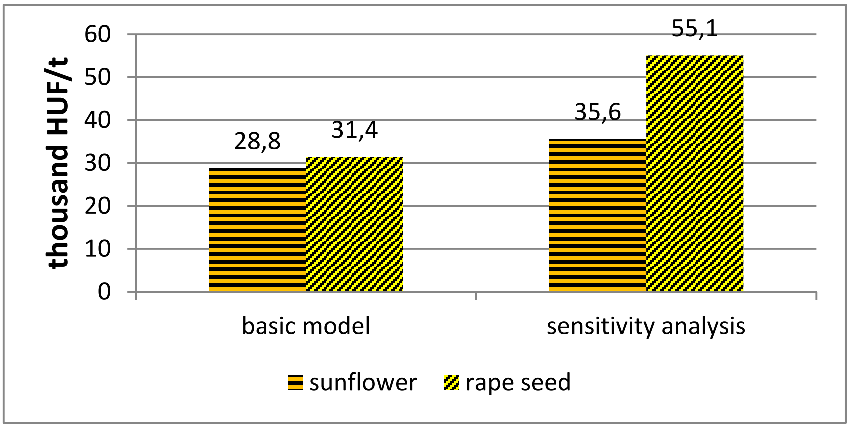
If we want to bound the agents of the product line, we can do it in the following way: it includes farms cultivating oleaginous plants, plant oil factories producing biodiesel raw material (as well), enterprises dealing with collection of used cooking oil (UCO), biodiesel factories and refining plants carrying out incorporation (*Figure 1.*). Access of new agents is not probable in current legal and economic conditions, except for the market niche including the collection of residential used cooking oil, which has an enormous potential (~20 thousand t/a). However, the exploitation of this potential has a major logistic stumbling block; furthermore the lack of environmental consciousness in the population makes the collection of residential used cooking oil even more difficult. Before starting a large-scale residential used cooking oil collection the launch of an explanatory campaign would be crucial.

The future prospects of agents was analysed with in-depth interviews. The agents of the sector have different problems, as it was requested, but a single area, the regulatory and control system proved to be a problematic issue for all of them. Characteristically, they complained about contradictory and incoherent laws, or rather, in several cases, about excessive requirements, which lead to the unwarranted rise of production costs. In fact, all agents mentioned the more flexible Austrian and German regulatory systems as an example to follow. The reconsideration and correction of the legal system are of cardinal importance as to the future development of the sector.

3.2. The added value in biodiesel sector

Figure 2. illustrates the added value of oleaginous plant cultivation. It can be detected that while added value is normally between 28-31 thousand HUF/t, if cultivation method complies with the recommended it can increase and reach 35.6 thousand HUF/ t in case of sunflower and 55.1 thousand HUF/t in case of rape seed.

Figure 2.: Specific added value of oleaginous plant cultivation

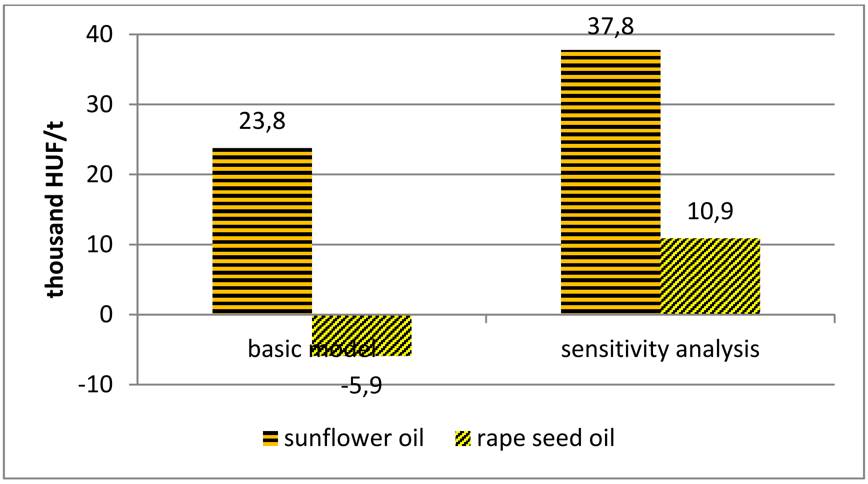


Source: own results

The reason for considerable increase is that significant part of plant protection costs as well as machinery costs act as fixed costs owing to the fixed technology. The most significant cost increasing factor is the nutrient management, which has a crucial influence on yields and harvests as regards the recommendations of KITE. So it is easy to see that saving with application of artificial fertilizer promising short-distance benefits causes significant loss in yields.

The added value of plant oil production is very low, it is far the lowest in this sector (*Figure 3.*). The examined enterprise ended with a deficit in 2011 in compliance with the profit and loss account. However, it is not at all a unique case in plant oil sector; another company exclusively dealing with raw material production for biodiesel also ended with an extensive loss, and one of the greatest domestic plant oil producers was losing as well. Naturally plant oil production is not at all always a loss making activity; this situation rather owes to the adverse combination of conditions (standing oil-seed prices).

Figure 3.: Specific added value of plant oil production



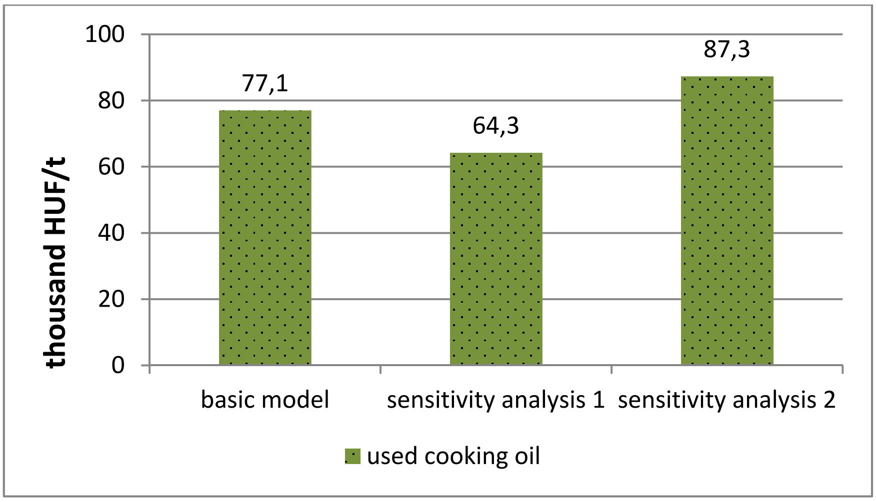
Source: own results

Figure 3. well demonstrates that sunflower oil production generates a modest added value of 24 thousand HUF/t, the added value of rape seed oil production is negative. Since technology and the selling price of both oils are the same, thus difference can be traced back to the higher purchase price of rape seed by 18 thousand HUF/t on the one hand, and to the more temperate oil yield (42% in contradiction to the 44% average of sunflower) on the other hand. This difference can not even be compensated by the significantly higher purchase price of rape seed grits. I supposed in sensitivity analysis that in close integration, oil factories could procure raw material with 5% reduction in price. In this case the added value of sunflower oil production could approximate the added value of production, and the added value of

rape seed oil production would be positive, about 11 thousand HUF/t. Relying upon these facts, a closer integration between producers and processors would be desirable, however it has a considerable stumbling block, i.e. the lack of contractual discipline – in many cases from both parties, as it is typical in case of other agricultural and food industrial activities.

The added value of the collection of used cooking oil is the highest among the agents of the sector, it is more than 77 thousand HUF/t (*Figure 4.*). The relatively low raw material cost can be the reason for this on the one hand, and processing does not require any major transformation – used oil needs only for heating and filtering – on the other hand. The added value is further increased by the fact that currently the only places of collection are institutional kitchens, from where raw material flows in large quantities, which has a favourable effect on transport costs. From the side of income, in the last years the world market price of used cooking oil significantly increased owing to the extension of biodiesel utilisation and currently it shortly lags behind the price of rape seed oil.

Figure 4.: Specific added value of used cooking oil collection

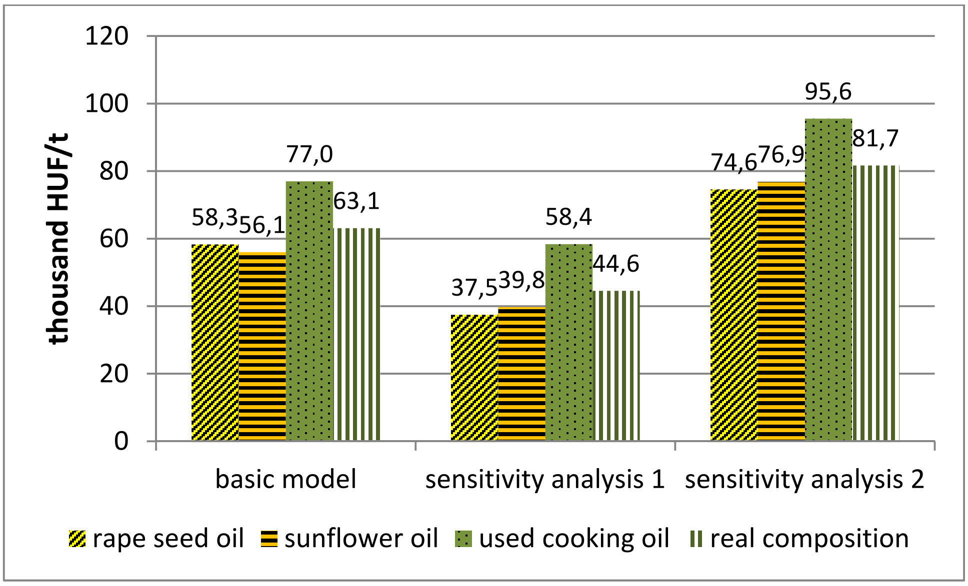


Source: own results

In the course of sensitivity analysis, the development of added value was examined supposing that the ratio of watery fat - originating form collected used cooking oil representing a significantly smaller value and being useful only for fumigation - would be more or less (30 or 20% instead of 25%). Since it is not an industrial product, there is no homogenous quality of the received oils, thus change in composition (mainly toward negative) can be a real risk for enterprises dealing with collection. It is obvious that 5% increase in the ratio of watery fat decreases the specific added value by about 13 thousand HUF/t, i.e. quality of collected raw material has a defining importance.

The added value of biodiesel production is the second largest in the product line after the collection of used cooking oil. Added value was examined in case of three major domestic raw materials (rape seed, sunflower, used cooking oil), and in case of composition being close to real (35% rape seed oil, 35% sunflower oil and 30% used cooking oil). Results are presented by *Figure 5*. Specific added value varies between 56-77 thousand HUF/t depending on raw material.

Figure 5.: Specific added value of biodiesel production

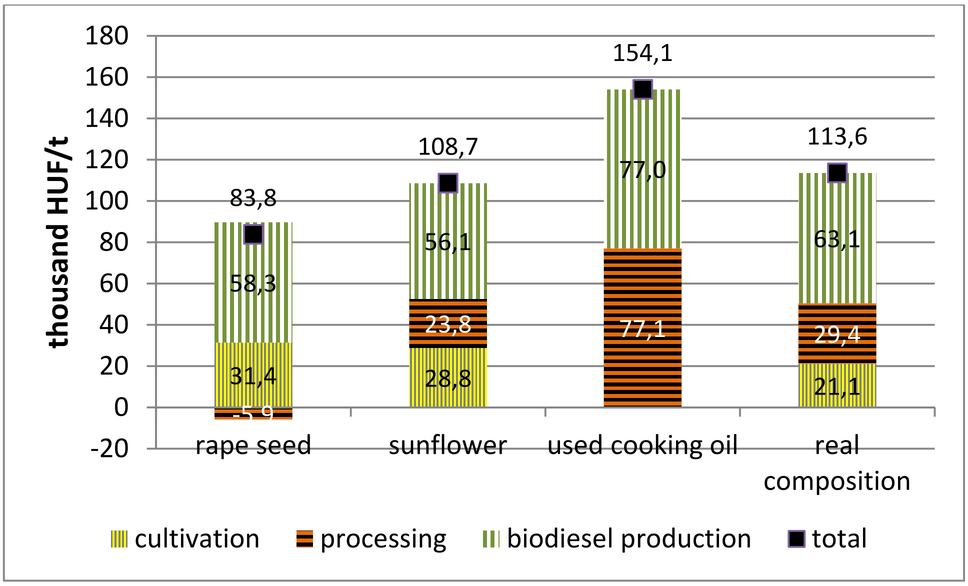


Source: own results

In sensitivity analysis, 5% reduction or increase in biodiesel's price was taken into account, which can be considered reasonable on the basis of last year's data, since wholesale price of biodiesel varied between 1199-1323 EUR/t in 2012 as regards the records of UFOP, which indicates about 10% fluctuation in prices. On the basis of sensitivity analysis 1% change in biodiesel's price raises about 2.4% change in added value. The real added value of the sector is between the value of the base-case and 2nd sensitivity analysis owing to the earlier mentioned higher purchase price.

Figure 6. contains the total added value of the Hungarian biodiesel product line per one tonne raw material. During totalling I calculated with the results of basic models in every time. Summing up different added value arising from different stages of the product line I found that the added value of rape seed-based biodiesel is overall lower than in case of sunflower-based biodiesel, for all that both rape seed cultivation and transesterification of rape seed oil generate higher added value. The negative added value of rape seed oil production can be the reason for the aforementioned statements.

Figure 6.: Specific added value of biodiesel product line



Source: own results

So increasing the ratio of sunflower in biodiesel would be desirable, since it generates higher added value, i.e. higher GDP in the one hand and it also has a greater impact on employment than rape seed cultivation on the other hand. Furthermore, it can be produced by larger yield safety in case of applying recommendations for cultivation technique in continually more arid climatic conditions. However, increase in utilisation of sunflower is restrained by the existing biodiesel standard, which was drawn up for coleseed having better cultivation conditions primarily in Western-Europe. Theoritically a Hungarian biodiesel license (TBK biodiesel) could make standard-quality biodiesel production possible from sunflower owing to the lower iodine value (100-110) of the final product. Its widespread use might make exploitable the potential being hidden in the higher added value of sunflower-based biodiesel.

To sum up, biodiesel product line at current standard of production generates about added value of 15.2 billion HUF at national economy level being produced only for domestic utilisation (taking into account that only 10 thousand t from used cooking oil originates from Hungarian sources). On the basis of the objectives of Action Plan this value can expand and reach 20.3 billion HUF by 2020 calculating by current price level.

3.3. Cost, yield and income relations in biodiesel product line

Table 1. contains the main agronomy features of each agent of the product line per production capacity unit (ha in case of crop cultivation, t/a in case of processing sector[1]). It is obvious that consideration of area payments far increases the profitability of rape seed- and sunflower cultivation. If area payments are not included in calculations, the cost-related profitability in case of rape seed cultivation is 12.2% and in case of sunflower production is 6.9%. It also means that support gives the major part of the arising income, i.e. competitiveness of production can be questioned. Leaving this out of the consideration, profitability follows the order experienced during the calculation of added value.

On the basis of my results the average cost of 1 litre biodiesel is 302.3 HUF and its wholesale price is 326.7 HUF. Considering the average costs it can be claimed that trading biodiesel purely as a B-100 fuel would be non-competitive in fuel market under current circumstances, since 1 litre would cost 565.16 HUF, while the average price of diesel is 435 HUF/l[2]. Trading B-100 fuel would not even competitive, if the government was consequent in determining the rate of excise duty and decreased the excise duty of biodiesel to 95.15 HUF/l in compliance with its heating value.

[1] Final product
[2] www.nav.gov.hu average price of March 2013

Table 1.: Agronomy features of the agents in biodiesel sector

	M.U.	rape seed cultivation	sunflower cultivation	rape seed oil prod.	sunflower oil prod.	used cooking oil collection	biodiesel production
Main product	-	rape seed seed	sunflower seed	rape seed oil	sunflower oil	refined oil	biodiesel
Yield	t	2,30	2,27	1	1	1	1
Selling price	thsd HUF/t	140,4	130,5	279,0	281,2	260,9	371,2
Yield value	thsd HUF	322,9	295,9	279,0	281,2	260,9	371,2
Production value	thsd HUF	384,9	357,9	358,1	332,2	264,8	381,1
Production cost	thsd HUF	277,4	263,5	383,7	328,1	244,6	353,3
Net income	thsd HUF	97,1	81,0	-25,6	4,1	20,2	27,8
Cost related prof.	%	33,72	29,24	-6,67	1,26	8,25	7,86
Net production cost	thsd HUF	287,9	277,1	304,5	277,1	240,7	343,4
Average cost	thsd HUF/t	125,2	122,1	304,5	277,1	240,7	343,4

Source: own results

Table 2.: Sensitivity analysis of the agronomy features

	M.U.	rape seed cultivation	sunflower cultivation	rape seed oil prod.	sunflower oil prod.	used cooking oil collection	biodiesel production
Main product	-	rape seed seed	sunflower seed	rape seed oil	sunflower oil	refined oil	biodiesel
Yield	t	3,5	3	1	1	1	1
Selling price	thsd HUF/t	140,4	130,5	279,0	281,2	260,9	389,7
Yield value	thsd HUF	491,4	391,4	279,0	281,2	260,9	389,7
Production value	thsd HUF	553,4	453,4	358,1	332,2	263,9	399,6
Production cost	thsd HUF	326,7	314,8	366,9	314,1	230,0	353,3
Net income	thsd HUF	212,8	125,0	-8,8	18,1	33,9	46,3
Cost related prof.	%	62,46	38,06	-2,39	5,78	14,71	13,12
Net production cost	thsd HUF	340,7	328,4	287,7	263,0	227,0	343,4
Average cost	thsd HUF/t	97,3	109,5	287,7	263,0	227,0	343,4

Source: own results

Table 2. contains the results of sensitivity analysis. Supposing ideal case by every agent of the product line, profitability significantly increases in every case. The profitability of sunflower cultivation increases to the smallest degree, since sunflower is a less intensive crop on account of which there is a slighter yield reaction on added inputs. It is worth studying that the assumption of closer integration made the added value of rape seed oil production positive, but it could not push profitability into the positive range. EUR-HUF exchange rate also has a significant influence on the profitability of biodiesel production, as account typically occurs in EUR – but this analysis does not cover this area.

3.4. Job creation potential of the Hungarian biodiesel sector

Table 3. illustrates the direct job creation potential of biodiesel sector determined by calculations based on service data. I calculated the number of workplaces per million litre (Ml) capacity taking into account the current composition of production.

Table 3.: Direct job creation potential of the Hungarian biodiesel sector

Activity	Capacity	M.u.	Workplace (capita)	Per biodisel production (capita/Ml)[3]	Potential 2020 (capita/Ml)
Rape seed cultivation	1000	ha	5,01	1,60	1,60
Sunflower cultivation	1000	ha	5,95	1,83	1,83
Plant oil production	42[4]	thous and t	51	0,78	0,68
Used cooking oil collection	10	et	90	0,50	0,66
Biodiesel production	162	et	58	0,32	0,22
Total	-	-	-	***5,03***	***4,99***

Source: own results

[3]Supposing the composition of 35% rape oil, 35% sunflower oil and 30% used cooking oil (from this only 10 thousand t is from Hungary)
[4] it can be expanded to 80 thousand t +2/3 employments

I took the aside utilisation value of the Action Plan for 2020 (209 thousand t) as a basis in determination of potential workplaces, supposing that existing plants are able to fulfil this quantity enlarging their capacities without applying new workers. I also supposed that half of the residential used cooking oil (10 thousand t) would be exploited by 2020 and collection of it would create new workplaces.

The aggregated employment effect of the sector was determined by the modification of the model of NEUWAHL et al., 2008 further improved by BAI, 2009 (*Table 4.*).

Table 4.: Aggregated employment effect of the Hungarian biodiesel sector

Activity	Capita/MtOE/a[5]	Bai, 2009 Capita/Ml/a	Own model Capita/Ml/a
Agriculture	5900	7,7	3,4[6]
Used cooking oil collection	-	-	0,7
Traditional energy sector	-800	-1,0	-[7]
Engineering- and food industry	2720	3,5	1,5[8]
Services (e.g. storing)	-3650	-4,8	-2[9]
Transportation	-100	-0,1	-
Biofuel production	730	1,0	0,3
Total	***4800***	***6,3***	***3,9***

Source: Own calculations based on BAI, 2009

It can be seen that the total employment effect of domestic biodiesel sector is significantly more modest than the results of BAI, 2009 resting on the model of NEUWAHL et al., 2008. On the one hand, the reason for this is that the originate model overestimates the number of agricultural workplaces – probably owing to the fact that it relies on earlier published models representing unreal high labour demand in case of oleaginous plant cultivation compared to the current technological conditions. On the other hand, the originate model

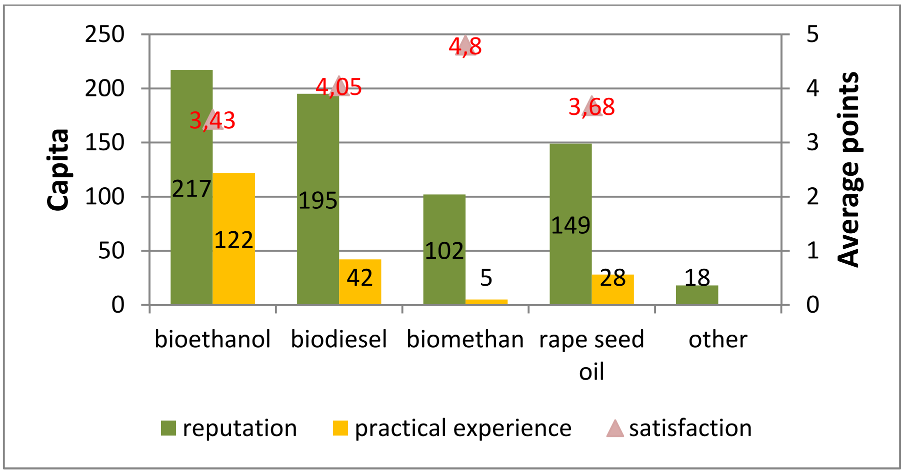
[5] Originate numbers of Neuwahl et al., 2008
[6] Considering only plant cultivation sectors
[7] Considering that domestic incorporation objectives are so modest that they have no real effect on traditional diesel production, as well as incorporation and sale occur through the existing network
[8] With regard to the fact that workplaces in mechanical engineering typically realize in abroad
[9] Considering that the original model of Neuwahl et al., 2008 probably contains mistakes in calculations

calculates with significant job creation potential in engineering industry, however it does not emerge in Hungary, since devices manufactured abroad are typically utilised in biofuel factories.

3.5. The knowledge and attitudes of Hungarian drivers related to biofuels

In the course of the analysis of the knowledge and attitudes of Hungarian drivers related to biofuels, the internet was found as the main source of their body of knowledge on biofuels, providing a quick information flow on the one hand, but it is responsible for the spread of lot of false information on the other hand. The knowledge of Hungarian drivers do not lag behind the knowledge of West-European or North-American drivers; moreover, in some aspects they can be considered more up-to-date. Bioethanol was known and used by the majority of drivers, which can be explained with the boom of E-85 trade in the years of 2010 and 2011. Biodiesel was the second best known biofuel; sunflower and rape seed seed were the best known stocks of biodiesel production (*Figure 7.*).

Figure 7.: Reputation of each biofuel among the respondents



Source: own results

Regarding the attitudes towards biofuels, the Hungarian driver society could be divided into three groups by cluster analysis: supporters, uncertain and sceptical individuals. The most populous group included the supporters, and in accordance with the mean values of answers the whole statistical universe had a rather positive attitude towards biofuels (*Table 5.*).

Table 1.: Characteristics of the clusters

Clusters		Highest educational level	Age	Annually driven distance	Interest	Willingness to pay	Career
1.[10]	Rank Mean	182,90	195,23	197,43	217,44	209,18	212,55
	N	206	206	206	206	206	206
2.[11]	Rank Mean	209,08	191,88	199,13	187,18	183,85	183,20
	N	119	119	119	119	119	119
3.[12]	Rank Mean	198,91	190,81	195,02	174,12	199,05	149,47
	N	61	61	61	61	61	61
Chi^2		4,497	0,146	1,501	8,933	15,546	19,037
Significance**		0,084	0,930	0,472	0,011	0,000	0,000

Source: own results

[10] supporters
[11] uncertain individuals
[12] sceptical individuals

4. NEW AND INNOVATIVE RESULTS OF THE DISSERTATION

The complex economic analysis of the Hungarian biodiesel sector with some social aspects was set as the main objective of this Ph.D. thesis. On behalf of implementing the above-mentioned objective four specific sub-objectives and four related hypothesis were composed; in the course of their accomplishment I obtained the following new and innovative results:

1. On the basis of the agronomical planning model, developed in the Agronomy School of University of Debrecen Centre for Agricultural and Applied Economic Sciences and its predecessor institutions, applying scientific methods **I defined the added value being realized by each agent of the product line and through the whole product line** outlining potentials for its extension as well. In conformity with H_2 hypothesis I proved that significant added value (more than 113 thousand HUF/t biodiesel) produced on the biodiesel product line, but its distribution among the agents is not consistent. Transesterification and the collection of used cooking oil have the largest added value and they are followed by oleaginous plant cultivation and then by plant oil production.
2. Also on the basis of the agronomical planning model, developed in the Agronomy School of University of Debrecen Centre for Agricultural and Applied Economic Sciences and its predecessor institutions, **I analysed the cost, yield and income relations in each stage of biodiesel sector** and I made proposals to increase profitability. Proving H_3 hypothesis I found that area payments significantly increased the profitability of oleaginous plant cultivation as well as considerable reserves were hidden in the system, which could be exploited by complying with the technological discipline. Analysing average cost, I proved that biodiesel is not competitive in itself (as B-100 fuel) under the current economic conditions, increase in its utilisation in middle-distance seems to be possible only by increasing of the compulsory incorporation ratio.
3. I composed **a new model** to prove H_4 hypothesis, which considers the characteristics of the Hungarian biodiesel product line and makes the quantification of job creating and retaining potential of the sector possible. On behalf of the model **I determined the**

number of arising/retained direct workplaces in the sector, as well as **the net job creation effect being realized at the level of the whole national economy** adjusting the model of NEUWAHL et al., 2008 to the Hungarian conditions.

4. **I analysed the knowledge and attitudes of Hungarian drivers related to biofuels** applying a stop-gap questionnaire survey. **I found that the knowledge of Hungarian drivers does not lag behind the knowledge of European average**; moreover, in some aspects they can be considered more up-to-date, but their knowledge can be not at all regarded deep and complete. **The Hungarian driver society could be divided into three groups by cluster analysis**: supporters, uncertain and sceptical individuals; **however the majority of people support biofules**. Overall, I managed to prove H_5 hypothesis, as the Hungarian drivers basically relate to biofuels – within that to biodiesel - in a positive way, but their knowledge is incomplete in connection with them and they mostly have practical experience only in relation to E-85 fuel.

5. THEORITICAL AND PRACTICAL UTILITY OF THE RESULTS

On the one hand, I consider that my new and innovative results can be practically useful for decision-making bodies, who can obtain accurate guidance from my study, to the promotion of decision making concerning to the biodiesel sector. On the other hand, my results can be useful for the agents of the sector in order to obtain a complex view on the other agents of the product line and to prepare common strategy, cooperation on the basis of the outlined problems, development potentials. And last but not least, potential consumers can be also interested in my work; they can effectively improve their knowledge on biodiesel, studying my dissertation. In my view, it would be worth doing further examinations to explore the critical points stressed from economic aspect in my dissertation, which are the followings: cooperation among the agents of the product line, residential collection of used cooking oil as well as potentials being hidden in the profitability of plant oil production – perhaps in diesel fuels of new generation.

6. PUBLICATIONS RELATED TO THE SUBJECT OF THE DISSERTATION

Publications can be taken into consideration in compliance with the rules of the doctoral school:

1. Bai A. – Stündl L. – Bársony P. – Fehér M. – **Jobbágy P.** – Herpergel Z. – Vaszkó G. (2012): Algae production on pig sludge. Agronomy for Sustainable Development. Vol. 32., Issue 3., pp. 611-618. (2011 IF. 3,330)
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5. **Jobbágy P.** (2010): A bioetanol-gyártás és a főbb abraktakarmányra alapozott állattenyésztési ágazatok mint potenciális versenytársak hozzáadott értékének összehasonlítása. Agrártudományi Közlemények - Acta Agraria Debreceniensis. 42. évf. pp. 111-115.

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