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M. Fritz, U. Rickert, G. Schiefer

The Profitability of Biodiesel Chain with Different Organizations

Franco Rosa
University of Udine, Department DIEA, Italy
rosa@uniud.itItaly

Summary

The dir 30/2003 by fixing the 5,75% target of biofuel incorporation to fossil fuel for vehicles for 2010 has increased the interest for a further development of the agro-energies in the EU and generated a virtuous competition among the Member States. Purpose of this paper is to analyze the dimension and profitability of the integrated biodiesel chain with different organizations to analyze their effectiveness in different industrial organization contest. Possible improvement of the economic performance is related with the constitution of local biofuel districts where cluster of farms producing oil seed are integrated with processors to reduce production-processing-transport costs: evidences of the last 15 years suggest a decline up to 20% in current €. The optimal size of plants with an higher level of exploitation of their capacity within an integrated organization is an important part of the cost-reducing process. This paper examines the theoretical plant size rules for a conventional processing business integrated in producer/processing enterprise, based on different form of integration and the spatial dimension of the oilseed input market is examined for its consequences for the scale economies of biodiesel processing facilities. The analysis drives to the following conclusions: i) the optimal size may grow further but the constrain is given by the supply of feedstock at farm level; ii) investment profitability measured with the return on capital is convenient if the dimension of the supply area is appropriate to the processing capacity of the plant; iii) the integrated cooperative network is improved to gain efficiency by reducing transaction costs; iv) the total producer plus processor profits and sharing among partners change with the type of organization used in the integrated chain.

1. Cost, technology and plant size

Sunflower, soybean and rapeseed feedstock, with similar oil composition (fatty acid) represent a viable integrative source of renewable energy in Western and Eastern countries of EU-27 confirmed by the disposal of the European Commission. The cultivation of feedstock and their industrial processing is substantially different from the simple oil extraction: the agricultural production requires risky decisions due to the evolving environmental conditions: climate, innovation, market affecting the production costs and revenues. In a broader sense, technology, production cost, market structures and environment are the four related determinants of the biodiesel chain performance.

1.1 Technology

the technological indivisibility drives to the exploitation of scale economies: most of the technologies used in the agricultural contest in presence of mature products and lower degree of innovation require huge investment for relatively long periods to gain scale economies that can not be afforded by the smaller units. There are evidences of growth in size in these recent years with Companies buying larger agricultural areas in different part of the world, and using the already existing technologies: automatic driving, precision farming with remote control, satellite monitoring, seeds modified to energy production, logistic facilities to haul large quantities of feedstocks from production to processing plants.

Large scale economies are typical of the petroleum refining industry that has the oligopolystic control of the fuel market: the output of processing unit tends within certain physical limits to be roughly proportional to the volume of the unit, “other things being equal”, while the amount of materials and fabrication effort (and hence investment cost) require to construct the units, is more apt to be proportional to the surface area of the cultivation area, unit's reaction chamber, storage tanks, connecting pipes, etc.

Another benefit of size arises from what Robinson called "the economic of massed reserves: the firms anxious to maintain continuity of production must hold equipment in reserve against machine breakdowns. Size also offers advantages maintaining capacity sufficient to meet fluctuations in demand. One condition which lead the current fuel industry to more concentrated market structure is the existence of substantial scale economies obtained at different level of the biofuel chain, permitting relatively large producers to manufacture and market their products at lower average cost per unit than smaller ones.

1.2 Cost and scale economies

The economies of scale are the evidence of unit costs decline with increases in plant and firm size, at least within certain limits. In nearly all production and distribution operations the achievement of scale economies appears to be subject to diminishing returns. The main determinant of scale economies in production is the specialization, driving larger investments in production unit for increasing their supply and achieving a certain control on price setting. Specialization may be achieved within a particular plant or production complex and also, when the firm operates more than one plant complex, across plant lines. Diseconomies of scale exist as well: as the enterprise increases in size, the executive staff is confronted with more and more decisions, and is removed further from the reality of the front-line production and marketing operations, so his ability to make sound decisions is attenuated, with a consequent rise in costs and/or fall in revenues. The consequence of the coordination problems is the upward pressure on costs which become increasingly intense as firm scales rise. At some critical point the diseconomies of large-scale management , overpower the economies of scale and unit costs begin to raise, giving the long-run average total cost curve its U-shape. The downward segment of the 'U' cost shaped curve is governed by conventional scale economies; the upward thrust by managerial diseconomies and difficulties in budgetary control.

1.3 Transportation costs

Transportation costs affect cost-scale relationships primarily at the level of a single plant or geographically clustered plant complex. The increase in the supply area causes the increase in transportation costs per unit sold. The magnitude of the increase depends in a complex way upon a number of variables. One is the size of the plant in relation to the size of the market served. If the plant supplies only a small fraction of market demand, it may be able to increase sales substantially without expanding its geographic penetration. In this case transportation costs will be an insignificant constraint on plant size. Usually the cost of transporting a given volume of freight rises less than proportionately with the distance shipped. The smaller the percentage increase in cost associated with shipping freight an extra 100 Km, the less will transportation costs constrain plant size. Fourth, the geographic distribution of potential customers matters: if the customers are distributed evenly over the map transportation costs, will rise less than proportionately with the number of customers served *ceteris paribus,* since shipping cost is related to the radius of shipment while volume of patronage is related to the square of the radius. If on the other hand customer density declines sharply-away from the home market, transportation costs may even rise more than proportionately; with the volume of output sold. Finally, the relationship of the commodity's production cost to its bulk is relevant. For bulky, low-value commodities unit transportation costs rise relatively rapidly with distance shipped. For compact, high-value item like transistors and machine tools, they rise only slowly.

Agro-energy district may be a possible solution to achieve scale economies: these realities are emerging now in the most progressed agricultural area of North West Italy were are concentrating innovative renewable energies projects (photovoltaic, biofuel, biomass short chain) and the district is emerging as the possible network organization to achieve scale and scope economies. With EnergEtica Onlus a Society is born with the mission to stimulate the projects in this field integrating the most important groups: Gavio, Ialiana Pellets, Radice Fossati, EGEA-Alba and mant agricultural farms that collaborate to make the biofuel project highly efficient.
A Service society is dedicated to facilitate the diffusion of innovations as the irrigation, fertilization technologies, seed selection and minimum tillage operations to reduce costs and energy waste.
The evidence of scale in the processing industry is given by the following table in which is reported the production capacity in the EU-27

Table 1. Biodiesel production capacity in the EU-27

Country	Production capacity Mio liters	Projection 2010 Mio liters	% change 2010/07	Total surface * (000 Ha)	Energy crops 2007 (000 Ha)
Germany	4980	5310	6,63	1567	646.4
Italy	1750	2000	14,29	264	35.6
France	1130	2870	153,98	2167	718.1
Spain	710	3800	435,21	619	182.1
Belgium	540	540	0,00	18	8.9
U.K	490	1230	151,02	604	222.7
Greece	420	520	23,81	4	1.52
Poland	400	650	62,50	801	320
Austria	330	700	112,12	95	17.2
Portugal	260	570	119,23	9	16.3
Cekia	200	350	75,00	365	146
Sweeden	200	260	30,00	83.5	46.4
The Netherlands	200	2570	1185,00	3	1,2
Others (14 countries)	425	2075	388,24		
Total Ue	12035	23445	94,81		

* Total surface cultivated to oilseed crops

In the EU-27 the increase in production of biodiesel is the major task of the EU to 2010 that has been stimulated by the incentive measure adopted in the MS to push forward the production: in 2007 have been produced 12 billion liters of which the 65% concentrated in Germany, France and Italy. In 2010 it is expected the duplication of production and a redistribution of the quota among the countries due to contribute of Spain and Netherlands: these five countries will represent the 70% of the total capacity. The higher growth ratios through 2007-2010 are expected for Netherland, Spain, U.K, and many Eastern countries while the Italy's growth ratio will be slower due to the already existing over capacity and difficulty to procure feedstock at lower costs. The incorporation policy according with the dir. 30/2003) can push forward the exploitation of the production capacity but the lower oil cost and feedstock costs discourage the increase in biodiesel production without further incentives.

The third variable is the geographic structure of the transportation cost..
The parameters characterizing an Iowa ethanol firm's external environment are given in Table 1. These estimates of exogenous factors are based on recent studies of costs and technologies, and historical averages for market prices. Sources for our estimates of the current situation are reviewed below. Also, moderate improvements in several factors have combined for a substantial improvernent in the biodiesel processing over the last two decades. Thus, we also describe the source and extent of improvements in processing yields, operating costs, and capital costs.

Table 2. Scale economies in processing plant in Iowa

Size of the plant (mio liters/year)	Investment (mio $)	Cost of seeds			
		28 cent/kg	42	56 cent/kg	71 cent/kg
		Average production cost ($/liter)			
2	1.2	0.66	0.79	0.92	1.04
11	4.4	0.45	0.57	0.7	0.83
57	12.3	0.38	0.5	0.63	0.75
114	19.2	0.37	0.5	0.63	0.75

Market: Transportation costs borne by the producer rise with output only if they cannot be passed along to customers in the form of higher prices. This occur when prices are uniform in all markets, or when the price in more distant markets is set by more advantageously located rival producers.

2. Production and consumption in Italy (2007)

The Italian production capacity of biodiesel including imports from other countries is estimated to 350.000 t (source 5 GAIN-Italy) well above the domestic consumption of 174187 t (Eurobserver). The biodiesel production is subject to severe fiscal regulation; the last legislative decree (see GU n. 239 11 October 2008, Agrisole oct 08, and nr 41, 14-23/ oct 2008, nr 42, 24-30/ oct) contains the norms for the reduction of excise duty[1] to the defiscalized plafond for the period 08-10. The decree assigns 250 thousand ton that represents the plafond defiscalized of which: 70.000 ton assigned to the “agrifuel chain” with national and EU contracts for oil production with rapeseed, sunflower and soybean and 180.000 ton from “non agrifuel chain” assigned starting with September 08 to the industry represented by 29 companies. (Decree published by Customer Agency 15 october, 2008). In the following table is reported the list of Italian companies that participated to the tender.

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[1] Excise duty is a tax levied on the producer of certain goods, commodities and activities. It is a separate tax from VAT, and is different from it in that VAT solely affects the consumer (although, naturally, the consumer also indirectly pays the excise, as it is included in the eventual sale price of the product). The excise duty can account for as much as half the price of the goods subject to it, and sometimes more.

Table 3. Italian companies with refining capacity

Company	Location	Capacity (1,000 MT)	Start
ACTIVE			
Comlube	Brescia	120	1995
DP Lubrificant	Aprilia (Rome)	150	2003
Fox Petroli	Vasto (Chieti)	130	1998
Italgreen Oil	Verona	300	2007
Ital Bi Oil	Bari	120	1996
Mythen	Cosenza	200	2000
Novaol	Livorno	250	1992
Oil Bi	Varese	200	1998
Polioli	Vercelli	20	2006
GDR	Milano	40	2006
NEW PLANTS			
Caffaro	Udine	100	2007
[1] Cereal Docs	Verona	120	2007
Olearia Olimpo	Bari	60	2007
Oxem	Pavia	200	2008
Red Oil	Napoli	30	2007
Sabe (SFIR)	Trieste	100	2009

Source:Gain report Italy and Assocostieri

For the 250.000 ton the reduced excise duty is 84,6 €/mc.[1] (instead of the full excise duty applied to gasoil of 423 €/mc) that is a 80% reduction with respect to the full duty. The MIPAAF[2] assign at the beginning of each year the quota for the agrifuel chain that will be distributed with priority before 31 July and the remain before the next February to the Company that will made demand.

The custom agency has assigned the 180.000 ton to 29 Companies of which 12 are Italian and 17 from the rest of EU countries. These companies can profit of the fiscal benefit of the excise duty that will cover part of the quantity required to cover the 2% planned target for 2008 equivalent to 900 thosand ton of biodiesel. With the auction to the italian companies were assigned 145 thosand ton representing the 80% of the plafond. The Companies starting with November 08 participate to the tender for the assignment of the remaining 70.000 ton of the agrifuel chain by exhibiting the cultivation contract signed with producers. [3]

Italy imports a large amount of rape and soybean oil processed in biodiesel and re-exported into EU countries; the quantity of biodiesel production including also imports of seed and oil from other EU countries was in 2007, 470.000 t, an increase of 5,1% with respect to 2006 (EEC data). Italy is the second country in order of magnitude after Germany for biodiesel production (domestic production plus import). Nevertheless the area cultivated to oil crops for biodiesel production was very limited in relation with consumption: 45.000 Ha in 2006, 35.000 in 2007 and

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1. The quota was 300.000 t in 2004, reduced to 200.000 in 2005 and the excise duty was reduced from 100% to 80%, then the in-quota production will pay only the 20% of the 423 €/cubic meter of the normal consumption tax.

2. Ministry for Agricultural and Food Policies

3. National agrifuel crop contracts are available at the web site SIAN (Servizio informativo agricolo nazionale): contracts including the request for energy crop premium for 2008 and contracts not including the EU premium but registered in the web Mipaaf. Agea will provide to certify the conformity. The Government intend to postpone the deadline for the mixing and the trading of green biodiesel to 30 june 2009.

12.000 in 2008 mainly dedicated to rapeseed and sunflower crops. The national biodiesel contracts in 2006 were subscribed by 5009 farms. The 70% of the total biodiesel production is represented by rapeseed oil mostly imported from EU, the 20% is from soybean oil most from domestic production; the 80% of imported oil are from rapeseed and sunflower the rest is palm oil

Table 4. Italy 2007: biodiesel processing capacity

Nr of processing plants Italy	17
Actual production capacity (000 ton)	470
Potential capacity (mio ton)	1,5
Total Plafond with 20% accise reduction (000 ton)	250
Plafond assigned to non agrifuel chain (000 ton)	180
Plafond assigned to agrifuel chain (000 ton) with furthere reduction in accise	70
Domestic production (000 ton)	28,8
Acreage (000 Ha)	40

3. The investment Analysis: a framework of analysis for biodiesel Processing Firm

Three aspects of the firm decisions will be analyzed. First, the investment theory is revisited in the context of the biodiesel processing plant. While new ground is not broken, a preliminary demonstration of the profitability of biodiesel processing is provided, and the advanced features of finance theory that are relevant to this problem are evaluated. Second it is shown the classic_plant_scale problem for the agricultural enterprise embedded in an appropriate finance theory. Specifically, it is developed an optimal plant scale rule for a processing business that purchases the bulky input in the sunflower market. Third, it is provided plant scale rules for producer/processing enterprises. Specifically, it is developed the optimal plant scale rules for a processing enterprise and for an integrated sunflower processing enterprise in different organizational frame, a type of organization chosen by many producer-owned firms.
Enterprises in EU agro-biofuel chain are facing dimension and organization problems to reduce their costs in the highly competitive sector. At the beginning of 1980's, agribusiness processing firms started to build several large plants with capacities ranging from 100 to 300 thousand ton per year of feedstock processed, following the typical industrial model of the refinery industry. However, new technologies developed in last years make feasible to reduce the size of local plants for a more diffused agro-fuel industry; other form of biofuel business enterprise are now operating at the agricultural and agro-industry levels; new type of integrated coop organizations are emerging in this contest.

Concern for the appropriate scale and organization underscores a broader issue of the underlined profitability of biodiesel processing plant. Current low cost of fossil oil do not create favourable conditions for the biofuel growth in general. Further, recent technology developments lowered costs and improved processing yield by advantaging of local conditions, nevertheles it is important for
the enterprise with appropriate scale and organization is an important element of a long-term competitive strategy.

This research has the purpose to investigate the Biodiesel organization chain, and profitability builds on a representative biodiesel processing enterprise. A trade-off between capital costs and assembly costs in selection of optimal assembling in a geographically dispersed input supply is assumed. By comparing the business and producer-owned organizations for processing enterprises it is examined the scale choices for conventional biodiesel processing business, a co-op,

and ad integrated producer-owned biodiesel processing enterprise.
It is examined the plant size choice for a representative ethanol processing firm facing a typical economic environment *in* Italy. The empirical content of the representative Italy firm's analysis includes a recent surveys on operating costs, the plant cost-size relationship and simulation about the oilseed input delivery to some of the existing bio-diesel plant.

The investment analysis is typically based on the accumulation of the cash flow, which is the stream of annual net revenues resulting from the difference between revenues and operating expenses.
The biodiesel chain requires fixed proportions of biodiesel producers/processor per unit of sunflower processed. The first stage is given by the production the second is the processing with production of oil and panelcake in the third stage the oil is converted in biodiesel with the transesterification process (FAME,_Fatty acid methil estere).
For the continuation of the economic analysis it is required to fix equivalent quantities of the product along the chain using conversion coefficients that represent the fixed proportions (assuming constant return to scale) between a given quantity of seed and the corresponding quantity of the derived product. Here following are defined these quantities:

Qgt = quantity of sunflower seeds (basic product);
Qot = co Qgt; Qot is the quantity of oil and co is the seed/oil conversion coefficient;
Qpt = cp Qgt; Qpt is the quantity of panel cake and cp is the conversion coefficient oil/cake;
Qdt = cd Qgt; Qdt is the quantity of biodiesel and cd is the conversion coefficient seed/biodiesel.

The analysis of the sunflower suggest that from one Ha it is obtained an average production of 2,5 ton of seeds and one ton of oil is converted in biodiesel with a loss of 5% in weight. Then the conversion coefficients are: co = 0,4; cp = 0,6; cd = 0,4 x ,95 = 0,38. To simplify the analysis it is assumed the equivalent proportion through the chain: one unit of primary product corresponds one equivalent unit of processed product and assuming linear variations of production input at different chain levels, the marginal cost of processing is at fixed proportions along the chain.
Fixed proportions means that one unit of sunflower produced will require one unit of the processing plant measured in units of sunflower produced; then for a processing capacity of 100 thosand ton means that 100 thousand Ha cultivated to sunflower crop. Only the products obtained from the first processing step of the biodiesel chain are considered: oil and panel are jointly realized in the same crushing plant and represent a consistent part of the value added of the entire business chain. The oil can be use is in the same producing unit for operating farm machinery or to produce in a cogenerative energy process electricity and heat to take advantage of the green certificates, the panel cake are used for feeding animals in farm. With separation between agricultural and industrial production, the objective of the processing plant that operates independently from the farm unit is the profit obtained from the difference between the revenue and cost cash flow; this gross margin is the price paid to farmer imposed by the subscription of a contract multiplied by the quantity of product delivered minus the operative costs Cp of the plant represented by fertilizer, electricity, materials and direct labour of processing.

1)

$$\pi = MtQgt - CpQgt \quad = (Mt - Cp)Qgt; \qquad Mt = coPot + cpPpt - Pgt; \qquad Rt = coPot + cpPpt$$

The margin Mt is a composite market price for processing one unit of sunflower; the composite

output price is obtained by summing the price equivalent of oil and panel revenues:
coPot + cpPgt per unit of sunflower processed net of production cost of sunflower seed Pgt obtained at time t. If the processing firm operate in a competitive market, the price is usually represented by the contract price net of operational costs. This configure a situation in which producer and processors can cooperate under different agreement forms: i) independent units with exchange regulated by market transactions; ii) successive monopoly in which processor will accept the price of feedstock as fixed; iii) integrated cooperative plants in which farmers will be paid with market price plus a quota of the profit realized by the processor.
In case of successive monopoly, the biodiesel processor is assumed to be price-taker in the sunflower seed markets. There are 27 processing firms in the EU-27; of these 12 are located in Italy, Germany and France and no one firm has a dominant market share and by observing the recent trends in the commodity oilseed market, they do not reveal efficient price signals for the oil industry, since the market price information are more diffused at the consumption level.

Table 5. Italy: biodiesel tender: quota assigned to EU companies

Company	Locatlon	Quota (tonnes)
Agroinvest	Achladi. Fthiotis. Greece	1,253.268
Biodiesel Karnten	Arnoldstein, Austria	2,976.512
Biodiesel Vienna	Vienna, Austria	469.976
Bionor Transfornacion	Berante villa, Spain	609.228
Caffaro	Torviscosa (UD)	52.220
Campa Biodiesel	Ochsenfurt, Germany	3,150.577
Cereal Docks	Camisano Vicentino	3,899.056
Cornlune	Castenedolo (BR)	5,221.951
Diester Industrie	Grand Couronne, France	6,370.780
DP Lubrificanti	Aprilia (LT)	8,738.064
FAR	Vercelli	417.756
Fox Petroli	Vasto (CH)	35,457.045
Ital Bi Oil	Monopoli (BA)	15.944.356
Ital Green Oil	S.Pietro di Morubio (VR)	1,810.276
Mythen	Ferrandina (MT)	7,223.698
Natural Energy West	Mare, Germany	9,886.893
Novaol Italia	Livorno	48,477.109
Novaol Austria	Bruck/Leitha, Austria	1,758.057
Oil.B.	Solbiate Olona (VA)	16,814.681
Rheinische Bioester	Neuss, Germany	3,533.520
Alchemia	Adria (RO)	62.255
Diester Industries	Sete, France	830.067
Greenergy	West Riverside, England	830.067
Ineos Enterprises	Verdun Cedex, France	996.080
Linares Biodiesel	Linares, Spain	415.033
Mannheim Biofuel	Mannheim, Germany	1,037.584
Neochirn	Feluy, Belgium	996.080
Petrotec (Borken)	Borken, Germany	352.778
Petrotec (Emden)	Emden, Germany	415.033

Source: Agenzia delle dogane (reported by Licht)

Once the investment framework is established, we will focus on the effects of price-setting in a local sunflower input market on plant scale choices. Investors seek to maximize the discounted value of the future cash flows less the current cash outlay for the physical capital of the plant $(K(Qc_t))$. A "capitalized profits" form of the expected present value with anticipation of the rate of price increase net of the cost of processing plant K given by:

2) $\text{VAN}_t^e = \sum_{i=1}^{N} \left(RN_t^e / (1 + r^*)^i \right) - K$

The VAN must be considered as a rent to be capitalized obtained from a plant of appropriate size with respect to the supply of feedstoch an then the following formula is given:

2.1) $\text{VAN}_t^e = \pi_t^e / r^* - Kf(Qgt)$

the term π_t^e is the expected net future income discounted at ratio r; the superscript ^{e} is the expectation about a future event and $_t$. underscript identifies the reference period, r* is the real discount ratio, K*f*(Qgt) is the capital function of the processing plant that is a non linear U shaped function of the quantity of feedstock processed , (return to scale).

The real discount factor r* is an adjusted real interest rate is different from the nominal ratio because it takes into account the possible changes in futures prospects for the price changes and incorporates the expectations about future price increase that is the risk implied in the realization of future profit prospects. The formula is :

3) $r^* = r - \alpha + \phi\rho\sigma$ (Dixit e Pindick, 1994)

a is the anticipated growth ratio (varying between 0 and 1) in product price f, r, s represent respectively the risky prospects of the market price; the correlation between sunflower profit and the market portfolio; the standard deviation of % change in biodiesel processing price. From the data the real interest rate r* is 11% by summing to the long-term average of the riskless interest rate (8%) and the 3% of risk.

The first order condition from the expected present value criterion (equation 2.1) provides a rule for optimal capital growth. In Tobin's investment analysis, the capacity should increase until the capitalized value of the marginal investment is equal to the purchase cost, i.e,, qi . Alternatively, marginal profitability can be decomposed to obtain the usual competitive pricing rule,

4) $\text{Mt} = Cp + r^* \frac{\partial K}{\partial Qgt}$

this price is equals to the marginal production cost that includes the operating cost component and the capital cost component. The left side is the marginal processing return that must cover the operation cost Cp and the capital costs. Based on the historical price series it is assumed the Mt = 290 €/t of the sunflower oil, operating cost per ton of sunflower is 200 €/t and for difference the capital cost 90 €/t for a plant with capacity equal to 100 thousand ton; the actual operating cost is 80 €/ton and the difference multiplied by the capacity is equal to 1 million € that is the sum to cover the capital cost of ten million € for a life horizon estimated 10 years. This is the break even situation and prices increasing the margin will procure profit affecting the capital rent.

4. Biodiesel processing

A typical situation is represented by a processing capacity much higher with respect to the relatively small size of farms dispersed in a large geographic area, then the transport costs will have an important role in the development of this analysis. To take account of these cost components the following part is organized by using the following information: i) a profit function that includes the transport costs; ii) a relation to take account of the potential local supply and the effective supply available to the processing plant; iii) the specification of the sunflower market price relationship in the local market area.

The enterprise profit function should reflect the spatial dimensions of the investment problem, because biodiesel processing facilities are uniquely large among grain processing enterprises (Gallagher et al). Hence, it is specified a model that relates plant size together with the determination of the local sunflower input market area. Further, it is assumed the processing firm is the only buyer of the farmer's production. Thus, corn price is no longer fixed in the local market area. Instead, the processing firm has some power to set prices in the local market area by selecting an appropriate plant capacity. The profit function for the processor has the following terms: revenues (R^e_t). sunflower costs (Cc_0), and operating costs (Cp). Also, the correlation between sunflower processing capacity and market area (d_t*) is specified:

5) $\pi_t^e = (Mt_t^e - Cp)\,Qgt - r^*K\,f(Qgt)$; where $Mt = coPot + cpPpt - Pgt$; and $Qgt = Qgt\,(d_t^*)$

The limit of the market area (d_t*) defines the sunflower input capacity sustainable by the local input market area when the parameters of intensity of supply *e* and *y* are known; *e* represents the ratio between sunflower production delivered to the processing plant and the total area; *y* is the yield. Assuming the circular form of the supply district with ray d defining the market boundary, the supply function is:

6) $Qgt\,f(d_t^*) = p\,d_t^{*2}\,e * y$

For instance for a typical market boundary with distance of radius equal to 70 Km (that is the distance fixed for a short chain) the theoretical area is 15386 Kmq or 1,54 million Ha SAU assuming that only ¼ of the area is dedicated to sunflower and only the 40% of this production is used for biodiesel production with yield equal to 2,5/ton /Ha, the total deliverable production to processing plant is approximately 240 thousand ton. that is the production to feed a plant with appreciable gain in cost for scale economies.

The dimension of the market boundary depends on the presence of competitors for the sunflower input near the processing plan. In absence of competition the convenience criteria for producers is defined by variable cost plus shipping cost $ck\,d_t^*$ from farm to processing plant.

The short-haul transport rate, is usually expressed in €/ton/Km and the total price is:

7) $Pg_t = Po + ck\,d_t^*$

The processor pays to all farmer the same price Po for sunflower delivered at the boundary of the area and shipped to the plant and this is the maximum price paid. The price decreases with the increase of the distance between farm and processing plant, then the convenience to increase the supply area is given by the sunflower cost:

$$8)\ Cg_t = \int_{dt=0}^{dt*} (Po_t + c_k\, d_t^*)2\,\pi\, d_t\, e\, y\, \Delta d_t$$

The size of the plant is optimized when the increase of the total plant cost that is the sum of the operative and capital cost is equal to the revenue increase obtained with the expansion of the plant.

In the following part it is assumed Rt in substitution of Mt because Rt represent the only composite revenue of the processed products (see 1); it is excluded the sunflower cost that is now variable in function of the quantity of product collected in the supply area. By substituting in 5, Mt with Rt and differentiating with respect to Qgt it is obtained:

$$9)\ \mathrm{Max}\pi_t^e = \partial(\mathrm{Rt} - \mathrm{Cp})\partial\mathrm{Qg_t} - \mathrm{r}*\frac{\partial K}{\partial Qgt} - \frac{\partial Cg_t}{\partial Qgt} = 0$$

from which it is derived Rt_t^e :

$$9.1)\ \mathrm{Rt}_t^e - \mathrm{Cp} = \mathrm{r}*\ \frac{\partial K}{\partial Qgt} + \frac{\partial Cg_t}{\partial Qgt}$$

and the optimal cost is:

$$9.2)\ \frac{\partial Cg_t}{\partial Qgt} = Pot + 3/2\ c_k d_t^*$$

The optimal condition suggests that the increase in marginal revenue is equal the marginal cost of production that is a variable in function of supply area. This equation then allows to take into account the plant scale and suppy area that will be used in the following empirical applications.

5. Return maximizing coop

For the processing co-op that maximizes the total returns to members and all producers in the input market area will be members, the objective function of this enterprise is to maximize the processed product revenues less processing costs less farm producer costs (Royer 2001). This means to maximize the joint producer and processor profits. Adding the spatial dimension, the net processing and crop production return for a unit of corn located at a distance d_t Km from the plant the condition is the following:

$$10)\ \mathrm{N}(d_t) = (R_t^e - Cp) = \mathrm{r}*\ \frac{Kf(Qgf(d*))}{Qg(d_t^*)} + (Co + c_k\, d_t)$$

The cost of feedstock for the joint producer/processor enterprise is defined by the initial payment paid by the cooperative to the member given by:

$$10.1)\ Cg_t = Co + c_k d_t$$

because an individual distance from the plant defines his transport costs. That is, sunflower producer-members are paid net processing revenues less the average capital cost, sunflower production costs, and actual transport costs to the processing plant. The net return could be obtained by using two payments. The processor first reimburses the sunflower price to producers for crop production and transport charges that are specific to an individual location farm. Later, the processor distributes the entire earnings, using the equation above and an individual location as a guide. Notice that a producer pays the transport costs based on his actual distance from the plant

(d_t), while he pays average capital costs based on the enterprises' choice of market boundary (d^*_t).

The total surplus to all plant members with a given market boundary d^*_t is,

11) $\Pi(d^*_t) = (R^e_t - Cp)\,Qgt(d^*_t) - r^*K f(Qgt f(d^*_t)) - Cg_t(d^*_t)$

11.1) with $Cg_t f(d^*_t) = \int_{dt}^{dt^*} (Co + c_k d_t) * (2\,p\,d_t) * e\,y\,D\,dt$

The $Cg_t f(d^*_t)$ is the sunflower cost equation for the integrated producer/processor defined the initial payment the processor corresponds to producers and substitutes the previous Cg_t because is in function of the supply area. The Pgt is represented in function of basic cost plus progressive cost in function of the distance:

12) $Pgt = Co + c_k d_t$

Hence the price paid for the feedstock is the sum of production and transport costs; this condition underlines the advantage of integration production/processing in a inique orgnization. The optimal size of this integrated unit is obtained by differentiating the previous objective function with respect to the variablr d*t:

13) $R^e_t - Cp = r^* \dfrac{\partial K}{\partial Qgt} + \dfrac{\partial Cgt}{\partial Qgt}$ where $\dfrac{\partial Cgt}{\partial Qgt} = Co + c_k d^*_t$

This business unit combines elements of a co-op and an integrated corn processing business. The co-op's "business-at-cost" principle motivates a sunflower payment of production plus transport cost that reflects the present resource cost and, provides the appropriate supply-inducing price for the optimal plant scale decision. Also, a co-op could decide about the annual capital payments at the market cost of capital to the firm by making payments to equity, borrowing from members, or from a bank depending on the best opportunity cost. Due to usual condition of lower liquidity Co-op have some difficulties to borrow from bank at lower costs, and procure capital with retained patronage refunds (Cobia and_Brewer 1989, pp. 247-249). The private enterprise "maximum profit" principle guides the capacity and dimension about market area decisions, using joint profits from sunflower production and processing. Finally, it is assumed that all producers in the input market area become members and deliver to the coop the sunflower crop net of the quantity used for rearing cattle. Producers will have an incentive to provide their production for processing if the sunflower cost reimbursement and sunflower processing return payment exceeds the price for export marketing. Persistent excess returns for processing would likely convince producers in a potential area toward complete conversion to processing. However, initial participation rates could be lower in a dynamic choice model that balances a long-run supply commitment against short-run marketing of sunflower to the export market, accounts for initial uncertainty about long-run net benefits, and considers the risk of price fluctuation in the oil export market. In short, the assumption of high levels of producer participation in processor supply agreements is tantamount to a demonstrated long-term profit advantage for committing capital to the processing enterprise.

6. Open Co-op

The open co-op operates at business cost. In general, the open co-op expands until the net average revenue less operating and capital costs per ton processed is equals to the supply price for the input (Helmberger and Hoos, 1962). Also, suppose that the co-op pays the same price to all members for corn delivered to the processing plant, regardless of their location, then the private sunflower cost function, Cg_b, describes the co-op's input expenditures.

$$14\ (R_t^e - Cp) - r^* \frac{Kf(Qgt)}{Qgt} = (Co + c_k\, d_t^* \quad)$$

Consequently, the co-op's equilibrium condition requires that the open co-op will expand plant capacity and market area up to the level where plant net operating revenues less annual capital costs will balance the expenditures on sunflower input. On the LHS, the average revenue for an incremental ton of sunflower capacity is adjusted downward for operating cost and the average annual cost of capital. The average input expendìture for the sunglower input, $Cg_b(d^*,)/Q(d^*_t)$, is given in its simplified form on the RHS.

7. Empirical analysis

The analysis is developed with the examination of 4 case studies that represent different organization adjustments of the biodiesel chain organization. Two previous considerations are:
i) the first is the scale economies will procure diminishing average costs of the processing plant (Gallagher and others, 2005) given by the sum of operative costs for purchasing inputs like seeds, fertilizers, energy, material, direct labour and fixed costs for capital depreciation, maintenance and insurance and overhead;
ii) the size of supply area depends on the plant capacity and producer's supply and transport cost set up by the processing plant. The following average cost function was estimated with respect to the quantity of feedstock delivered to the processing plant: CME = 12.000.000/Qgt + 0,0003Qgt; the first part of the equation is the fixed cost computed on initial investment of 12 million € while the second part is the variable cost that is linearly growing with the quantity of product delivered.
The numeric development is presented in the following table:

Table 6. Numeric development of the CME function

Prodotto	CME
t	€/t
17682,71	683,93
53048,12	242,12
88413,53	162,25
123778,94	134,08
159144,35	123,15
194509,77	120,05
229875,18	121,16
265240,59	124,81

The optimal capacity of the plant (DOM) is 194 thousand ton of feedstock processed with minimum average cost 20 €/t. The results of the simulation are reported in tab. 10.
The supply of feedstock determine the exploitation of the plant capacity that is required to develop this analysis: the size depends on the physical features of the geographic area analyzed, distribution, size intensity of delivery, sunflower yield of the farms that participate to the biodiesel program road network and climatic conditions, presence of supply concentration and storage and facilitating services: technology transfer and consultant, contract agreements, financial and marketing intelligence. At present time these services are performed by the already existing Cooperative organization "Consorzi agrari" that for long time operated in the collection and sto-

rage of agricultural products and crushing companies, interested to grow their business by supplying to farmers production inputs, output delivery and assistance in the integration process. In the region Friuli V.G. Cereal Docks is one of the most active in building the integrated supply chain while other companies namely Caffaro biofuel are only interested in buying the feedstock.

Next elaboration is the development of the equation 6 already discussed; the supply area is split in eight concentric annulus of constant length equal to 10 Km in each of one is present a cluster of farms, varying by number, size, intensity and production features that are the parameters needed to compute the feedstock supply.

This problem is afforded with reference to Friuli V. G region using the ISTAT data from the survey on the structural characteristics of the farms (Indagine sulle caratteristiche strutturali delle aziende agricole).[1]: The cluster is composed as it is represented below:

1) farms group 1: (Az1); survival farms, less than 2 Ha, average surface 1,08 Ha;
2) farms group 2: (Az2); small size, between 2 and 10, average surface 4,50 Ha;
3) farms group 3: (Az3); medium size, between 10 and 50, average surface di 20,06 Ha;
4) farms group 4: (Az4); large size, more than 50 Ha with average surface 122,21 Ha.

The next table reports the structure of the agricultural sector in the region FVG.

Table 7. Distribuzione delle aziende agricole friulane ripartite per dimensione

		Nr of farm by size			
	< 2 Ha	2-10 Ha	10-50 Ha	> 50 Ha	TOTALE
VAL ASS	6968	11831	4403	617	23819
Val%	29,254	49,670	18,485	2,590	100,000
		SAU			
VAL ASS	7541	53236	88338	75406	224521
Val%	3,36	23,71	39,35	33,59	100,00
	Average size per farm				
VAL ASS	1,082	4,500	20,063	122,214	9,426

Fonte: ISTAT, Indagine strutturale sulle aziende agricole italiane

To determine the mix of farms in each anulus the regional distribution is calculated with the following formula :

15 - $S_{i=1..n}$ Ni*Si = Ss where Ni and Si indicate the number and average surface of the farms in each of the size classes and Ss indicate the total regional SAU equal to 224521 Ha and then it is reported the regional mix to the annulus with a simple proportion based on the assumption that the farms are randomly distributed in the region.

Example: the first anulus has a radius of 10 Km the area is 31400 Ha; the farm number of the first size class is computer with the following proportion : 224521: 31400 = 7541 : X; X = 1054,63 and dividing this value for the average surface it is obtained the number of farms equal to 974,50; or it is sufficient to multiply the number of farms of the size class for the coefficient 31400/224521.

It is also assumed that in the different sectors the mix of farms is the same in proportion of the one reported in table 8 because it is non influential for the farm mix the distance respect the origin.

The agricultural surface dedicated to energy cultures is growing linearly beginning with 10% for the smaller farms and progress 5% for the following dimensional groups. The energy SAU

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[1] For more accurate analysis it is needed to georeferentiate all the farm with data from AGEA and Informatic Cadastre.

of the first group (Az1) is 974,5*1,082*0,1 = 105,4 and this method is applied for the following groups. The average regional production of sunflower is 2,5 t/Ha. In the following table are reported the values concerning the farm distribution, the acreage and production of the ten annulus assuming each anulus a constant size of 10 Km.

Table 8. Distribution of farm, SAU and production in the supply area (maximum radius 100 Km.)

Supply area			Number of farms distributed by dimension					Surface dedicated to energy crops					Production
Anulus	Radius	Hectares	Az 1	Az 2	Az 3	Az 4	Totale	Az 1	Az 2	Az 3	Az 4	Totale Ha	t
settore 1	10	31400	974,5	1654,6	615,8	86,3	3331,2	105,4	1116,9	2470,9	2636,4	6329,6	15824,0
settore 2	20	94200	2923,5	4963,8	1847,3	258,9	9993,5	316,3	3350,6	7412,6	7909,3	18988,8	47472,0
settore 3	30	157000	4872,5	8273,0	3078,9	431,4	16655,8	527,2	5584,3	12354,3	13182,2	31648,0	79120,0
settore 4	40	219800	6821,5	11582,2	4310,4	604,0	23318,2	738,1	7818,0	17296,0	18455,1	44307,2	110768,0
settore 5	50	282600	8770,5	14891,4	5542,0	776,6	29980,5	949,0	10051,7	22237,7	23728,0	56966,4	142416,0
settore 6	60	345400	10719,5	18200,6	6773,5	949,2	36642,8	1159,8	12285,4	27179,4	29000,9	69625,6	174064,0
settore 7	70	408200	12668,5	21509,9	8005,1	1121,8	43305,2	1370,7	14519,2	32121,1	34273,8	82284,8	205712,0
settore 8	80	471000	14617,5	24819,1	9236,6	1294,3	49967,5	1581,6	16752,9	37062,8	39546,7	94944,0	237360,0
settore 9	90	533800	16566,5	28128,3	10468,2	1466,9	56629,8	1792,5	18986,6	42004,5	44819,6	107603,2	269008,0
settore 10	100	596600	18515,5	31437,5	11699,7	1639,5	63292,1	2003,4	21220,3	46946,2	50092,5	120262,4	300656,0
Totale		3140000	97449,8	165460,4	61577,4	8628,9	333116,5	10544,1	111685,8	247085,5	263644,6	632959,9	1582399,7

Source: elaboration on regional ISTAT data

7.1 Case 1 – Independency between agricultural production and processing enterprises

It is analysed the profit of the processing plant in case of independency. It is assumed that the feedstock price delivered to processor is fixed and determined exogenously. With the 5 the profit is determined by:

$$16)\quad \pi_t^e = (Mt - Cp)\,Qgt - r{*}Kf'(Qgt)\ ; \quad Mt = coPot + cpPp - Pgt$$

co e cp are the transformation coefficients of the sunflower seed in oil and panel with values: co = 0,4 e cp = 0,6 the sunflower oil is paid 1370 €/t to Rotternam future (sept 08) and panel 220 €/t the sunflower seeds 360 €/t; operative costs are equal 100 €/t. The crushing plant is able to estract mechanically from 300 to 450 Kg oil from a ton of seed high oleic the average quantity is equal to 30 thosand ton per year of olio. The following average cost function has been estimated: CME = 1500 – 50Q + 0,49Q^2; it works at the optimal level of 50 thousand ton of seed delivered with average minimum cost of 225 €/t. Table 4 reports the data of the average cost function.

Table 9. Numeric development of the average cost function

Lavorazione t x 1000	CME
10	1049
20	696
30	441
40	284
50	225
60	264
70	401
80	636
90	969

Source our elaboration on industrial data

The margin for one ton of seed is:
Mt = (0,4* 1370 + 0,6*220 – 360) – 100 - 225 = 115 €/t
At the level of 50 thousand ton the profit is 115 *50000 = 5,75 milioni €

7.2. Case 2 – Convenience to expand the supply area.

The next simulation is directed to clear the effect of growing the supply area. In table 5 are reported the results of the size change for different annulus each one absorbs a given working capacity that is related to the supply of raw material hence the cost function allows to evacuate the convenience to grow the supply area. The following average cost is used : CME = 12000000/ Qgt + 0,0015Qgt. The other values reported in €/t are the price of sunflower oil equal to 1370 €/t, the price of sunflower panels 220 €/t from these products id obtained the composite revenue (Rtc) per ton of seed , the cost of row material 360 €/t, the operative costs: **1**00 €/t. The difference between revenue and costs represents the unit profit of the plant varying with the supply area. In tab. 11 the optimal area is around 40 Km with profit equal to 276,4 €/t. To producers is paid the the price determined to the Bologna commodity market of 360 €/t. Tab 10 – Independent solution: Profit of the plant for ton of seed delivered

Table 10. Independent solution: Profit of the plant for ton of seed delivered

Radius	Rtc	Cathegory of average cost			
Km	€/t	Feedstock	Operation	Plant	Profit
10	950	360	100,0	773,4	-283,4
20	950	360	100,0	297,9	192,1
30	950	360	100,0	226,8	263,2
40	950	360	100,0	213,6	276,4
50	950	360	100,0	219,6	270,4
60	950	360	100,0	234,3	255,7
70	950	360	100,0	253,8	236,2
80	950	360	100,0	276,0	214,0
90	950	360	100,0	300,2	189,8
100	950	360	100,0	325,5	164,5

Source our elaboration on industrial data

7.3 Case 3 – Cooperative solution with closed number of producers members

From equation 10 the participation solution admit that the member are compensated with net return calculated on the basis of the difference between composite revenue and costs respectively: production, processing and transport. The transport cost of the seed from the farm to the processor is evaluated on the average of the transport made by a truck with capacity 20 t/ per hauling and average cost per Km equal to: 0,03 €/t/km. Transport cost is a variable growing with the increase of the farm-processing plant distance $c_k d_t$. The function will account of the progressive reduction of the kilometric cost per unit of product with the growing distance because of the evidence of scale economies. The equation is CME = 0,20 Qgt – 0,0000008 Qgt^2 . The cost is also related to the feedstock delivered and supply area depending on d*t and is the same as the one reported in 2. The number of members is assumed to be fixed. In tab.6are reported the values of the net revenue computer on different dimension of the supplì area. With the net revenue is calculated the convenience of the member to operate in the coop enterprise by comparing this prie with the market price. 360 €: the optimal value is reached with a dimension of the supply area of 30 Km radius and net revenue equal to 763 €.

Table 11. Soluzione compartecipata: calcolo dell'utile netto per tonnellata di girasole

Radius	Revenue	Cost cathegories			Net revenue (NR)	NR/Member
Km	€/t	operational	trasport	plant	€	€/t
10	10760318	1582400	30146	12375598	-3227825	-510
20	32280955	4747199	162845	15380385	11990526	631
30	53801591	7911999	362040	21389958	24137594	763
40	75322228	11076798	591675	30404319	33249436	750
50	96842864	14241598	815690	42423466	39362110	691
60	118363500	17406397	998030	57447399	42511674	611
70	139884137	20571197	1102636	75476119	42734185	519
80	161404773	23735996	1093451	96509626	40065699	422
90	182925410	26900796	934418	120547920	34542276	321
100	204446046	30065595	589479	147591001	26199972	218

Fonte: nostra elaborazione

7.4 Case 4 - Cooperative solution with a free entry of members

The last case regards the cooperative solution with free entry of delivery producers; this situation makes impossible to reach the optimal value but it will be needed to determine the limit value at the break even. That is a net revenue per unit of product at least equal to the market price. This allow to increase the supply area to a distance between 80 and 90 Km and from table 6the number of farms is around 100 thousand or the 46% of the total and the total quantity of product delivered is 280 thousand ton. The open coop allows to use the maximum amount of available resources and is able to enforce its market position with a relevant control of the available feedstock in the supply area and the member receive a price that is superior to the market one. The negative side of this participation is the difficulty to manage the feedstock supply in absence of any regulation concerning both the number of member and their product delivery. These considerations are suggested by the observations of the producer's behaviour in the recent past years when the soaring up of the agricultural commodity prices induced many farmers to avoid to establish contractual relations with industrial partners.

8. Conclusions

In this analysis it was analyzed the optimization process of the agro-biodiesel chain by simulation different participative models of cooperative/non cooperative chain agreements. This work examines the recent transformations induced in the agro-energy sector by the emerging of a agro-energy farm and survival by adopting different agreements with the industry. The integration of the farm into the agro-industrial chain requires to examine the consequences of scale and logistic problems related to the size of the processing plant, the size and characteristics of the supply area the logistic costs related to the dispersion of the farm in the supply area. The part regarding the investment opportunity has been resolved with modeling the return depends on the distance between the farm and processing plant and by modeling the supply area taking account of the characteristics of the farm present in the supply area. The following part has simulated different forms of organizations based on independent and cooperative forms using enterprise models framed to take account of the specificity of the biofuel sector. The four case discussion have disclosed more information about the real application of the theoretical models. The results have confirmed: i) the relation between the choice of specific organization form and results obtained; ii) the importance of the scale economies and logistic costs implied in the enlargement of the supply area; iii) the type of farms that are in the supply area (dimension, supply capacity, yield).

Finally an important aspect of this strategy is offered by the market price trends of biofuels commodity that could discourage operators from long term investment if the rate of return are low. In this case it important that the institution offer incentives fiscal incentives and incorporation quota are the two instrument to be use in order to achieve higher level of energy security and environmental safety.

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