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Economies of Scale and Concentration in the Greek and the Norwegian Aquaculture Industry. An empirical Study.

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ABSTRACT
The purpose of this study is to investigate whether there are economies of scale in the Greek and Norwegian fish farming industry, and to examine the structure of the sector. To investigate economies of scale, use the Cobb-Douglas production function, while we examine the structure of the fish-farming by computing the HHI indicator over different years. We find that the market concentration level is high in Greece in both relative, to Norway, and in absolute terms. From the other part, Norway, the leader of the fish farming of Atlantic salmon and Rainbow trout globally, suffers from economies of scale in the examined period. Given the fact that both Greek and Norwegian production is targeting large markets in Europe (UK, France, Italy) both the findings in Greece and Norway may be worrying signals, that large M&A activity may lead to decreasing competition and increasing returns to scale in the industry, as previously happened in the food retail industry. Given the important contribution of fish farming to poverty alleviation, food security and social well being, European regulators should investigate whether it is optimal to exercise policies that enhance technology transfer and limit further market concentration.
***Keywords**: Fisheries, industry structure, regulation, Government Expenditures and Health, Market Structure*

1. INTRODUCTION

Seafood is the fastest growing food sector. Global demand for seafood is growing at nearly double digit numbers annually, but commercial fishing has reached its maximum sustainable level. Therefore the need for rapid development of the aquaculture industry will eventually fill this growth gap, thus changing the value chain dynamics. The question is whether consumers can actually receive the benefits of aquaculture at a competitive price. Consumers can receive the benefits of competition if aquaculture industry is an industry that does not have economies of scale and high concentration that deters the entry of new players. The efficiency of the market matters especially when taken into account that during the last 25 years, aquaculture production has changed from a minor contributor less than 8% in 1975 to the world's seafood supply to contributing about 30% on global supply in 2000, according to Asche and Tveteras (2002). Aquaculture also is favoured by changes in retail outlets. According to Murray and Fofana (2002), who studied the pioneering UK retail chain industry, the concentration in food retail industry and the related need for consistent standards and vertical integration as well as the need for increasing processing in fish products will benefit aquaculture industry in the long run which seems much better suited to cope with these trends.

Our study investigates the economies of scale and the concentration level in Greek and Norwegian fish farming industry, out of the most crucial countries in fish farming in Europe. Norway is major producer in Europe concerning the fish farming of Atlantic salmon and trout, and Greece is the larger producer country of sea bream and sea bass in the Mediterranean. An early study in the Greek aquaculture sector, by Karagiannis and Katranidis (2000) who analyze the technical relationships involved in the production of sea bass and sea bream in Greece, found decreasing returns to scale. On the contrary, research in Norway and Chile show increasing returns to scale. Salvanes (1989) who made also an empirical analysis of economies of scale and substitution possibilities of the Norwegian fish farming industry in 1989, and tests the equity-efficiency hypothesis for the Norwegian aquaculture industry, found evidence of returns to scale, and Perlmana and Juaacuterez-Rubiob(2010) who studied salmon production in Chile found evidence of economies of scale and market concentration. Our aim, using a recent data set (2002-2008), is to compare the topics mentioned in a two cross-country analysis, under the light of more recent data, compared to these used in early studies.

2. METHODOLOGY

We use the Cobb-Douglas production function to investigate economies of scale in the fish farming industry in Greece as well as in Norway. The Cobb-Douglas model that is used in the present analysis is a two-input production function where the output (production) is determined by the capital and the labour. This type of production function is particularly useful since it is loglinear and can be used to determine whether the inputs exhibit increasing, decreasing, or constant returns to scale. The concentration level of the fish farming industry of the examined countries is also measured using two different tools: the concentration ratio of the CR4 (the four-firm ratio) and the well known HHI indicator. The four-firm ratio CR4 is a simple approach to measure concentration of market share within a particular industry: the ratio of total revenues of the four major firms in the sector is compared with the revenues of the whole industry and a market is said to be highly concentrated if CR4>50%. This ratio is measured in the following sections but as sometimes it is vulnerable to unreliable conclusions (firms with great difference in their shares in the market may have the same ratio) the measurement of HHI follows to enhance the conclusions that are made. The Cobb-Douglas production function is widely used in economics, to represent the relationship of an output to inputs. It was proposed by Knut Wicksell (1851 - 1926), and tested against statistical evidence by Charles Cobb and Paul Douglas in 1928. In 1928 Charles Cobb and Paul Douglas published a study in which they modelled the growth of the American economy during the period 1899 - 1922. They considered a simplified view of the economy in which production output is determined by the amount of labour involved and the amount of capital invested. While there are many other factors affecting economic performance, their model proved to be remarkably accurate.

The function they used to model production was of the two-input form:

$$Y(L, K) = b\, L^{a} K^{\beta}$$

Where:

- Y = total production (the monetary value of all goods produced in a year)
- L = labor input (the total number of person-hours worked in a year)
- K= capital input (the monetary worth of all machinery, equipment and buildings)
- b = total factor productivity
- a and β are the output elasticities of labor and capital, respectively. These values are constants determined by available technology.

Output elasticity measures the responsiveness of output to a change in levels of either labour or capital used in production, ceteris paribus (all other influencing factors are held constant). For example if $\alpha = 0.15$, a 1% increase in labour would lead to approximately a 0.15% increase in output. Returns to scale refer to a technical property of production that examines changes in output subsequent to a proportional change in all inputs (where all inputs increase by a constant factor). If output increases by the same proportional change then there are constant returns to scale (CRTS), sometimes referred to simply as returns to scale. If output increases by less than that proportional change, there are decreasing returns to scale (DRS). If output increases by more than that proportion, there are increasing returns to scale (IRS).

Moreover if:

- $a + \beta = 1$, the production function has constant returns to scale
- $a + \beta < 1$, returns to scale are decreasing
- $a + \beta > 1$, returns to scale are increasing

In particular, assuming perfect competition, a and β can be shown to be labor and capital's share of output.

The equation Cobb-Douglas that was used follows:

$$Q_t = A\, L_t^{a} K_t^{b} e^{\varepsilon t}$$

Where,

- Q : industry product as sales in monetary unit
- L : industry labour as cost of sales in monetary unit
- K : industry capital as equity in monetary unit

The exponential form is transformed into logarithmic in this analysis, as follows:

$$LogQ = LogA + aLogL + bLogK + \varepsilon_t$$

In the model developed, LogA is the constant coefficient, a, b are regression coefficients and ε are the estimated residuals. Each of the a, b coefficients define the effects of the independent variable it comes before, on the change of Q. Different tools are used to measure concentration of market share within a particular industry. One simple approach, concentration ratios, compares the ratio of total revenues of the major players with the revenues of the entire industry, using the top four firms CR4 or the top eight firms

CR8. If the four-firm ratio is equal to or greater than 50 percent, or if the eight-firm ratio is equal to or greater than 75 percent, then the market is said to be highly concentrated.
Concentration ratios are helpful in conducting trend analysis, to determine changes over time. However, the ratios themselves are not sensitive to the individual power held by individual firms. For example, two different industries may have equal ratios, but the shares of the firms within each of the industries may differ greatly.

The Herfindahl-Hirschman (HHI) Index, used by the Antitrust Division of the Department of Justice in the United States [1]is another method to measure concentration in a market. The HHI is calculated by summing the squares of the individual market shares of all the participants. Unlike the four-firm concentration ratio, the HHI reflects both the distribution of the market shares of the top four firms and the composition of the market outside the four firms. It also gives proportionately greater weight to the market shares of the larger firms, in accord with their relative importance in competitive. The Agency divides the spectrum of market concentration as measured by the HHI into three regions that can be broadly characterised as not concentrated (HHI below 1000), moderately concentrated (HHI between 1000 and 1800), and highly concentrated (HHI above 1800).
An alternative method to measure concentration is the Lorenz Curve[2]. The Lorenz Curve assumes that in a market individual firm shares should be divided equally. Using data from a market, the researcher can plot the individual shares on a graph, illustrating the level of inequality (or curve) that exists in the market being examined. The utility of this approach lies in its graphical presentation, but the curve can be hard to interpret[3]. Like the HHI, the larger the number of firms the more challenging to use this method as a means to measure concentration. Despite the lengthy literature on various possible measures of market structure, there is no clear theoretical basis for choosing among the various measures, and undoubtedly the HHI has arguably been favoured among the measures probably because it provides interalia a measure of concentration that accounts for both the number and size distribution of all firms in a market. In our study the concentration level of the fish farming industry of the examined countries is measured using the four-firm ratio and the HHI.

3. DATA

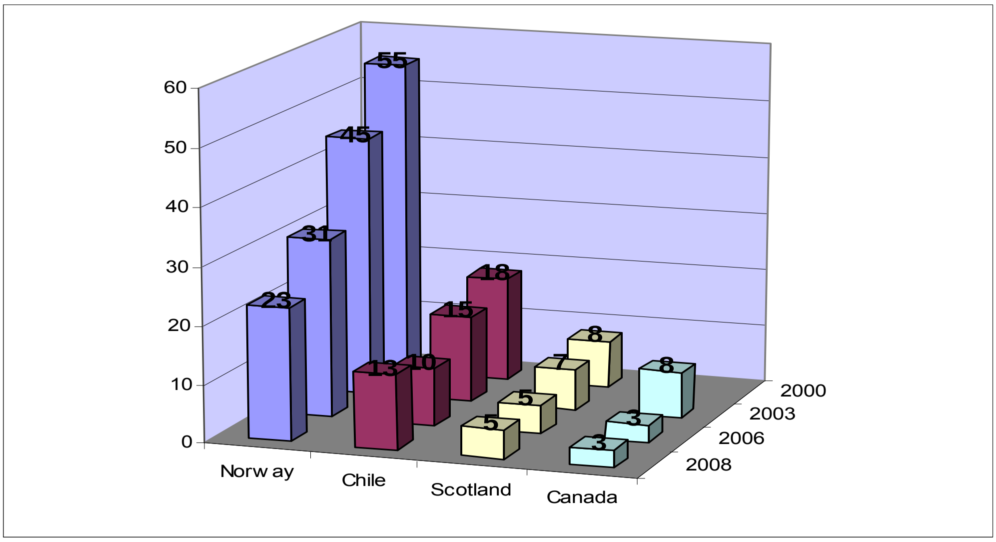
In this study, fish farming data during the 2004-2008 production seasons are used. The dataset is obtained from the financial statements of the top Greek fish farming enterprises and the cumulative data is obtained from the General Secretariat of International Economic Relations and Development Cooperation of the Greek Ministry of Foreign Affairs [6]. The corresponding Norwegian data was received from the Norwegian Directorate of Fisheries[4]and is identical with the data used in its publication on the profitability of the Norwegian Fish Farming Industry for the years 2002-2008 (see Table 2 . Cobb-Douglas production function was applied to the data gathered and the regression analysis was performed in order to analyze how effectively the input factors were used separately in both countries.

Table 1: Production of Gilthead sea bream/European sea bass in the Mediterranean, in tons (Source: FEAP: Production and Price Reports of Member Associations 2008)

Country	***2003***	***2004***	***2005***	***2006***	***2007***	***2007 Market Share***
Greece	97.000	82.000	85.000	100.000	120.000	48%
Turkey	27.000	31.000	38.600	46.000	64.000	26%
Spain	17.000	17.700	21.100	29.100	33.000	13%
Italy	16.700	17.500	17.100	18.000	18.300	7%
France	4.800	5.600	6.200	7.800	6.200	2%
Portugal	4.000	4.000	4.000	3.000	3.000	1%
Croatia	2.500	2.400	3.000	2.600	3.000	1%
Cyprus	2.000	2.000	2.000	2.200	2.500	1%
Malta	1.000	900	900	900	900	0%
Sum	172.000	163.100	177.900	209.600	250.900	100%

[1] U.S. Department of Justice and the Federal Trade Commission. Issued: April 2, 1992, http://www.justice.gov/atr/public/guidelines/hmg.htm#15
[2] A.Albarran, B. Mierzejewska (2004), for example use the Lorentz to measure Media Concentration in the US and European Union.
[3] See Litman, (1985) for a discussion
[4] Norwegian Directorate of Fisheries, "Profitability Survey on Norwegian Fish Farms", http://www.fiskeridir.no/english

Figure 1: Number of companies that produce 80% of the total production of Atlantic salmon and trout



(Source: Kontali)

Table 2: Aggregated Sector Data of the largest companies in the Greek and Norwegian aquaculture industry

Year	***Greek fish farming industry (1000 €)***			***Norwegian fish farming industry(NOK)***		
	Output	***Capital***	***Labor***	***Output***	***Capital***	***Labor***
2002	-	-	-	37,746,131	2,931,556	5,498,667
2003	-	-	-	37,984,684	2,701,919	5,650,877
2004	308,348	586,609	252,414	51,539,975	3,654,957	8,678,294
2005	330,504	673,241	274,318	82,488,368	5,570,728	23,789,286
2006	430,745	830,600	379,767	108,995,764	7,074,640	27,870,279
2007	575,130	1,409,336	392,535	106,742,655	7,565,049	20,317,167
2008	602,150	1,561,998	371,519	127,507,369	8,722,627	26,548,501

4. EMPIRICAL RESULTS

4.1 Period: 2002-2008

We examine with the above Cobb-Douglas method, the appearance of economies of scale in fish farming industry using the cumulative sector data set for Norway (2002-2008) and for Greece (2004-2008). Both models, concerning Greek and Norwegian industry are statistically very important, so much in individual level t-statistics as in total level distribution F (Table 3).

According to the results of regression analysis, among Greek data the elasticities of Labour and Capital are 0.388 and 0.541 equivalent. Consequently, this means that if we keep constant the input of capital, an increase in the work at one unit, will lead to an increase of production at 0.388 and respectively, if we keep constant the work and increase the capital at one unit, then the production it is increased at 0.541. If we add up the two elasticities, then we see that their sum is equal with 0.93 that is smaller from the unit and consequently there exists declining output of scale in the Greek fish farming industry of 2004-2008.

In order to still advance however a step more further the work, a t-test is conducted for the examination of the case H_0: $b_K+b_L=1$ with the alternative H_1 : $b_K+b_L \neq 1$; where b_K is the elasticity of capital and b_L is the elasticity of work. The case H_0 is accepted in significance level 1%, so our conclusion is that in Greek fish farming industry there are constant returns to scale.

Even though the fish farming sector enjoyed a spectacular growth in the beginning of the 90's up until 2003, economies of scale haven't appeared yet. The past massive entrance of new companies into the sector brought an oversupply that lead to increased competition and low sell prices. In order to find a way to strengthen their financial situation, several companies merged into large groups, in the present and in the recent past, aiming to achieve economies of scale and hence maximize their profit margin. However the target of economies of scale and high profit margins still remains to be attained.

The same analysis is adapted to the Norwegian data set and the regression shows that the elasticities of labor and capital are respectively 0.150 and 0.858. We see that ceteris paribus, if we increase the labour by one unit and keep the capital constant, the corresponding increase in production is only 0,15 while an additional investment in the capital (keeping the labour constant) leads to a production increase by 0,86. This may indicates that Norwegian fish farming industry relies on capital more than on labour and this leads to a non-well exploited labour capacity. Nevertheless the investment on capital seems to perform well. This may be explained by the Norwegian focus on marine industry development through research and education. More than a billion Norwegian kroner are allocated each year from the Norwegian national budget to marine research. The Norwegian marine industry may focus more in the technology development than in labour efficiency.

The sum of the two elasticities is 1,008 and after the t-test the null-hypothesis $b_K+b_L=1$ is rejected and a second t-test concludes that $b_K+b_L>1$. Thus, we find increasing returns to scale in the Norwegian fish farming industry during the period 2002-2008. Figure 2 confirms the results provided from the regression analysis: the industry grows significantly in terms of sales and profit margins from 2004 onwards, while its operating profit margin reached a limit of 30% in 2006. Operating profit margin had a peak in 2006, reducing significantly in 2007, (but still high, standing at 13.2%). The main reason for decreasing profitability is the significant decrease in average sales price of Atlantic salmon and Rainbow trout during the last two years, mainly due to over-capacity (average sales price for Atlantic salmon decreased by 19% from 2006 to 2007, while average sales price for Rainbow trout decreased with 27 % during the period).

Figure 2: Development of Operating margin in the Norwegian fish farming sector (2002, 2007)

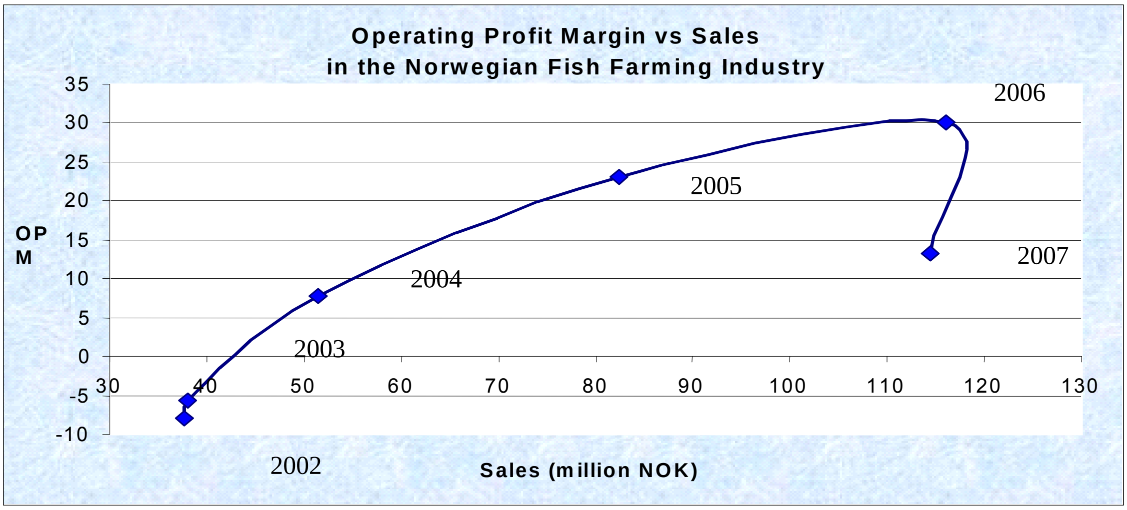


Table 3: Cobb-Douglas regression analysis summary, Greece and Norway

Greek fish farming industry				***Norwegian fish farming industry***			
F-*value*	***Parameter***	***Estimate***	***t-value***	***F-value***	***Parameter***	***Estimate***	***t-value***
	constant	0.6245	0.8775		constant	2.3779	4.1736
474.477	b_K	0.5405	13.2056	759.826	b_K	0.8579	9.1169
	b_L	0.3875	4.4434		b_L	0.1502	2.4455

4.2 Top Fish Farming Producers

We investigate Cobb-Douglas equations for the year 2008. The data set used, consists of the financial data of the ten largest fish farming enterprises, for Norway, as well as for Greece.

Findings are similar to these when using the whole sample of companies operating in the sector. Economies of scale do exist in the fish farming sector during for the period 2002-2008 in Norway, among the largest aquaculture companies, but the corresponding Greek sector was facing constant returns to scale. The Cobb-Douglas analysis in the Greek sample shows (Table 4), that economies of scale do finally appear in 2008 and as $b_K+b_L=1.25$ while in 2007, $b_K+b_L=0.86$ so the returns to scale were decreasing. In addition, the regression coefficients for FY2008 are 0.25 and 1.01 respectively for capital and labor, while being 0.63 and 0.23 respectively for FY2007.

The Norwegian data set comes to different conclusions. The sum of the regression coefficients, $b_K+b_L=1.02$ (see Table 5), indicates typically the existence of economies of scale for 2008, but as it is not significantly different to the unit. As we also can see in figure 2, the financial years 2007 and 2008 were not as profitable years as 2006, when the operating profitable margin of the sector was extremely high, at 30%. The results of this section, reflect the decrease of the high profitability in more modest level (OPM=9% for the industry in 2008 and 13.2% in 2007), probably due to over-capacity and excess production. The calculated regression coefficients are 0.30 for the capital and 0.72 for the labor, so a 1% increase on the labor leads to an increased production by 0.72, however, the results of an additional investment on capital regarding the largest firms were not that spectacular.

Table 4: Cobb-Douglas regression analysis, Ten Largest Greek fish farming firms, 2007 and 2008

2008						2007					
F-value	Para-meter	Estimate	t-value	p-value	R_sq	F-value	Para-meter	Estimate	t-value	p-value	R_sq
94,59	constant	-2,1648	-2,0577	0,0853			constant	1,8310	4,1736	0,3697	87,0%
	b_K	0,2456	8,4779	0,0001	96,9%	20,05	b_K	0,6357	9,1169	0,0703	
	b_L	1,0060	4,4434	0,0044			b_L	0,2287	2,4456	0,2086	

Table 5: Cobb-Douglas regression analysis, Norwegian Fish Farming Industry, 2008

F-value	*Parameter*	*Estimate*	*t-value*	*p-value*	*R_sq*
29308,2	constant	-			99,9%
	b_K	0,3010271	2,025794	0,135894	
	b_L	0,7227799	5,089013	0,014665	

4. 3 Concentration

Concerning Greece, the top nine largest, in terms of annual turnover, enterprises, account for 83% of the fish farming market, hence their market shares are used to calculate HHI. The whole industry consisted of 106 companies having 318 units in 2008 and their number is estimated to decrease in 2010 at 80 companies with 330 units in their possession. Figure 3 is a strong indicator of the existence of concentration in the Greek fish farming industry while the concentration in Norway doesn't seem to be so intense (Figure 4). Particularly, the number of companies in the Norwegian fish market reduced at a smaller degree, to 110 in 2007 (while 121 in 2006), with 602 licences on their own. For the calculation of HHI we used the market shares of the top eight Norwegian enterprises. Table 6 and Table 7 indicate the concentration rates in Greek and Norwegian fish farming industry correspondingly. The four-firm ratio CR4 is about 60% for both countries and for the examined period 2004-2008, indicates highly concentrated market. As CR4 isn't the safest way to measure concentration level, we also computed the HHI. The average HHI estimation is 1410 for the Greek firms and 1093 for the Norwegian without large variations through the examined years (Figure 5 represents HHI for both countries). According to the criteria used by the Antitrust Division of the Department of Justice in the United States, both market seem to be moderately concentrated as HHI is smaller than 1800. More particularly as Norwegian HHI is slightly above the 1000 level we may conclude that the concentration is not significant in Norway. In contrast concentration is more obvious in Greece but with a downward tendency from 2004 to 2008.

Table 6: Concentration levels in the Greek Fish Farming Industry, 2004-2008

Year	***Concentration***	
	HHI	***Top Four (percent)***
2004	1481	65%
2005	1589	63%
2006	1391	61%
2007	1397	63%
2008	1190	63%
Average HHI	1410	

Table 7: Concentration levels in the Norwegian Fish Farming Industry, 2005-2008

Year	***Concentration***	
	HHI	***Top Four (percent)***
2005	1089	56%
2006	1013	59%
2007	1175	61%
2008	1095	60%
Average HHI	1093	

The reason of the relatively modest concentration in Norway is mainly that production capacity is driven by the award of licences. Norwegian law until 2005 limits one corporate group to holding no more than 25% of all the licences. A new licence system that was introduced in 2005, changed the previous, based on feed quotas system, to one based on Maximum Standing Biomass. This one has greatly increased available capacity in Norway but this additional capacity has not yet been utilised from the Norwegian fish farming enterprises. In Contrast, the Greek law is not yet severe concerning the limits of expansion in the industry while Norwegian licensing limit was introduced in 1973. The Greek Competition Commission has not managed yet to limit fish farming industries.

Figure 3: Number of fish farming companies and licences in Greece (1997-2010, Source: General Secretariat of International Economic Relations and Development Cooperation of the Greek Ministry of Foreign Affairs)

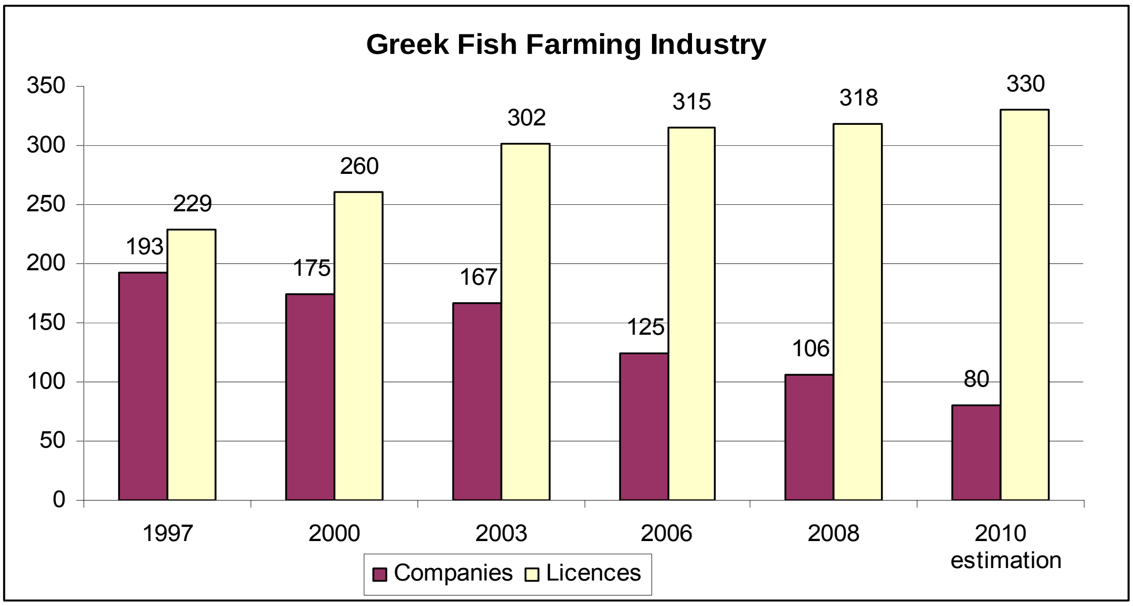


Figure 4: Number of fish farming companies and licences in Norway (2004-2007, Source: Norwegian Directorate of Fisheries)

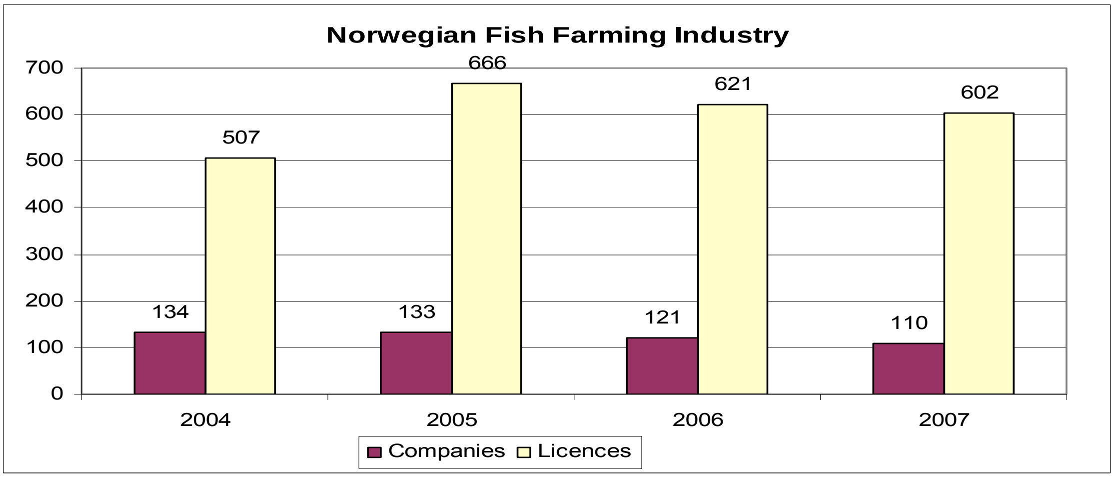
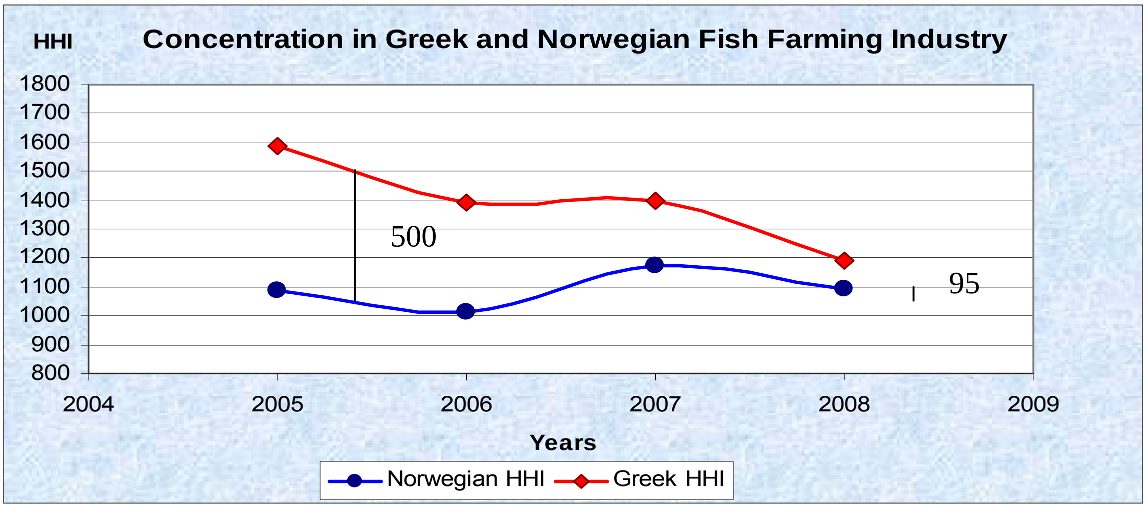


Figure 5: Comparison of concentration level (HHI) in the Greek and Norwegian fish farming industries



5. CONCLUSIONS

According to FAO (2002) aquaculture can make an important contribution to poverty alleviation, food security and social well-being, and already does so in many developing countries, contributing almost a third of global fisheries production. To that extent, the close investigation of the structure and performance of the fish-farming industry may be socially increasingly important. During the last 25 years, fish farming industry has been developed rapidly in Greece. Exploiting the competitive advantages of its climate, morphological structure and large coastline(two thirds of the European coastline), Greece became the main sea bream and sea bass producer in the Mediterranean, and one of the major exporters of this species in Europe. Greek fish farming industry has further potential for development in the near future, given that Cobb-Douglas model indicates that the Greek fish farming companies capital's elasticity of production is relatively low(0.54), compared to Norwegian one (0,85). The rapid growth requires an extensive financial, scientific and educational plan from both governmental and private sources, as in Norway.

Furthermore, concentration level is high in Greece (average HHI=1410), compared to Norway's concentration (average HHI=1093), and in absolute terms, for the dual purpose of either reducing the concentration level and the unemployment rate, decentralization in Greek fish farming industry should be motivated. Luckily, concentration, at the moment, is not associated with economies of scale in Greece.

From the other part, Norway, the leader of the fish farming of Atlantic salmon and Rainbow trout globally, suffers from economies of scale for the period 2002-2008. Over-capacity and excess production may lead to increasing concentration, and related decreasing competition, in the future. Our study contradicts to an earlier study by Karagiannis and Katranidis (2000) who found decreasing returns to scale in Greek fish-farming industry. On the contrary, our findings in Norwich industry are in line with research in Norway and Chile that show increasing returns to scale by Salvanes (1989) and Perlmana and Juaacuterez-Rubiob(2010). Given the fact that both Greek and Norwegian production target large markets in Europe (UK, France, Italy) both the findings in Greece and Norway may be worrying signals, taking into account the findings of Murray and Fofana (2002) that show concentration in food retail industry. It may be possible, within the years to come, large M&A activity to lead to decreasing competition and increasing returns to scale in the industry, as previously happened in the food retail industry. Given the important contribution of fish-farming to poverty alleviation, food security and social well-being, European regulators should exercise policies that enhance technology transfer and limit market concentration in this already concentrated sector.

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