PRODUCTION STRUCTURE AND CAPACITY UTILISATION IN MULTI PRODUCT INDUSTRIES: AN APPLICATION TO THE BASQUE TRAWL INDUSTRY[1]

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ABSTRACT

To empirically study production structure and the capacity level at which vessels are harvesting, a short-run translog cost function is estimated. From the estimated parameters, two capacity utilisation measures are calculated (returns to scale and a dual capacity utilisation measure). Empirical results show that there is no excess capacity in the Basque trawlers fleet. The current regulations therefore seem to be consistent with optimal capacity utilisation.

Keywords: cost structure, capacity utilisation, input and output regulation

Introduction

Capacity has been studied widely both theoretically and empirically in fisheries economics. However, the definition of capacity is controversial among economists. When we talk about capacity, there is a necessity to differentiate between overcapacity and excess capacity. Ward *et. al.* (2004) define overcapacity as a long-term concept and excess capacity as a short term concept. They define overcapacity as that part of the difference between what a fleet could produce, if fully utilised under normal operating conditions, and what it actually produces. Overcapacity is a structural problem that is not self correcting over time. They define excess capacity as the difference between what a firm could produce under normal operating conditions (during a given period of time, under given stock conditions) and what is actually produces for a given set of input and output prices. Excess capacity is a result of market failures.

The broad opinion has been that European fisheries have had excess capacity problems in their fleets during the last decades. The European Union has a Common Fisheries Policy (CFP) in order to manage fisheries for the benefit of both fishing communities and consumers. One of the key objectives for the CFP has been to keep the right size of the European Community's fleet. To do so, over the last 20 years, European fisheries have been involved in four different multi-annual guidance programmes (MAGPs).[2] MAGPs are subsidy programmes designed by European Commission to freeze capacity of each European member state's fleet in terms of tonnage and engine power.

The Basque trawl industry has been involved in a subsidy programme that concluded in 2003. The aim of this paper is therefore to study the production structure and capacity utilisation in the Basque trawlers industry. Principally, the main purpose is to analyse specific policy implications for optimal management of this industry based on the current production structure and capacity utilisation. It is calculated whether vessels are working at full capacity utilisation or not under the current regulation. To the best of my knowledge, capacity has not been studied yet in the Basque trawler industry. An analysis of the capacity utilisation issue is therefore not only interesting from a Spanish and Basque point of view, but also in a larger European context in which future policies will be determined.

The Basque trawler industry is regulated by input and output controls. Vessel owners then take production as given due to the total allowable catches. Furthermore, they are considered price takers in the market. Consequently, a cost function specification is used and the objective is to minimise the cost of harvesting the given output level. Several studies have used a cost function approach to study capacity utilisation. Bjørndal and Gordon (2000) used a translog cost function to study the Norwegian pelagic fisheries. Nøstbakken (2006) utilised a generalised translog cost function to deal with zero outputs. Apart from the fisheries economics literature, the cost function approach has also been used to study other industries. Christensen and Greene (1976) estimated a translog cost function to analyse scale economies in US electric power generation. Caves *et al.* (1981) introduced different functional forms for the cost function to study capacity utilisation in US railroads. In the current study, a multi-product translog cost function

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[2] Spanish fisheries have been involved in three MAGPs.

is estimated for different vessel types. Based on the estimated parameters, own price elasticities and different measures of capacity utilisation are calculated. Two different capacity measures are employed: returns to scale and a dual CU measure.

Two types of vessels take part in the Basque trawl industry. Vessel types are differentiated by production technologies: otter bottom trawlers, known as Baka trawlers, and pair trawlers operating with Very High Vertical Opening (VHVO) nets. Data used in the analysis are from 1996 to 2001. During this period, the fleet was involved in the last subsidy programme. The programme concluded in 2002 and hence a big difference is not expected from the fleet capacity situation documented by the data used in this analysis and the situation in 2002.

This paper is organised as follows. Section 2 briefly introduces the Basque trawler industry. The methodology used in the analysis is described in Section 3, while results are presented in Section 4. In the final section, policy implications for the fisheries are considered, and possibilities for further research discussed.

The Basque trawler Industry

Spain is an important producer and per capita consumer of fish products in the world. The Basque trawlers are part of the so called Spanish "300" fleet.[3] Trawlers and longliners working in areas outside the Spanish waters and targeting demersal species compose the fleet. Data used in the analysis have been obtained by AZTI - TECNALIA from logbooks and sales slips sheets, including harvested species, fishing area and fishing days. Data are available on catches per trip, however, some of the data are only available on a yearly basis, and hence, annual data are used in the analysis. Table 1 presents some summary statistics for the fleets. The data set covers approximately 60% of the population.

Over the studied period, 1996-2001, there are two vessel types in the Basque demersal fishery: otter bottom trawlers and pair trawlers operating with VHVO nets. Individual Baka trawlers harvest in deep waters by trawling a bottom net close to the seabed. Fishing trips last on average six days and the haul duration is between four and five hours. The catch, which consist of mixed demersal species as hake, megrim, anglerfish, horse mackerel, pout and others, is generally landed in Basque (Ondarroa and Pasajes) and French ports from where the catch is transported by trucks to be sold in local Basque markets. Since 1992, the harvesting technology of the fleet has been transformed. One of the most important transformations has been the development of pair trawl technology. Comparing with other fishing gear, the main characteristics of the new gear is that a VHVO net is trawled between two vessels. The new technology was developed to raise efficiency on vessels specialised in harvesting hake. Hake is not the most expensive species; nevertheless, the total allowable catches (TAC) are higher for hake, which makes this species a desired target species. In five years, 20 vessels had invested in this new technology.

Fishing and vessel characteristics differ between the two vessel types. Baka trawler's vessel characteristics by year are presented in Table 1. The average size of the Baka trawler's vessels is an overall length of 34.6 metres, with gross registered tonnage (GRT) 246 tonnes. Length and GRT do not change considerably over the studied years, but engine horsepower does. The mean of horsepower changes from 712 KW in 2000 to 584 KW in 2001. This reduction might be an indicator of the effort reduction that was held during the period studied. Further, the average of construction year for this vessel type is 1980. However, in 2001 the average construction year is 1988. The reason for the increase might be that six new vessels were built in 2000 while some old vessels were withdrawn and transformed into pair trawlers.

With regard to pair trawler's vessel characteristics, Table 2 summarises the statistics. The mean overall length and gross registered tonnage are 35.06 meters and 224.60 tonnes, respectively. With regards to engine horsepower, the average is 549.11 KW, but looking at annual figures the average is decreasing. Although the technology was developed 15 years ago, the average vessel age is higher, with an average construction year of 1985. The reason might be that instead of building new vessels, the owners transformed the technologies of their current vessels. With regard to fishing equipment, the most common VHVO net is between 25 and 35 meters height and 75 to 90 meters wide. The number of days used per trip is between five and six. However, the haul duration is longer than for Baka trawls since pair trawls use between seven and eight hours for each haul. The catch is either landed in French ports (Lorient, Brest, La Rochell etc) and transported by trucks to the main Basque ports Ondarroa and Pasajes, or landed in these main Basque ports and sold on their local markets.

Basque trawlers harvest mainly demersal fisheries from the Bay of Biscay to the north-east of Scotland. Baka trawlers operate in ICES divisions VIIIa, b, d, and ICES Sub-areas VI and VII. Pair trawlers harvest in the same areas as Baka trawlers, with the exception of ICES sub-area VI. Maximum days allowed to spend harvesting in each

[3] See Lazkano (2005) for an extensive description of the Basque trawler industry.

fishing area are restricted by total allowable effort. The regulation sets up higher amount of days in divisions VIII a, b, and d than in sub-area VII and sub-area VI.

Table 1. **Vessel Characteristics for Baka trawlers**

		Num. of v regist.	Num of Observ	GRT in tonnes	Length in meters	Horse power KW	Construct. year
1996	m	27	16	256.67	34.35	636.77	1975.54
	sd			33.49	3.66	168	7.28
1997	m	23	13	243.07	33.15	620.17	1975.08
	sd			35.11	3.65	124.17	7.83
1998	m	22	22	239.85	33.98	653.54	1977.15
	sd			53.64	4.48	154.2	9.44
1999	m	22	22	241.77	34.42	664.33	1978.93
	sd			55.8	3.8	146.81	10.07
2000	m	28	28	263.58	36	712	1979.8
	sd			45.59	2.29	160.72	9.93
2001	m	27	15	238.58	35.42	584.35	1988.16
	sd			52.22	3.19	182.17	12.06
2001	Mean	24	15	196.48	33.43	519.08	1985.5
	sd			52.56	3.78	310.46	11.28

Source: AZTI – TECNALIA

Table 2. **Vessel Characteristics for Pair trawlers**

		Num. of v regist.	Num of Observ	GRT in tonnes	Length in meters	Horse power KW	Construct. year
1996	m	22	18	234.76	36.16	618.71	1981.71
	sd			63.3	2.97	307.94	10.86
1997	m	22	15	243.39	36.95	593.64	1985.09
	sd			52.99	2.73	277.86	12.65
1998	m	26	17	221.54	34.53	505.54	1986.69
	sd			54.87	3.95	254.32	12.39
1999	M	30	18	231.97	35.38	525.5	1985.43
	sd			59.81	4.22	272.63	12.77
2000	M	20	15	211.68	33.58	566.89	1983.89
	sd			61.23	4.22	296.17	10.76
2001	M	18	15	196.48	33.43	519.08	1985.5
	sd			52.56	3.78	310.46	11.28

Source: AZTI - TECNALIA

Many different species are harvested: demersal species, cephalopods and specially megrim, anglerfish and hake. Hake is the most important species both with respect to economic value and the quantity landed. Demersal species, such as cod and haddock, are no highly migratory species that live and feed on the seabed.

The catch composition is along with harvest technology a feature that differentiates the two vessel types. Baka trawlers' catches are clearly multi-product as can be seen from the catch statistics presented in Table 3. Their catch is diversified and targeted species varies with the season of the year. Hake (*Merluccius merluccius*), megrim (*Lepidorhombus boscii* and *whiffiagonis*) and anglerfish (*Lophius budegassa* and *piscatorious*) are the three key species of this fleet and their catches represent approximately 40% of the total catches. Horse mackerel, pout, whiting and rays are also important, accounting for 25% of the total catches. The rest of the species they catch composes the remaining 35% of the catches.

Table 3. **Average catches per vessel in tonnes**

		Anglerfish	Megrim	Hake	Horse mackerel	Pout	Whiting	Rays	Others
Baka trawlers	1996	39.86	69.88	56.54	82.12	59.29	7.39	26.72	164.94
	1997	26.58	40.85	121.09	42.59	34.47	3.74	31.04	160.13
	1998	43.43	41.02	21.56	25.52	34.24	1.32	31.51	141.29
	1999	45.51	37.60	39.44	21.69	32.80	1.44	16.90	122.69
	2000	52.18	51.62	42.16	11.68	25.38	0.91	8.43	172.04
	2001	37.70	55.26	40.65	19.75	36.83	4.79	12.66	112.28
Pair trawlers	1996	7.89	0.210	449.26	49.63	35.16	2.18	0.19	31.34
	1997	7.93	0.21	369.93	12.81	23.94	11.75	0.32	26.81
	1998	8.02	0.46	265.53	15.40	23.42	7.32	0.51	28.95
	1999	7.79	0.72	264.07	25.78	23.10	8.10	0.38	28.97
	2000	10.37	11.93	314.82	46.12	38.11	32.94	4.60	66.02
	2001	11.28	1.20	436.77	22.42	39.95	44.29	1.33	37.93

Source: AZTI - TECNALIA

Pair trawlers' technology was developed to harvest hake. Table 3 confirms that pair trawlers mainly harvest hake, as this species contributes for 73% of the total catches. In addition to hake, they also harvest other species, whose landed quantities vary from year to year.

The average prices of hake, megrim and anglerfish are displayed in Table 4. Pair trawlers obtain higher prices for anglerfish and megrim than Baka trawlers, but harvest mainly hake. Although it depends on the year, the most well paid species is anglerfish followed by hake and megrim.

Table 4. **Prices in Euros per Kg of the three key species**[4]

		1996	1997	1998	1999	2000	2001
Baka	Anglerfish	4.41	4.62	4.67	6.31	6.23	6.18
	Hake	4.71	4.86	5.03	4.19	3.91	4.35
	Megrim	5.07	4.65	3.72	4.19	3.31	3.26
Pair	Anglerfish	5.21	4.75	4.8	6.15	7.29	6
	Hake	4.08	4.17	3.94	3	3.42	3.42
	Megrim	na	na	3.95	3.92	5.2	4.34

Source: AZTI - TECNALIA

The Basque demersal fishery is regulated by input and output controls. The main input control is regulation with Total Allowable Effort (TAE) and technical measures. Besides, non-transferable quotas restrict harvests. TAE regulation was introduced earlier than the TAC regulation. Effort is measured by an entry coefficient per Sub-area that can be converted into days. The average number of fishing days does not change substantially from year to year. However, maximum number of fishing days per year allocated to pair trawlers is higher than for Baka trawlers. TAC was first implemented when Spain joined the EU in 1986. The EU distributes the TACs among Member States in quotas. Even if the share has been maintained stable over time, the growing scarcity of the key stocks has spoilt significantly the fishing opportunities for these fleets. Table 5 presents the evolution of TACs and Spanish quotas over the studied period. In the Basque fisheries non-transferable harvest quotas were established in the early 1980s. The maximum amount each company is allowed to harvest is allocated among companies and the individual company is free to redistribute their quota among their vessels, as they want.

The highest Spanish quota corresponds to hake. Over the studied period, hake quota does not vary considerably until 2001, when there is a substantial reduction due to the reduction of SSB. Megrim and anglerfish quotas are also reduced from 2000 to 2001, but the reduction is lower.

[4] Real prices based on 2003

Table 5. **Total allowable catches (TAC) and Spanish quota in tonnes**

	TAC			Spanish quota		
	Hake	Anglerfish	Megrim	Hake	Anglerfish	Megrim
1996	51,100	30,400	21,200	14,300	1,900	6,920
1997	60,100	34,300	25,000	16,900	2,140	8,160
1998	59,100	34,300	25,000	16,600	2,140	8,160
1999	55,100	34,300	25,000	15,400	2,140	8,160
2000	42,100	29,570	20,000	11,800	1,840	6,530
2001	22,600	27,600	16,800	6,300	1,700	5,500

Source: AZTI - TECNALIA

Methodology

The duality theory developed by Diwert (1974) has allowed empirical studies of production structure either by estimating production functions or cost functions. In the short term, Basque trawlers are considered price takers in the output market and harvests are restricted by non-transferable quotas. The input demand is conditioned on the input prices for given output levels. The cost function estimation is therefore accurate to study production structure in the short term.

The cost function approach has been commonly used in the literature and different flexible functional forms have been suggested by Caves *et al.* (1980) for multi-product industries. The translog cost function allows scales economies to vary with different output levels, which is essential to permit to the cost curve the classical U shape. Christensen and Greene (1976) estimated a translog cost function to study the production structure in the U.S. electric power industry. Caves *et al.* (1980) proposed a generalised translog cost function which allows some outputs to be equal to zero. And Caves *et al.* (1981) estimated to study the production structure in the U.S. railroads industry. Pulley and Braunstein (1992) proposed a composite cost function for cases when the generalised translog cost function is near to the translog cost function.

The vessel's variable costs depend on variable inputs prices, fixed or quasi-fixed inputs and outputs. Among flexible functional forms, the quadratic and generalized leontief also provide the necessary curvature of the cost function, however, they require more parameters to estimate than the trans-log functional form. To gain degrees of freedom, the trans-log functional form is used to specify the short-term cost function:

$$\ln VC = \alpha_0 + \sum_{q=1}^{m} \alpha_q \ln Y_q + \alpha_k \ln K + \sum_{i=1}^{n} \beta_i \ln w_i + \frac{1}{2}\sum_{s=1}^{m} \sum_{q=1}^{m} \delta_{qs} \ln Y_q \ln Y_s + \frac{1}{2}\beta_{kk} (\ln K)^2$$
$$+ \frac{1}{2}\sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln w_i \ln w_j + \sum_{q=1}^{m} \sum_{j=1}^{n} \rho_{qj} \ln Y_q \ln w_j + \sum_{i=1}^{n} \rho_{ik} \ln w_i \ln K + \sum_{q=1}^{m} \gamma_{qk} \ln Y_q \ln K + \varepsilon \quad (1)$$

VC is variable cost, representing crew, fuel and vessel maintenance costs; *i* is equal to *c* (crew), *f* (fuel) or *v* (vessel maintenance). For Baka trawlers, *q* is equal to *h* (hake), *m* (megrim), *a* (anglerfish), *v* (the sum of horse mackerel, ray, whiting and pout) or *o* (others). And for pair trawlers, *q*=(*h*, *o*), where *h*, and *o* represents hake and others respectively. *K* stands for vessel capital and ε is a random error assumed to be normally distributed. The specification of the variables is described later on. [5]

Applying Sherphard's Lemma, the cost share equation for each input can be written as:

$$S_i = \frac{\partial \ln VC}{\partial \ln w_i} = \alpha_i + \sum_{j=1}^{m} \gamma_{ij} \ln w_j + \rho_{ik} \ln K + \sum_{q=1}^{n} \rho_{qi} \ln Y_q \quad (2)$$

Equations 1 and 2 are estimated simultaneously using Seemingly Unrelated Regression (SUR). To avoid non-singularity in the covariance matrix, the crew share equation is dropped out from the system. The iterative estimation process converges to the maximum-likelihood results.

The equations must satisfy the homogeneity of degree one, monotonicity and concavity in factor prices (Diewert 1974). Adding parametric restrictions to the estimated cost equation imposes the homogeneity of degree one.

[5] In this analysis 35 different species are used. Even though some of them are not fixed by quotas, all the species that have a market value are. Then, the assumption that outputs are fixed by quota is assumed to be correct in the model.

$$\sum_i \beta_i = 1 \quad \& \quad \sum_i \gamma_{if} = \sum_i \gamma_{iv} = \sum_i \gamma_{ic} = \sum_i \rho_{iq} = \sum_i \rho_{iK} = 0$$

where i is equal to f, v, c, and q is all outputs. The monotonicity and concavity in input prices are tested after estimation. They will be satisfied if the fitted share values are positive and the Hessian matrix of the cost function is negative semi definite.

Variable inputs are basically crew costs, fuel and various costs, which are interpreted as vessel maintenance costs. Approximately 40% of the crew wages are proportional to the catches. Nevertheless, separate data are available on gross wages and the part that is proportional to the catches. It is thus possible to include the crew costs in the analysis avoiding high correlation between crew and outputs. Fuel costs represent the expenditure on fuel. Vessel maintenance costs stands for several expenditures related to the maintenance of the vessel: gear, replacement, packaging, reparation, port costs, fisherman guild fees and "other costs".

For every variable input, data have been used to generate input price indices. First, a crew price index w_c has been generated by dividing the expenditure on wages by the number of permanent fishermen onboard the vessel. Fishermen are rarely hired temporary, and the number of permanent fishermen is considered representative. There are no available data on wage differences between fishermen and the skipper; hence, all of them are considered equals. Second, to calculate the fuel price index, there are no available data on the quantity of fuel consumed. Therefore, following Bjørndal and Gordon (2000), a Cobb-Douglas aggregator function is used to calculate a proxy variable for quantity of fuel. In order to avoid an endogeneity problem the level of output and GRT are not used to calculate the proxy. Then two vessel characteristics, horsepower and vessel length, are used as variables in the aggregator function and both of them are given equal weights. Hence, by dividing the fuel expenditure with the proxy variable measuring the quantity of fuel, the fuel price index w_f is generated.[6] Finally, vessel maintenance is defined as the expenditure on gear, replacement, packaging, port costs, reparation costs and "other costs". The price index w_v is calculated as the expenditure on vessel maintenance divided by the total revenue.

Summary statistics for all the price indices are presented in Table 6. Baka trawlers' average fuel price index over the six-year period 1996-2001 is 815 while the same for pair trawlers is 714. For both vessel types, the fuel price index increases substantially from 2000 to 2001, the reason being increases in the market price of oil. With regard to the crew price index, the average value for Baka trawlers is 28,759 while the average for pair trawlers is 29,748. Finally, the average value of the vessel maintenance price index for Baka trawlers is 876 and 1,078 for pair trawlers.

Table 6. **Input price indexes in Euros**

		Fuel price		Vessel price		Crew price	
		Mean	sd	mean	Sd	mean	Sd
Baka	1996	766.72	276.86	503.08	134.07	28,080.06	6,787.67
	1997	855.00	419.36	802.47	290.62	33,511.28	18,840.76
	1998	607.16	197.49	896.42	378.90	27,389.01	12,544.47
	1999	714.83	159.49	946.79	326.76	27,443.47	5,440.00
	2000	968.36	199.61	927.00	283.83	29,336.16	7,747.02
	2001	973.09	355.97	1,093.45	683.11	27,846.91	8,550.39
Pair	1996	668.15	130.80	551.11	204.80	26,791.32	4,736.36
	1997	721.01	160.08	981.66	1,138.27	27,802.15	7,068.05
	1998	537.49	138.68	1,158.57	949.63	31,641.09	5,300.05
	1999	585.48	290.94	2,013.12	2,798.40	24,924.37	11,083.88
	2000	930.68	256.54	538.35	235.80	35,894.13	5,732.09
	2001	1,062.26	162.06	436.46	82.38	33,998.00	9,695.79

The fixed or quasi-fixed input, vessel capital, is defined as gross registered tonnage (GRT).

[6] It could be argued that the price of oil in the port should be valid as a proxy for fuel price. However, this industry is subsidised in oil and hence using the real price of oil will account for effects that are not real in this industry. Even though it is known that this industry hasfuel subsidies, the quantity of the subsidies are not in the data set and hence I cannot account for this effect in the model.

Even though pair trawlers are a specialised industry, both vessel types harvest several species. The data are, however, aggregated based on the fisheries definition by Prellezo *et al* (2005). Based on principal component and cluster analysis, and by using catch, area, gear, base port and season data, Prellezo *et al* (2005) defined six different fisheries for the Basque trawlers. A fishery is defined as a group of vessel voyages targeting the same (assemblage of) species and/or stocks, using similar gear, during the same period of the year and within the same area. Based on it, two outputs are defined for pair trawlers. As they mainly harvest hake; one output is hake and the other one "others", the sum of the remaining of the catches. Baka trawlers have a very diverse catch and five different outputs are defined: hake, megrim, anglerfish, "various"; defined as the sum of horse mackerel, ray, whiting and pout harvest quantities in kilograms, and "others", the sum of the remaining species' harvest quantities in kg.
From the estimated equations, input demand elasticities and cost elasticities are calculated as follows:

$$\eta_i = S_i * \left[\frac{\gamma_{ii} + S_i (S_i - 1)}{S_i^2} \right] \tag{3}$$

Otherwise, in order to study capacity utilisation, different capacity utilisation measures are calculated, along with returns to scale, a dual capacity utilisation measure. As noted, the vessel owners' incentive is to minimise the cost of harvesting their quota. Berndt and Morrison (1981) suggested capacity output as the level of output at the minimum point of the short-run average cost curve. They also pointed out that capacity output alternatively could be defined as the level of output at which the total short and long run average cost curves are tangent when the firm is producing at constant returns to scale in long-run. As returns to scale (RTS) equal to one correspond to the minimum on the average cost curve, excess capacity will be present if RTS>1. RTS are then used in the current analysis as an indicator of capacity utilisation. From the estimated equations returns to scale can be defined as:

$$RTS = \frac{1 - \left[\frac{\partial \ln VC}{\partial K} \right]}{\left[\sum_{i=1}^{q} \frac{\partial \ln VC}{\partial \ln Y_q} \right]} \tag{4}$$

As noted by Nelson (1989), capacity utilisation can be defined as the ratio of actual output to some measure of potential output given a firm's short-run stock of capital. Capacity utilisation (CU) tries to capture the output gap between the actual output and capacity output. Klein (1980) defined as a measure of capacity output the point at which short-run and long-run average cost curves are tangent. In the current analysis a dual measure defined in terms of costs is calculated following Segerson and Squires (1990). This CU measure tries to capture the cost gap that exists when the actual output level is not equal to the output level at which the short run average cost curve is tangent to the long run average cost curve. Following Segerson and Squires (1990), the dual CU measure can be calculated as:

$$CU_{dual} = \left[\frac{C^*}{C} \right] = \left[\frac{VC(Y_1 ... Y_m, w_i, K) + Z_K K}{VC(Y_1 ... Y_m, w_i, K) + w_K K} \right], \tag{5}$$

where $Z_K = -VC_K(Y_q, w_i, K)$ is the shadow value of the quasi-fixed input and w_K is the price of capital, where subscript K stands for partial derivative with respect to K. There are data available on the acquisition value of the vessels and in some cases also on additional equipment purchased after vessel acquisition. Therefore, the capital price index is calculated as Squires (1987c), Bjørndal and Gordon (1993) and Conrad and Unger (1987). All values have been deflated by the GNP implicit price deflator[7] at the time of acquisition. Hence, the user cost of capital is calculated as:

$$q_n = P_{nK} * (i + \delta_{nK}) \qquad n = 1...N$$

[7] Data available from INE, Instituto Nacional de Estadística (Spanish National Statistics Institute).

where P_{nK} is the price of capital for the *n*th boat, *i* is the interest rate on government bonds and δ_{nK} is the depreciation rate. A depreciation rate of 8% is applied.
Then, the dual capacity utilisation measure can be interpreted as follows. $CU_{dual} > 1$ implies that the shadow value of capital is higher than the capital price, $Z_K > P_K$, and investment incentives exist. When $CU_{dual} < 1$, $Z_K < P_K$ and the firm would want to disinvest. Finally, if $CU_{dual} = 1$, the firm has no incentives to change its investment level.

Empirical results

Production is influenced by the resource abundance of the target stocks, and hence exogenous biological conditions should be addressed in the model. The target species for Basque trawlers are demersal species, which are spread over the seabed. When the stock is reduced, catch per unit of effort is reduced, and cost of harvesting increases (Bjørndal (1987), Clark (1990)). This implies that fishermen have to do an additional effort to harvest as the stock size is reduced. Over the studied period, due to the reduction in TAC, it seems that the stock of the key species has only changed from 2000 to 2001. Therefore a dummy variable representing year 2001 has been included in both estimations. However, this does not change the estimation of the cost function and neither estimated measures of capacity utilisation. Further, the dummy was not statistically significant and has not been included in the final model.

Table 7. **Estimation results**

	Baka Coef.	trawlers Std. Err.	Pair Coef.	trawlers Std. Err.		Baka Coef.	trawlers Std. Err.	Pair Coef.	trawlers Std. Err.
α_f	0.16***	0	0.12***	0	δ_{vo}	-0.01	0.01	-	-
α_v	0.41***	0	0.56***	0.01	ρ_{fh}	-0.01**	0	-0.04***	0
α_c	0.43***	0	0.31***	0	ρ_{fm}	-0.01	0.01	-	-
γ_{ff}	0.11***	0.01	0.10***	0.01	ρ_{fa}	0	0	-	-
γ_{vv}	0.18***	0.01	0.23***	0	ρ_{fv}	-0.01***	0	-	-
γ_{cc}	0.19***	0.01	0.19***	0.01	ρ_{fo}	-0.02***	0	-0.02***	0
γ_{fv}	-0.05***	0	-0.07***	0	ρ_{vh}	0.03***	0.01	0.11***	0.01
γ_{fc}	-0.06***	0	-0.03***	0.01	ρ_{vm}	0.02***	0.01	-	-
γ_{vc}	-0.13***	0.01	-0.16***	0	ρ_{va}	0	0	-	-
α_h	0.05***	0.01	0.51***	0.01	ρ_{vv}	0.01***	0	-	-
α_m	0	0.02	-	-	ρ_{vo}	0.06***	0.01	0.08***	0.01
α_a	0.07***	0.01	-	-	ρ_{ch}	-0.03***	0.01	-0.08***	0.01
α_v	0.11***	0.01	-	-	ρ_{cm}	-0.02	0.01	-	-
α_o	0.23***	0.02	0.13***	0.01	ρ_{ca}	0	0	-	-
δ_{hh}	0	0.02	0.26***	0.01	ρ_{cv}	-0.01***	0	-	-
δ_{mm}	0.05	0.07	-	-	ρ_{co}	-0.03***	0.01	-0.05***	0
δ_{aa}	0.02	0.01	-	-	α_K	0.20***	0.05	0.15***	0.04
δ_{vv}	0.03***	0	-	-	β_{KK}	0.26	0.24	-0.04	0.13
δ_{oo}	0.17***	0.04	0.21***	0.01	ρ_{fK}	0.04***	0.01	0.08***	0.01

δ_{hm}	-0.06***	0.02	-0.16***	0	ρ_{vK}	-0.08***	0.02	-0.09***	0.02
δ_{ha}	0.01	0.01	-	-	ρ_{cK}	0.04***	0.02	0.01	0.02
δ_{hv}	0.01	0	-	-	γ_{hK}	0.05	0.04	-0.01	0.03
δ_{ho}	0.00***	0.02	-	-	γ_{mK}	0.12**	0.07	-	-
δ_{ma}	0	0.03	-	-	γ_{aK}	0.05	0.04	-	-
δ_{mv}	0.01	0.01	-	-	γ_{vK}	-0.02	0.03	-	-
δ_{mo}	-0.12***	0.03	-	-	γ_{oK}	-0.26***	0.08	-0.04***	0.02
δ_{av}	-0.02	0.01	-	-	α_0	13.66***	0.01	13.67***	0.01
δ_{ao}	0.03	0.02	-	-					

The estimated parameters for the cost function, along with their standard errors and individual significance tests, are presented in Table 7. For both vessel types, the translog cost functions explain 95% of the variation of the data. Besides, most of the parameters are statistically significant and the signs of the first order estimated parameters are as expected. The signs of inputs price parameters are positive for both vessel types, i.e., changes in crew (α_c), fuel (α_f) and vessel maintenance (α_v) prices have an increasing effect on variable costs. Moreover, output elasticities, α_h, α_m, α_a, α_v and α_o for hake, megrim, anglerfish, various and others, respectively, are positive for both vessel types, therefore, increases in landed quantities raise variable costs. Nevertheless, Baka trawlers' variable costs have more inelastic response to changes in harvest levels than pair trawlers. Remember that Baka trawlers are not as specialised as pair trawlers with regard to harvesting technology. Hence, a more inelastic response for Baka trawlers was expected. In the fisheries economics literature, Bjørndal and Gordon (2000) also found inelastic cost elasticities associated with harvest levels in their study of the Norwegian spring spawning herring fishery. Consequently, the translog cost function appears to fit the data well. After estimation it is confirmed that the models satisfy the concavity and monotonicity properties in input prices.

Own price elasticities and their standard errors are presented in Table 8. For both vessel types, input price elasticities are negative and statistically significant. They are very close to, but significantly different from zero. Hence, changes in price indices influence the demanded quantity negatively, but they do not induce large changes. For all price indices, Baka trawlers have more elastic response to price changes. The given quota determines the amount of inputs needed to harvest it. Demanded input quantity is therefore not much affected by price changes but is affected by quota changes. Furthermore, fuel cost is subsidised in part by the fisheries manager, which might be another reason why vessel owners are not vulnerable to fuel price changes. In the fisheries economics literature there are several studies that analyse the input demand of multi-product firms. The different analyses reveal that the elasticity of input demand depends on whether the fishery is regulated or not. Input and/or output regulated fisheries tend to have inelastic responses in own price elasticities. In the output restricted Norwegian pelagic fleet, Bjørndal and Gordon (2000) and Nøstbakken (2005) found inelastic price responses. In input regulated fishery for salmon in British Columbia, Dupont (1991) also found inelastic prices. Otherwise, in non regulated fisheries, Bjørndal and Gordon (1993), Squires (1987a), Squires (1987b) and Squires (1987c) found elastic price elasticities.

Table 8. Input price elasticities

	Baka trawlers		Pair trawlers	
	Coef	Se	Coef	se
Crew price elasticity	-0.119	0.016	-0.080	0.023
Fuel price elasticity	-0.194	0.037	-0.060	0.050
Vessel price elasticity	-0.150	0.017	-0.026	0.006

It is expected to find higher returns to scale for Baka trawlers. The harvesting technology of pair trawlers´ was mainly developed during the 1990s, as some Bou and Baka trawlers changed from individually harvesting many species to targeting fewer species in pairs. The first vessels started using the pair trawling technology in 1992. The investment to change the technology is fairly high because it requests several changes. The most important change is that pair trawlers operate with two vessels while the other vessel types use an individual vessel. Vessel owners need to invest in two of their vessels, thereby increasing the capital. Otherwise, there are advantages of changing the harvesting technology. The number of fishermen working in each vessel is a third less for pair trawlers: the average number of crew is 15 for Baka and Bou trawlers and ten in each pair trawler. Thus, from changing the technology of two vessels, crew costs decrease with a third of the crew. Given that total revenue is given by the quota, vessel owner would not invest unless they know or believe that the investment will pay off. The investment is self-inflicted and no subsidised, and hence capital invested in this new technology is expected to be utilised efficiently. This is the reason why large scale economies are not expected for pair trawlers.

Two different capacity utilisation measures have been calculated. On one hand, returns to scale measuring the minimum point of the short-run average cost curve as suggested by Berndt and Morrison (1981). On the other hand, a dual CU measure, defined as the output level at which the short-run and long-run average cost curves are tangent, as proposed by Klein (1980). Both results are displayed in Table 9.

Table 9. Returns to Scale and Dual CU measure

	Baka Coef	trawlers se	Pair coef	trawlers se
Dual CU	1.002	0.000	1.004	0.000
RTS	1.759	0.157	1.322	0.084

Returns to scale with standard errors were calculated and are presented in Table 9. For both vessel types, RTS estimates are significantly higher than one on the 5% significance level. Further, on the 5% significance level Baka trawlers RTS are less than two. Based on the capacity utilisation measure of Berndt and Morrison (1981) this result suggests that both fleets can take advantage of scale effects by increasing production. Such increase would lower the vessels´ average cost. Point estimate of RTS is seen to be higher for Baka trawlers than for pair trawlers. The difference, although relatively large, is however not statistically significant at the 5% level. The higher estimate of RTS for Baka trawlers might suggest that this fleet has relatively more to gain by taking advantage of scale economies. Given the harvesting technology transformation described before, there are intuitive reasons for this result.

The dual capacity utilisation measure is displayed in Table 9. For both vessel types CU is equal to one at the 5% significant level. Remember that $CU_{dual} > 1$ implies that the shadow value of capital is higher than the capital price, $Z_K > P_K$, and investment incentives exist. When $CU_{dual} < 1$, $Z_K < P_K$ and the firm would want to disinvest. Finally, if $CU_{dual} = 1$, the firm has no incentives to change its investment level. This measure therefore suggests that neither of the fleets have incentives to change their investment levels. This CU measure calculates the point at which the short-run and long-run average cost functions are tangent. Given that this measure takes into account short-run and long-run capital levels, in this analysis it is considered a better measure for capacity utilisation than RTS.

When the firm is operating at the point that maximises short-run profits, the marginal revenue is equal to the short-run marginal costs. For a competitive firm, marginal revenue is equal to price and hence, the profit maximising condition is output price equal to marginal cost. Coelli *et al* (2002) suggest the use of the point of short-run profit maximisation as the preferred measure of capacity. Coelli *et al* (2002) expanded the single output case to the multi output case, where the maximum capacity is obtained by proportionally expanding the output vector until short-run profit is maximised. Even though in the current research this is considered an ideal measure of capacity, the complexity of the multi-product industry inhibits the calculation of the measure. Remember that both Baka and pair trawlers are multi-product industries. Output definition for the cost function has been generated by aggregating landings of different species. In addition, data are available on output prices for the key species; hake, megrim and anglerfish; however, price data for the rest of the species have not been obtained. The complexity of the output definition for Baka trawlers and the lack of price data for most of the species make the calculation of the test of equality among output prices and short-run marginal costs difficult. Regarding Pair trawlers, two outputs have been defined, hake and others defined as the sum of catches of the remaining species. To test the equality between price and marginal cost vectors, the price of the output others is required, in addition to hake price. Price data are not available for all species included in the output others. It is not possible therefore to calculate the point of short-run profit maximisation as a measure of capacity.

Policy implications and concluding remarks

The success or failure of a regulatory regime depends on how firms respond to regulations. To understand the consequences of different regulatory regimes, managers need detailed knowledge of technologies employed in a fishery. In the current study, cost structure has been analysed for a fishery regulated with input and output controls. Capacity utilisation measures derived from the estimated cost function have indicated that the Basque trawlers industry has no incentives to change its investment level in the short term under the current regulations. The current regulations therefore seem to be consistent with optimal capacity utilisation. Future regulations should therefore be addressed to maintain consistency with future capacity levels.

Changes in resource abundance or input prices may change optimal capacity utilisation. An expansion of capacity may occur if fishing vessels expand their harvesting capacity by increasing engine size, investing in gear and installing additional electronic equipment. This might require a change in the regulatory regime if one is to avoid inconsistency with optimal capacity utilisation. The regulations should therefore take into account that changes in optimal capacity level might occur.

Furthermore, the principal effort to keep the consistency between regulation and the optimal capacity level must be lead by the fisheries manager. In 2001, the European Commission adopted the Green Paper to decide the future of the Common Fisheries Policy (CFP). In the Green Paper, the Commission set out a number of options for the future of the CFP and asked all those concerned for their views. The orientation is to move from an exclusive output management to a mix of output and input management tools. The main decisions are concerned to recovery plans for stocks in risk of depletion, define management options were output and input management tools are complemented, strengthen the controls and intensify cooperation and information among Member States, define a new fleet policy and define a new subsidies policy.

Spain and the Basque Country have achieved their MAGP objectives for engine horse power and GRT. Further, the current analysis suggests that Basque trawlers, who represent approximately 30% of the Spanish fleet, are harvesting at full capacity levels. New fleet policy and subsidy programs actually being designed by the European Commission seem to be consistent with the capital level in the Basque trawlers industry. With regard to subsidy programs, Basque trawlers have no incentives to change their investment level and hence, the CFP program agrees with the necessities of these specific fleets. Otherwise, the new fleet policy makes an effort to mix input and output management tools for the future management of the European fisheries. The Basque trawler industry is already regulated by input and output controls.

The purpose of the European Commission CFP is to combine in a more economically efficient way input and output controls in the future management of the fisheries. Basque trawlers have been regulated by both control types during the last decades, however, the reason for using these restrictions has been different from the one proposed by the Commission. The Commission wants to use TAE to control capacity in the fishery while the purpose of the TAE in the Basque demersal fisheries has been to limit the entry to different fishing areas. TAE has been used to obligate Basque trawlers to fish in determined ICES areas for a given number of days. If the Commission decides to use TAE to control capacity, the regulation can in the Basque trawler industry be used for both reasons, thereby taking advantage of the regulation to achieve both objectives.

With regard to output controls, TACs are established by the manager and country quotas are distributed among Member States. Each country redistributes its quota among companies and the individual company is free to redistribute their quota among their vessels, as they want. Country quotas are transferable among countries, however, individual companies and vessels are not allowed to transfer their quotas. The viability of the creation of a market for transferring quotas in the Basque trawler industry should be analysed. Specially, the transferability rules in order to avoid concentration of quotas by one vessel or company. Although this has not been analysed in the current analysis, it will be studied in the future.

It is widely known that the industry has been over protected by the fishery manager. In addition to the MAGPs, the most important subsidies have been tax relieves, funds to reduce fuel costs, low-interest loans and so on. This analysis suggests that the Basque trawlers industry is harvesting at full capacity levels which suggests that the industry should be able to survive reducing its economic dependence on the Basque and/or Spanish governments. The current situation of the fleet and different non subsidy mechanisms as transferable quotas will allow the fleets to harvest at profitable levels.

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