Economics and Environment Network

ANU THE AUSTRALIAN NATIONAL UNIVERSITY

http://een.anu.edu.au/

Capacity reduction and productivity: the case of a fishery

Kevin J. Fox, R. Quentin Grafton, Tom Kompas and Tuong Nhu Che

Australian National University

Economics and Environment Network Working Paper

EEN0303

July 2003

Capacity Reduction and Productivity: The Case of a Fishery

by

*Kevin J. Fox**

University of New South Wales

R. Quentin Grafton

The Australian National University

Tom Kompas

The Australian National University and

Australian Bureau of Agricultural and Resource Economics

and

Tuong Nhu Che

Australian Bureau of Agricultural and Resource Economics

July 2003

JEL Classification: C43, D24, Q22
Key Words: productivity, capacity reduction, fishery
Running Title: Productivity and capacity reduction

---

* Contact Author:
Kevin J. Fox
School of Economics
University of New South Wales
Sydney, NSW 2052
AUSTRALIA
e-mail: k.fox@unsw.edu.au
tel: +61-2-9385-3320
fax: +61-2-9313-6337

Abstract

The paper presents the first *ex-post* analysis of profit and productivity of individual vessels following a vessel or licence buyback in a fishery. Using individual firm-level data for the period 1997-2000, the paper analyzes a "natural experiment" of the effects of a 1997 scheme to reduce fishing capacity in the South East trawl fishery of Australia. The scheme was unique in the sense that the buyback was implemented in a fishery managed by individual vessel tradeable harvesting rights rather than input controls. Using an innovative index method that decomposes the contributions of output prices, input prices, vessel size and productivity to relative profits, the economic performance of vessels is analyzed in the year of the buyback and for three years afterwards. Profits for all vessel classes rose over the period 1997-2000 following the 1997 buyback of 27 fishing licences, but some of the gains were due to a rise in output prices that were independent of the adjustment program. All vessel classes (small and large) also experienced substantial productivity gains immediately following the 1997 licence buyback with an average increase over all vessels of 39%. This increase, coincident with a decline in catch per unit of effort for key species, provides strong support that the buyback was successful at improving economic performance. Ongoing productivity improvements for small vessels over the period 1998-2000 following the buyback is attributed to the existence of individual tradeable harvesting rights in the fishery.

1 Introduction

Many fisheries suffer from excess capacity (Kirkley, Morrison Paul and Squires 2002) despite the use of input controls and limits on the total number of vessels. The consequences of excess capacity include increased harvesting pressure on fish stocks and an inefficient allocation of resources. A common approach of regulators in input-controlled fisheries is to temporarily address the problem of overcapitalization with a buy back of vessels, gear and/or licences so as to reduce aggregate fishing effort. Such approaches are often supported by firms provided the buybacks are voluntary and financed by persons outside of the industry.

Typically, buybacks are funded by taxpayers and when voluntary the less technically efficient vessels predominate in terms of the fishing capacity removed (Pascoe and Coglan 2002). Despite their use in fisheries in Canada, the United States, the European Union, Japan, Taiwan, Norway and Australia (Holland, Gudmundsson and Gates 1999), and costing millions of dollars, until now there has been no study that quantitatively analyzes the effects of a buyback on the profits and productivity of the vessels remaining in a fishery.

Using a unique data set from the South East trawl fishery of Australia and a recent innovation that decomposes profits into contributions due to productivity, output prices, input prices and (quasi-) fixed inputs, the paper provides an assessment of individual vessel economic performance following a 1997 licence buyback. Section 2 of the paper describes the fishery and the details of the buyback program. Section 3 outlines the general method used to analyze firm-level economic performance and section 4 describes the decomposition approach for the particular fishery. Section 5 provides an assessment of the impacts of the licence buyback on economic performance by vessel class. The paper concludes with a review of the results and their implications for buyback programs in general.

2 Capacity Reduction and Australia's South East Trawl Fishery

The South East Trawl Fishery (SETF) is located in Australia's 200 nautical mile exclusive economic zone (EEZ) and stretches over a very large area of ocean from a latitude south of Sydney to encompass all of Australia's oceans off the coasts of Victoria and Tasmania until just beyond the eastern border of South Australia. The fishery is one of Australia's oldest, one of its most regulated and is managed by the Australian Fisheries Management Authority (AFMA). Its one hundred or so fishers employ trawls (otter board, Danish seine and mid-water trawl) and harvest over a hundred different types of species. Overall, the fishery accounted for about one fifth of the landed value of commonwealth fisheries, or over AUS$70 million in 1999-2000.

Over the past couple of decades the participants in the fishery have increased their vessel size and capacity. In part, these investments have been made to access deeper water and further offshore fisheries, such as the orange roughy, but have also occured because fishers have competed for a limited total allowable catch by increasing their effective fishing effort. Due to concerns about overcapitalization, input controls were introduced in 1986 that established vessel unitization whereby every boat was registered in terms of its hull and engine size, defined as boat units. Owners wishing to upgrade their vessels were required to purchase registered units from other operators with an "offset" amount to prevent overall increases in fishing power.

Vessel unitization and input controls failed to prevent an increase in the capital employed in the fishery. To help prevent further increases in capacity, AFMA introduced individual transferable quotas (ITQs) in 1992 that encompassed 16 of the major commercial species in the fishery. The initial allocation of ITQs was contentious as some fishers considered their allocations as insufficient compensation for their loss of previous fishing entitlements associated with their boat units. The introduction of ITQs also failed to bring about the hoped for reduction in the number of vessels operating in the fishery with relatively low levels of quota traded in the first five years of the ITQ program.

Acrimony from the initial allocations, and a concern that ITQs had not delivered the expected benefits to all fishers, led the regulator to institute a permit or licence buyback in 1997. The buyback had a dual purpose: one, to remedy the acrimony over the initial allocation and its associated uncertainty and litigation and, two, to reduce the perceived overcapacity in the fishery. In total, about AUS$4 million was spent in the buyback that included $2.35 million of targeted assistance to 18 fishers designed to avoid further legal action over the initial quota allocation and $1.7 million to buy back the fishing licences of 27 fishers (AMC Search Ltd.), with seven fishers receiving both a buyback of their licences and targeted financial assistance.

The licence buyback removed 14 active licences and 13 dormant or latent licences from the fishery. The result was to reduce the number of active fishing vessels from 108 to 94 and to remove vessel capital worth approximately AUS$7 million (AMC Search Ltd.). The buyout was perceived to improve the profitability in the fishery, as reflected in the boat licence to participate in the fishery, that rose in value from AUS$60,000 to AUS$85,000 immediately following the licence retirement. The 1997 buyback also coincided with the establishment of a limited brokerage service, with government assistance, that greatly increased the level of lease quota trading relative to the period 1992-96. For example, average yearly lease quota trades increased by more than 50% to 26,000 tonnes in the period 1997-200 compared to the preceding 5 years.

Despite the large expenditures on removing vessels and targeted financial assistance, no study has been undertaken to assess the impact on the economic performance of fishers. Indeed, as far as we are aware, despite the combined expenditure of many millions of dollars worldwide in the past three decades on vessel, gear and licence buybacks, our study is the first *ex-post* assessment of the impact of a buyback on individual vessel profitability and productivity.

3 Method for Decomposing Firm-Level Profits

The approach used to decompose relative profits and analyze productivity changes in the South East trawl fishery is described in detail in Fox, Grafton, Kirkley and Squires (2003). It offers important advantages over traditional measures of productivity in fisheries (Squires 1992; Jin *et al* 2002) in that it provides individual firm-level measures and quantifies the contribution of productivity, inputs and outputs to relative profits. Thus it provides an easy way to assess both firm and industry performance at a point in time and over time.[1]

We briefly review the profit decomposition approach using index numbers. We define the restricted profits of an arbitrary firm b, π^b, relative to the restricted profits of another firm a, π^a:

$$\theta^{a,b} \equiv \pi^b / \pi^a. \tag{1}$$

A productivity index between firms b and a, denoted by $R^{a,b}$, can also be defined as the ratio of an output index and input index between firms a and b , i.e,

$$R^{a,b} \equiv (\theta^{a,b}/P^{a,b})/K^{a,b}, \tag{2}$$

where the numerator is an implicit output index (Allen and Diewert, 1981), $P^{a,b}$ is a price index where variable inputs are treated as negative outputs and $K^{a,b}$ is an input quantity index. Productivity defined by (2) is the difference in the output quantity index that cannot be explained by differences in input utilization. By rearranging Equation (2), we obtain the following profit decomposition

$$\theta^{a,b} = P^{a,b} \cdot R^{a,b} \cdot K^{a,b}. \tag{3}$$

Using (3), the firms' relative profits can be defined in terms of contributions from output prices ($P^{a,b}$), productivity ($R^{a,b}$), and the input ($K^{a,b}$) without making any behavioural assumptions or restrictions on the specific form of the technology used by firms.

To apply the decompositions in the South East trawl fishery, we first define $p^b = (p_1^b, \ldots, p_M^b)$ as a price vector for vessel b of netput prices specified for M variable "netputs," denoted by $y^b = (y_1^b, \ldots, y_M^b)$. In the netput vector, if $y^b > 0$ the good is an output, but if $y^b < 0$ the good is a variable input. The vector of (quasi-) fixed input prices for vessel b is $r^b = (r_1^b, \ldots, r_N^b)$, where there are N fixed inputs, denoted by $k^b = (k_1^b, \ldots, k_N^b)$. Both price vectors satisfy the requirement that each element is positive.

As shown by Fox, Grafton, Kirkley and Squires (2003), the Törnqvist (1936) index has a number of useful properties for constructing the price and fixed-input indexes for use in (3). Using the Törnqvist index, $P^{a,b}$ and $K^{a,b}$ in (3) can be denoted as netput price and quantity indexes and are defined by (4) and (5), where $s_m = (p_m y_m)/(\sum p_m y_m)$ is the profit share of netput m and $s_n = (r_n k_n)/(\sum p_m y_m)$ is the profit share of fixed input n, i.e.,

$$\ln P^{a,b} \equiv \sum_{m=1}^{M} \frac{1}{2}(s_m^b + s_m^a) \ln(p_m^b / p_m^a), \tag{4}$$

and

$$\ln K^{a,b} \equiv \sum_{n=1}^{N} \frac{1}{2}(s_n^b + s_n^a) \ln(k_n^b / k_n^a). \tag{5}$$

The multiplicative nature of the Törnqvist index allows us to decompose the aggregate price and fixed-input indexes between vessels a and b into a product of individual price and input differences, i.e.,

$$P^{a,b} = \prod_{m=1}^{M} P_m^{a,b} \tag{6}$$

and

$$K^{a,b} = \prod_{n=1}^{N} K_n^{a,b}, \tag{7}$$

where the index for each netput m and fixed-input n is itself a Törnqvist index. In this manner, equations (3), (6) and (7) collectively represent a detailed decomposition of profits between firms a and b.[2] Using these profit decompositions, we can derive individual measures of relative profits over time and the contributions to relative profits from input and output prices, changes in vessel size and productivity.

4 Profit Decompositions and Productivity

The profit decomposition method is applied to the South East trawl fishery using vessel-level data on the implicit output price, fuel price, price for labor and a capital measure represented by vessel tonnage. The sample data was obtained by the Australian Bureau of Agricultural and Resource Economics (ABARE) and AFMA and is an unbalanced panel of 47 vessels over the period 1997-2000 giving a total of 131 observations.[3] Due to data inconsistencies, 11 observations were dropped leaving a total of 120 observations to calculate the profit decompositions.

Provided there is only one (quasi-) fixed input, profits are all attributed to the (quasi-) fixed input and s_n, or the share of capital in profit in (5), is unity. Thus the (quasi-) fixed quantity index defined by (5) reduces to the following,

$$K^{a,b} = k^b/k^a. \tag{8}$$

Variable inputs in the fishery are fuel (F) and labor (L). From equations (3), (6) and (7), our decomposition of the profit ratio between vessel a and vessel b, $(b = 1, \ldots, 120)$, $\theta^{a,b}$ is given by (9)

$$\theta^{a,b} = R^{a,b} \cdot PO^{a,b} \cdot PL^{a,b} \cdot PF^{a,b} \cdot K^{a,b}. \tag{9}$$

In this profit decomposition the performance of vessel b relative to vessel a can be decomposed into differences due to productivity ($R^{a,b}$), output ($PO^{a,b}$), variable inputs ($PL^{a,b}$ and $PF^{a,b}$) and vessel capital ($K^{a,b}$).

Individual prices per species per vessel are not available for the fishery. Consequently, for each vessel the price is defined as the total value of landings of fish from vessels divided by the total weight of the fish landed. This data limitation prevents us from assessing the relative profit contributions of the different fish species, but does not restrict us from assessing the overall impact of fish returns on individual and industry performance. Nor does it prevent us from applying the profit decomposition to assess the contribution of harvests to relative profits. $PL^{a,b}$ is an implicit labor price defined as total vessel labor payments divided by the number of trawling hours multiplied by the number of crew. $PF^{a,b}$ is a recorded price of fuel for the vessels and $K^{a,b}$ is the vessel gross registered tonnage.

For common-pool resources, an important issue to consider is the effect of the natural capital stock on profits and productivity. Data limitations on the stock assessment of the species in the fishery, however, preclude us from separating out the effects of changes in biomass from other changes over the four years of the sample data. As a result, measures of changes in productivity are not conditioned on the level of stock abundance. Although this limits our ability to discern what factors may have led to changes in productivity performance, it does not prevent us from analyzing whether fishers experienced productivity gains following the buyback, or the relative contributions of changes in prices and vessel size to relative profits over the period 1997-2000.[4]

For comparative purposes, a reference firm (a) must be chosen. Using a benchmark that is an observed firm or vessel helps fishers to better assess those factors that are constraining profits that are under their control (such as productivity) from factors that are not (such as fuel prices). A natural benchmark vessel is one that maximizes profit relative to all other vessels and over all periods which is observation 26 from a total of 28 observations in 2000.

The profit decompositions are presented in Tables 2 through 4 for the years 1997-2000. Geometric means of the index numbers are given in Table 6. To assist in the evaluation of the decompositions, the pooled index series are plotted in Figure 1, where the observations for each of the four years are separated by vertical dotted lines. When comparing the index values, if an index takes a value greater (less) than one, it contributes by expanding (contracting) the profit ratio, θ. For the reference firm, observation 26 in 2000, its index values are unity and the index values for all other firms are relative to this benchmark.

A value of less than one for the output price index indicates that the *contribution* of the output price to profit is less than in the benchmark firm. Only four observations have a *PO* greater than unity, and most vessels have values considerably less than unity. This suggests that an important factor contributing to the profits of the benchmark vessel was the price it received for its harvest. A value greater than one for the input indexes does *not* imply that the input prices are more than for the benchmark vessel. Rather, it indicates that the contribution of that input price to the profit ratio is *greater* than for the benchmark vessel. This could arise if the input price for the given vessel is *less* than that of the reference firm as an increase in the fuel price reduces profits. If the input price for a given vessel is identical to the benchmark vessel, the corresponding price decomposition index will be unity.

To illustrate that the profit decompositions are contributions to profits and *not* absolute ratios, Figure 2 presents the ratios of output and variable input prices and quantities relative to the benchmark firm. Although these ratios provide information on the variability of these measures across vessels and periods, they do not provide insight into what may be contributing to relative profitability. Moreover, these ratios cannot be used to construct a meaningful index of total factor productivity.

5 Profits, Productivity and the Vessel Buyback

Observation of the profit decompositions reveals a number of insights about vessel performance in the fishery. Figure 1 presents the profit decompositions by observation and by period where vessels in each period are ranked in ascending order based on vessel tonnage. Scatter plots of the *PO* index suggest that the contribution to profits from the implicit output price are higher for larger vessels and that its importance for all vessels rises over time. This is confirmed in Table 6 with the geometric mean for *PO* for all vessels rising from 0.194 and 0.238 in 1997 and 1998 to 0.379 and 0.371 in 1999 and 2000. In addition, the mean for large vessels is higher for all years than for small vessels. No noticeable trends appear for any of the variable inputs (PL and PF) across vessel sizes or over time.

The rise in the contribution of productivity to profits of small vessels explains why the gap in the mean of the profit ratio for large and small vessels narrowed substantially between 1997-1998 and 1999-2000. In other words, improvements in relative productivity of the smaller vessels explains why the profitability of smaller vessels has increased relative to larger vessels, although large vessels still remain more profitable overall.

It would seem, therefore, that a goal of the regulator to raise economic performance has been realized. The extent to which this improvement is attributable to the licence buyback, however, is not immediately clear. The profitability of both small and large vessels improved over the period 1997-2000 due to a rise in output prices, but this was independent of the buyback because the fishery has been managed by ITQs since 1992 that control the total landings of fishers. In other words, the buyback may have changed the distribution of returns in the fishery, but would not have changed the aggregate returns. A possibility exists, however, that the establishment of a limited brokerage firm (separate to the licence buyback) for trading quota in 1997 may have stimulated increases in output prices by allowing fishers to adjust their harvests to better suit market conditions and their catches. This possibility is supported by the fact that annual lease quota trades increased by over 50% for the period 1997-2000 compared to the period 1992-96.

If the vessel buyback and increased quota trading did have a positive economic benefit to fishers, it should also have raised overall vessel productivity. The evidence from the profit decompositions is that productivity rose over the period 1997-2000, but only for small vessels. To what extent the productivity changes are attributable to the vessel buyback and increased quota trading cannot be precisely discerned because the results are not adjusted for changes in fish stocks. Nevertheless, the results indicate a very substantial increase in productivity for both small and large vessels from 1997 to 1998, respectively, of 45% and

30% which is coincident with the licence buyback and improved quota trading. Moreover, such productivity gains were simultaneous with a decline in catch per unit of effort for seven of the 16 quota species over the period 1997-1998 (AMS Search Ltd. 2000). Since 1998, the contribution of productivity to profits for large vessels has fallen which may, in part, be explained by declines in some of the major offshore fish stocks, such as orange roughy, that are fished by the larger vessels (Bureau of Rural Sciences 2002).

In sum, the empirical evidence provides support for the hypothesis that the licence buyback instituted in the fishery in 1997 has had a positive impact on profitability via productivity improvements. Unlike vessel or licence buybacks implemented in other fisheries, such as British Columbia's salmon fishery or the US northeast multispecies fisheries (Holland, Gudmundosson and Gates 1999), it has occured within a fishery managed by individual and transferable output controls. Thus the South East trawl fishery offers a unique "natural experiment" where a buyback, coupled with ITQs, has provided on-going benefits to fishers. Such benefits do not appear to have diminished over time which might otherwise have been the case if the fishery had been managed by only input controls—a type of fisheries management that can result in both input substitution (Dupont 1991) and rent dissipation (Dupont 1990). In other words, because the South East trawl fishery is managed by individual harvesting rights it appears to have avoided the incentive for fishers to increase fishing effort that often follows buybacks (Campbell 1989; Weninger and McConnell 2000).[5]

6 Concluding Remarks

The paper presents the first *ex-post* analysis of firm profits and productivity following a vessel or licence buyback in a fishery. Using individual firm-level data for the period 1997-2000, the paper analyzes a "natural experiment" of the effects of a 1997 scheme to reduce fishing capacity in the South East trawl fishery of Australia. The scheme was unique in the sense that the buyback was implemented in a fishery managed by individual vessel tradeable harvesting rights rather than input controls. Using an innovative index method that decomposes the contributions of output prices, input prices, vessel size and productivity to relative profits, the economic performance of vessels is analyzed in the year of the buyback and for three years afterwards.

The results indicate an enormous range in the relative profits and productivities of vessels within the fishery and measurable differences across vessel sizes. In the three years following the buyback, all vessels have benefited from a rise in output prices, but this increase is independent of the buyback program as the fishery has been regulated by output controls since 1992. The results, however, do indicate a substantial increase in mean productivity across all vessel classes immediately following the licence buyback, despite declines in catch per unit of effort for key species in the fishery. Smaller vessels appear to have benefited the most from the changes with their mean contribution of productivity to profits rising 60 percent from 1997-98 to 1999-2000, while the productivity of large vessels in 2000 is virtually unchanged from their pre-licence buyback level in 1997.

The findings suggest that the buyback, coupled with individual tradeable harvesting rights, have been successful at improving economic performance. Such a desirable outcome is in direct contrast to the long-term outcomes associated with vessel and licence buyback in fisheries managed exclusively by input controls.

End Notes:

1. However, our approach does not separate out the effects of changes in capacity utilization (Jin *et al.* 2002) or technical change on productivity performance, although it could be extended to do so given appropriate data.

2. For related index-number decompositions in different contexts, see the seminal paper by Diewert and Morrison (1986) and also Fox, Kohl and Warren (2002).

3. Only 17 of the 47 vessels are surveyed in all four periods. Prices are net of general price changes through deflation by the consumer price index.

4. If the data were available, a natural capital stock index could be calculated as the available biomass per unit of the allowable harvest. Thus, for a stock-flow production technology, an increase (decrease) in the biomass, holding the allowable harvest fixed and all other factors constant, should make it easier (harder) for fishers to catch the allowable harvest and tend to increase (decrease) profits. Using the stock index it is, therefore, possible to construct a resource adjusted measure of efficiency (Fox, Grafton, Kirk ley and Squires, 2003)

5. Weninger and McConnell (2000) show that the net welfare effects of a buyback depends on the opportunity for remaining fishers to replace the removed capacity, the irreversibility of their capital investments and the speed of replacement of fishing capital. Campbell (1989) observes that the net benefits of a buyback varies positively with the share of the restricted input(s) as a proportion of total costs and inversely with the ability to substitute between restricted and unrestricted inputs.

References

Allen, R.C. and W.E. Diewert (1981), "Direct Versus Implicit Superlative Index Number Formulae," *Review of Economics and Statistics* 63, 430-435.

AMC Search Ltd. (2000), *An Economic Assessment of the South East Fisheries Adjustment Program (SEFAP)*, Draft Report.

Bureau of Rural Sciences (2002) *Fishery Status Reports 2000-2001* (Ed. Albert Caton) Agriculture, Fisheries and Forestry–Australia: Canberra.

Campbell. H.F. (1989), "Fishery buy-back programmes and economic welfare," *Australian Journal of Agricultural Economics* 33 (1), 20–31.

Diewert, W.E. (1992), "Fisher Ideal Output, Input, and Productivity Indexes Revisited," *Journal of Productivity Analysis* 3, 211–248.

Diewert, W.E. and C.J. Morrison (1986), "Adjusting Output and Productivity Indexes for Changes in the Terms of Trade," *Economic Journal* 96, 659–679.

Dupont, D.P., (1990), "Rent Dissipation in Restricted Access Fisheries," *Journal of Environmental Economics and Management*, 19, 26-44.

Dupont, D.P. (1991), "Testing for Input Substitutability in a Regulated Fishery," *American Journal of Agricultural Economics* 73, 155–164.

Fox, K.J., R.Q. Grafton, J. Kirkley and D. Squires (2003), "Property Rights in a Fishery: Regulatory Change and Firm Performance," *Journal of Environmental Economics and Management* 46, 156–177.

Fox, K.J., U. Kohli and R.S. Warren, Jr. (2002), "Accounting for Growth and Output Gaps," *Economic Record* 78, 312–326.

Holland, D., E. Gudmundson and J. Gates (1999), "Do fishing vessel buyback programs work: A survey of the evidence," *Marine Policy* 23 (1), 47-69.

Jin, D., E. Thumberg, H. Kite-Powell and K. Blake (2002), "Total Factor Productivity Change in the new England Groundfish Fishery: 1964-1993," *Journal of Environmental Economics and Management* 44, 540–556.

Pascoe, S. and L. Coglan (2002), "The Contribution of Unmeasurable Inputs to Fisheries Production: An Analysis of Technical Efficiency in the English Channel," *American Journal of Agricultural Economics* 84(3), 585–597.

Kirkley, J.E., C.J. Morrison Paul and D. Squires (2002), "Capacity, Capacity Utilization in Common-pool Resource Industries," *Environmental and Resource Economics* 22, 71–97.

Squires, D. (1992), "Productivity measurement in common property resource industries: an application to the Pacific trawl fishery," *Rand Journal of Economics* 23(2), 221–236.

Törnqvist, L. (1936), "The Bank of Finland's Consumption Price Index," *Bank of Finland Monthly Bulletin*, No. 10, 1–8.

Weninger, Q. and K.E. McConnell (2000), "Buyback programs in commercial fisheries: efficiency versus transfers," *Canadian Journal of Economics*, 33 (2), 394–412.

Table 1: Summary Statistics: Data on the South East Trawl Fishery

	Mean	Standard Deviation	Minimum	Maximum
All Years				
Revenue	485730	453259	86110	2467011
Landings	229164	182048	22266	1171634
Price	2.13	0.71	1.12	4.47
Crew Hours	3562	2391	128	14095
labor Price	75	106	15	684
Fuel Quantity	1175	1135	64	5312
Fuel Price	70	7.19	63	83
Vessel Tonnage	82	92	13	670
1997				
Revenue	390518	378994	116996	2110863
Landings	215714	191165	31531	1051230
Price	1.88	0.69	1.12	4.45
Crew Hours	4129	2963	1276	14095
labor Price	42	24	15	129
Fuel Quantity	1056	1008	111	4078
Fuel Price	67	0.00	67	67
Vessel Tonnage	94	124	13	662
1998				
Revenue	426822	383243	86110	2094586
Landings	229111	205366	38389	1171634
Price	1.91	0.55	1.22	4.47
Crew Hours	3654	2404	128	11829
labor Price	68	99	19	531
Fuel Quantity	1065	1001	107	4349
Fuel Price	63	0.00	63	63
Vessel Tonnage	73	52	13	196
1999				
Revenue	571656	526541	98993	2467011
Landings	241148	181019	22266	889694
Price	2.39	0.77	1.44	4.45
Crew Hours	3197	1965	360	7245
labor Price	98	129	16	515
Fuel Quantity	1329	1296	98	4521
Fuel Price	69	0.00	69	69
Vessel Tonnage	94	123	13	670
2000				
Revenue	568177	510214	105770	2336295
Landings	231226	149968	27093	615403
Price	2.38	0.69	1.24	3.90
Crew Hours	3223	2073	360	7038
labor Price	95	132	20	684
Fuel Quantity	1274	1260	64	5312
Fuel Price	83	0.00	83	83
Vessel Tonnage	94	124	13	662

Notes: There are 30 observations for 1997, 33 for 1998, 29 for 1999, and 28 for 2000. Landings are in the total volume of fish sold, in kilograms; Price is the average price for a kilogram of fish landed; Crew hours is the average number of crew times the number of trawling hour; Fuel Quantity is litres of fuel dispensed; Fuel Price is the average diesel price for Melbourne; Vessel Tonnage is gross vessel tonnage (GVT).

Table 2: Decomposition of Profit Ratios (θ), 1997

Obs	Profit	θ	R	PO	PF	PL	K
1	70758	0.045	1.063	0.167	1.018	3.713	0.068
2	44282	0.028	0.254	0.125	1.021	6.439	0.136
3	89039	0.057	0.076	0.887	1.018	4.838	0.173
4	79982	0.051	0.551	0.144	1.019	3.699	0.173
5	114085	0.073	0.471	0.216	1.020	3.985	0.178
6	41825	0.027	0.006	1.467	1.056	16.515	0.183
7	222867	0.143	0.700	0.469	1.022	2.269	0.188
8	111018	0.071	0.219	0.261	1.031	6.430	0.188
9	90375	0.058	0.281	0.155	1.035	6.498	0.199
10	103744	0.067	0.254	0.457	1.033	2.660	0.209
11	58257	0.037	0.271	0.158	1.023	4.081	0.209
12	85904	0.055	0.527	0.098	1.026	4.769	0.220
13	68112	0.044	0.312	0.136	1.029	4.361	0.230
14	230803	0.148	0.523	0.327	1.031	3.578	0.235
15	68845	0.044	0.092	0.146	1.054	12.795	0.246
16	46449	0.030	0.151	0.057	1.069	11.104	0.293
17	48848	0.031	0.018	0.080	1.127	63.301	0.314
18	82293	0.053	0.217	0.113	1.024	6.707	0.314
19	24682	0.016	0.096	0.022	1.087	21.596	0.314
20	75102	0.048	0.178	0.103	1.103	6.509	0.366
21	142183	0.091	0.473	0.102	1.061	4.898	0.366
22	70310	0.045	0.023	0.140	1.131	30.238	0.408
23	211007	0.136	0.104	0.412	1.055	6.241	0.481
24	166302	0.107	0.182	0.257	1.053	4.156	0.523
25	429122	0.276	0.416	0.321	1.046	3.400	0.580
26	280435	0.180	0.391	0.232	1.029	2.887	0.669
27	160346	0.103	0.125	0.247	1.058	4.164	0.758
28	297546	0.191	0.227	0.260	1.053	3.279	0.941
29	376475	0.242	0.308	0.191	1.028	4.164	0.962
30	1315549	0.846	1.549	0.372	1.024	1.400	1.025

Table 3: Decomposition of Profit Ratios (θ), 1998

Obs	Profit	θ	R	PO	PF	PL	K
1	86829	0.056	1.241	0.226	1.027	2.845	0.068
2	16898	0.011	0.042	0.155	1.133	13.313	0.110
3	55508	0.036	0.183	0.196	1.030	7.104	0.136
4	100832	0.065	0.396	0.193	1.027	4.791	0.173
5	94219	0.061	0.513	0.210	1.031	3.167	0.173
6	107753	0.069	0.435	0.228	1.034	3.808	0.178
7	71117	0.046	0.025	1.377	1.061	6.739	0.183
8	249416	0.160	0.783	0.451	1.036	2.328	0.188
9	60510	0.039	0.138	0.140	1.121	9.516	0.188
10	155553	0.100	0.673	0.206	1.039	3.501	0.199
11	108173	0.070	0.281	0.364	1.054	3.081	0.209
12	71802	0.046	1.401	0.209	1.032	0.732	0.209
13	112869	0.073	0.384	0.224	1.031	3.736	0.220
14	94994	0.061	0.424	0.207	1.036	2.927	0.230
15	175170	0.113	0.399	0.284	1.050	4.031	0.235
16	106950	0.069	0.175	0.214	1.070	6.974	0.246
17	105070	0.068	0.257	0.201	1.028	4.864	0.261
18	71132	0.046	0.235	0.135	1.078	4.559	0.293
19	94300	0.061	0.191	0.170	1.034	5.739	0.314
20	42500	0.027	0.154	0.079	1.106	6.466	0.314
21	157209	0.101	0.304	0.251	1.077	3.365	0.366
22	162236	0.104	0.569	0.113	1.088	4.074	0.366
23	124993	0.080	0.082	0.355	1.092	6.188	0.408
24	403648	0.260	0.600	0.363	1.049	2.441	0.465
25	423410	0.272	0.347	0.512	1.048	3.037	0.481
26	299533	0.193	0.390	0.298	1.063	2.982	0.523
27	575114	0.370	0.508	0.479	1.047	2.502	0.580
28	231265	0.149	0.308	0.158	1.112	4.116	0.669
29	158076	0.102	0.196	0.148	1.096	4.230	0.758
30	88383	0.057	0.013	0.184	1.134	22.644	0.899
31	346500	0.223	0.277	0.316	1.062	2.544	0.941
32	525067	0.338	0.358	0.290	1.045	3.244	0.962
33	1242506	0.799	2.496	0.301	1.041	0.997	1.025

Table 4: Decomposition of Profit Ratios (θ), 1999

Obs	Profit	θ	R	PO	PF	PL	K
1	95612	0.061	0.640	0.525	1.018	2.676	0.067
2	78348	0.050	0.183	1.223	1.030	2.019	0.108
3	170551	0.110	1.241	0.229	1.017	2.223	0.170
4	158788	0.102	0.713	0.369	1.020	2.166	0.176
5	75908	0.049	0.130	0.291	1.040	6.862	0.181
6	319083	0.205	2.328	0.231	1.073	1.909	0.186
7	176897	0.114	0.518	0.360	1.025	3.031	0.196
8	150846	0.097	0.683	0.231	1.018	2.781	0.217
9	138419	0.089	0.951	0.185	1.016	2.186	0.227
10	139477	0.090	0.195	0.564	1.018	3.367	0.238
11	52075	0.033	0.054	1.308	1.039	1.895	0.243
12	274419	0.176	0.764	0.280	1.053	3.101	0.253
13	163293	0.105	0.631	0.199	1.015	3.197	0.258
14	293310	0.189	0.546	0.457	1.037	2.612	0.279
15	232226	0.149	0.395	0.435	1.040	3.000	0.279
16	80927	0.052	0.145	0.319	1.049	3.719	0.289
17	143426	0.092	0.346	0.235	1.021	3.588	0.310
18	818644	0.526	1.975	0.941	1.021	0.853	0.325
19	118230	0.076	0.131	0.240	1.060	6.315	0.362
20	67930	0.044	0.037	0.224	1.088	11.726	0.413
21	257383	0.165	0.194	0.656	1.038	2.723	0.460
22	192546	0.124	0.071	0.387	1.073	8.886	0.475
23	384738	0.247	0.826	0.242	1.038	2.311	0.516
24	186784	0.120	0.110	0.367	1.077	4.108	0.671
25	660626	0.425	0.458	0.677	1.033	1.821	0.728
26	81921	0.053	0.020	0.134	1.129	19.779	0.888
27	1001635	0.644	0.958	0.663	1.033	0.970	1.012
28	340356	0.219	0.128	0.436	1.072	2.862	1.278
29	1450059	0.932	0.513	0.605	1.029	0.835	3.502

Table 5: Decomposition of Profit Ratios (θ), 2000

Obs	Profit	θ	R	PO	PF	PL	K
1	64913	0.042	0.354	0.607	1.000	2.932	0.066
2	51205	0.033	0.180	0.717	1.000	2.375	0.107
3	174455	0.112	1.032	0.257	1.000	2.507	0.168
4	85654	0.055	0.788	0.132	1.000	3.057	0.173
5	52302	0.034	0.096	0.244	1.000	8.014	0.179
6	185908	0.120	1.057	0.230	1.000	2.682	0.184
7	210768	0.136	0.546	0.461	1.000	2.776	0.194
8	183056	0.118	0.920	0.260	1.000	2.295	0.214
9	123742	0.080	0.809	0.226	1.000	1.940	0.224
10	147108	0.095	0.321	0.481	1.000	2.613	0.235
11	62293	0.040	0.090	1.046	1.000	1.779	0.240
12	345517	0.222	0.670	0.513	1.000	2.589	0.250
13	121216	0.078	0.394	0.200	1.000	3.880	0.255
14	347852	0.224	0.677	0.447	1.000	2.682	0.276
15	237970	0.153	0.442	0.426	1.000	2.950	0.276
16	72522	0.047	0.124	0.302	1.000	4.365	0.286
17	138227	0.089	0.404	0.209	1.000	3.427	0.306
18	786485	0.506	3.040	0.697	1.000	0.743	0.321
19	120919	0.078	0.162	0.224	1.000	5.993	0.357
20	94309	0.061	0.027	0.289	1.000	16.867	0.454
21	146312	0.094	0.093	0.146	1.000	14.770	0.469
22	281465	0.181	0.736	0.177	1.000	2.720	0.510
23	542030	0.349	0.524	0.416	1.000	2.415	0.663
24	496239	0.319	0.291	0.738	1.000	2.065	0.719
25	129089	0.083	0.023	0.491	1.000	8.549	0.878
26	1555275	1.000	1.000	1.000	1.000	1.000	1.000
27	268126	0.172	0.072	0.530	1.000	3.601	1.262
28	899473	0.578	0.193	0.681	1.000	1.273	3.459

Table 6: Decomposition of Profit Ratios (θ), Means

Obs	No.	Profit	θ	R	PO	PF	PL	K
All Years	120	234625	0.099	0.278	0.281	1.038	3.828	0.318
Small	73	121619	0.068	0.299	0.260	1.042	4.172	0.201
Large	47	401174	0.182	0.217	0.304	1.063	4.006	0.648
1997	30	173551	0.073	0.207	0.194	1.046	5.728	0.303
Small	19	88535	0.049	0.197	0.182	1.039	6.503	0.203
Large	11	320398	0.145	0.227	0.218	1.058	4.601	0.602
1998	33	203622	0.089	0.288	0.238	1.061	3.995	0.306
Small	20	99080	0.056	0.285	0.223	1.052	4.298	0.195
Large	13	364457	0.181	0.293	0.265	1.073	3.568	0.608
1999	29	286361	0.126	0.319	0.379	1.042	2.968	0.337
Small	17	161388	0.092	0.429	0.364	1.031	2.806	0.204
Large	12	293173	0.196	0.209	0.402	1.057	3.213	0.686
2000	28	283015	0.120	0.317	0.371	1.000	3.076	0.331
Small	17	153218	0.083	0.408	0.345	1.000	2.913	0.202
Large	11	483611	0.211	0.214	0.415	1.000	3.346	0.709

Note: The arithmetic mean is used to average over the profit values, while the geometric mean is used to average over the indexes. Vessel tonnage (K) is used to split up observations into "small" and "large" vessels. Small vessels are defined as those being lighter than the sample average($K < 0.318$), and large vessels are defined as those being heavier than the sample average ($K > 0.318$). "No." denotes the number of vessels in each year/size category.

Figure 1: Profit-Ratio Decomposition

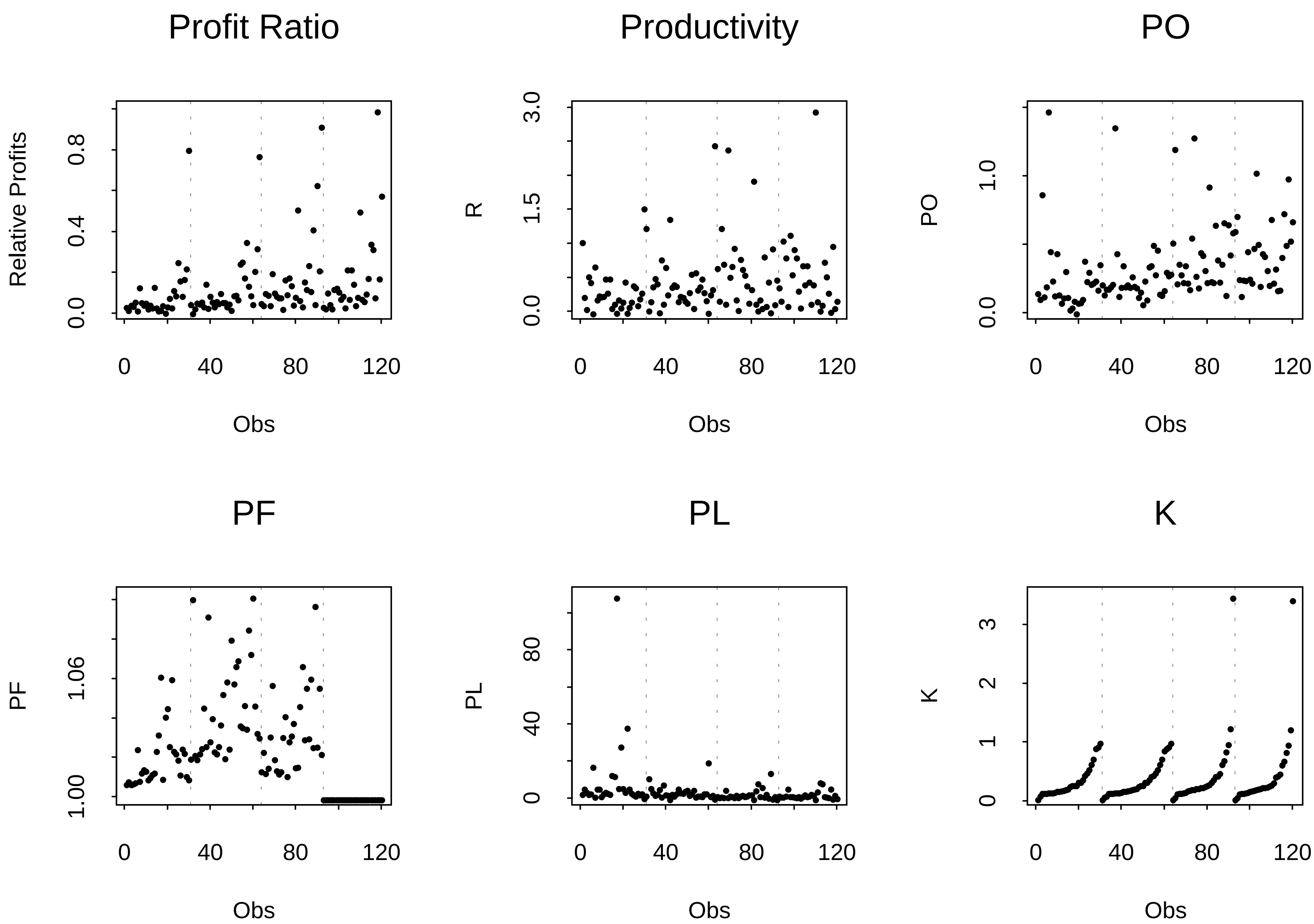

Figure 2: Price and Quantity Relatives