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Australian Government
Australian Bureau of Agricultural and Resource Economics and Sciences

AARES
Australian Agricultural and Resource Economics Society
9–11 February 2011 Melbourne Victoria

11.03

An index number decomposition of profit change in two Australian fishing sectors

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Abstract

Changes in net economic returns in a fishery over time can provide some indication of which direction a fishery's economic performance is moving. However, without information on the causes of those movements, it is difficult to say if a fishery is moving closer to or further away from a point associated with maximum economic yield. A further complication is that different drivers of profitability can cause profit to move in different directions and at variable magnitudes over time. The key variables that influence a fishery's profitability include: prices received for catch; prices paid for inputs (such as crew and fuel); vessel productivity (that is, the ability of each vessel to convert its inputs into outputs or harvested catch); and the fishery's stock biomass, with a higher stock biomass allowing catches to be made at lower cost and greater profit. This paper presents an index number profit decomposition analysis of two sectors of the Australian Southern and Eastern Scalefish and Shark Fishery. The analysis presented decomposes and quantifies the relative contribution of each of the above-mentioned drivers to changes in vessel-level profitability over time. More specifically, the results are interpreted to reveal how historical changes in profit have come about as a result of both changes in variables that fishery managers do have some indirect influence over (fish stocks and productivity) and changes in variables that fishery managers do not have control over (output and input prices). It is shown that, for the two sectors assessed, two key factors that have influenced recent profitability changes are: a recently implemented government restructuring package; and previous adjustments to total allowable catch settings for key species.

Acknowledgments

The author would like to acknowledge the following people for their assistance with this research: Jemery Day and Geoff Tuck from the CSIRO; David Galeano, John Garvey and Thim Skousen from AFMA; and Robert Curtotti, Patricia Hobsbawn, James Larcombe, Paul Phillips, Peter Martin, Phil Sahlqvist, Walter Shafron, Ilona Stobutzki and Peter Ward from ABARES. This paper presents results from research that was funded by the Fisheries Resources Research Fund.

ABARES project: 43064

ISSN: 1447-3666

1 Introduction

Over the past two decades, management of Australia's Commonwealth fishery resources has become increasingly reliant on economic information. This has been driven by the Australian Fisheries Management Authority's legislated objective to manage fisheries in a way that maximises the net economic returns to the Australian community. More recently, the release of the *Commonwealth Fisheries Harvest Strategy Policy* in 2007 has put this economic objective at the forefront of decision-makers concerns when making fishery management decisions. This policy requires that harvest strategies (a set of rules that guide decisions on appropriate fishery harvest levels) be developed for Commonwealth fisheries that seek to maintain fish stocks at a target biomass equal to the stock size required to produce maximum economic yield (MEY). MEY refers to that point in a commercial fishery where fishing effort, catches and fish stocks are at levels that result, on average, in the net economic returns to society being maximised from the commercial use of that fishery resource (Kompas and Gooday 2005). The implementation of harvest strategies since then has increased the demand for economic information to feed into policy decisions about how best to pursue the MEY target.

To accurately determine the level of catch, effort and stock abundance settings that are most likely to achieve MEY, a bioeconomic model is typically required. However, bioeconomic models are data-intensive (requiring biological, economic and fishery-based data), complex and require a high level of technical expertise and experience to construct and interpret. For many fisheries, this means that constructing a bioeconomic model will be highly costly and that such an approach may not be justified on a cost–benefit basis.

For some of Australia's key Commonwealth fisheries, time-series estimates of net economic returns are available. Such estimates reveal the actual net economic return achieved in a given year, but not the maximum economic return that could have been achieved. Changes in net economic returns over time can indicate which direction profitability is moving. However, without information on the causes of those movements, it is difficult to say if a fishery is moving closer to or further away from a point associated with MEY. Key variables that influence a fishery's profitability include prices received for outputs (catch), prices paid for inputs (such as crew and fuel), vessel productivity (the ability of each vessel to convert its inputs into outputs) and fishery stock levels (higher stocks result in catches being made at lower cost). A further complication is that different drivers of profitability can cause profit to move in different directions and at variable magnitudes over time.

Consequently, for most of Australia's Commonwealth-managed fisheries, there is an increasing need to develop other more informative but less costly tools and indicators to inform fishery management policymaking according to a MEY objective. One tool that has been developed recently is the index number profit decomposition method, which allows the different drivers of profit changes in a fishery to be assessed, quantified and compared. As its name suggests, this method decomposes the relative contributions of the key drivers of profit changes at the vessel level into their separate elements, including the effect of a fishery's stock abundance. It does this by quantifying changes in vessel-level profit according to the contributions from changes in key drivers, with each individual vessel's performance being defined by an index relative to a selected reference vessel.

This approach was first applied by Fox et al. (2003) to the British Columbia halibut fishery and has since been applied to Canada's Scotia-Fundy mobile gear fishery (Dupont et al. 2005), the Commonwealth Trawl Sector (formerly the South East Trawl Fishery) (Fox et al. 2006; Grafton and Kompas 2007) and the Eastern Tuna and Billfish Fishery (Kompas et al. 2009). This paper presents an update of the previous work for the Commonwealth Trawl Sector and applies the method to the Commonwealth Gillnet, Hook and Trap Sector for the first time. For the Commonwealth Trawl Sector, the decomposition is adapted from the single-output analysis used by Fox et al. (2006) and Grafton and Kompas (2007) to a multi-output analysis, so that the relative effect of the prices of different outputs on profitability can be assessed. The same multi-output approach is applied to the Gillnet, Hook and Trap Sector.

The results presented in this paper are relevant to current policymaking for both fishery sectors. As already discussed, the results generated can provide a clearer picture of which direction a fishery might be moving relative to MEY. Additionally, both sectors have recently gone through significant structural change following a government-funded vessel buyback that concluded in 2006–07. A general assessment of the effect of this buyback has been previously undertaken by Vieira et al. (2010), using a variety of different indicators. However, the method used here allows a relatively more refined assessment because it allows the effect of the buyback on profitability to be isolated from other potential drivers of profit change. Given this, and that this paper uses a longer time series of data, the results presented here offer relatively stronger evidence about the effect of the buyback.

In the following section, a brief description of the two fishery sectors covered in this paper is provided. Section 3 provides a general description of the index number profit decomposition method. This is followed by an outline of how the method was applied to the two fishery sectors and the data that were used. Section 5 contains an analysis of the results for the two fisheries, outlines the key reasons behind changes in profitability in each sector over the past decade and assesses whether the recent buyback has had an effect. The final section discusses some issues with the decomposition approach, the results and their relevance to policy, and the relevance of the approach to decision-making for fishery managers in the context of MEY.

2 The fishery sectors

The Commonwealth Trawl Sector and the Gillnet, Hook and Trap Sector form part of the Southern and Eastern Scalefish and Shark Fishery, a complex multi-sector, multi-gear and multi-species fishery. The fishery includes two other smaller sectors—the Great Australian Bight Trawl Sector and the East Coast Deepwater Trawl Sector. It covers an area from southern Queensland, around Tasmania and west to Cape Leeuwin in Western Australia.

The Commonwealth Trawl Sector is one of Australia's oldest commercial fishing sectors, commencing operation off the coast of Sydney in the early 1900s. The primary harvesting method used in the sector is otter trawling, although a number of Danish seine vessels operate out of Lakes Entrance in Victoria. More than 100 species are routinely caught in the sector. However, five key species constitute more than 60 per cent of the landed trawl tonnage. These include blue grenadier, tiger flathead, orange roughy, silver warehou and pink ling. The sector's gross value of production in real terms has been declining steadily over the past decade, falling from $96.1 million in 1999–2000 to $55.9 million in 2008–09. This decline has been driven by falls in catches as a result of cuts to total allowable catches in response to concerns about the sustainability of key stocks.

The Gillnet, Hook and Trap Sector comprises what were previously the South East Non-Trawl Fishery and the Southern Shark Fishery. Both fisheries were in operation for a long time before being merged—the South East Non-Trawl Fishery since the early 1900s and the Southern Shark Fishery since 1927 (AFMA 2004). Gear types used in the sector include gillnets, droplines, demersal longlines, automatic longlining and traps. The key species caught in the sector is gummy shark. It typically accounts for around 60 per cent of landings in the sector, the majority of which is taken using the gillnet method. School shark is the other key species taken using this method. The production value of the sector in real terms has followed an increasing trend in recent years and peaked at $18.1 million in 2008–09. Gummy shark accounted for 59 per cent of this value.

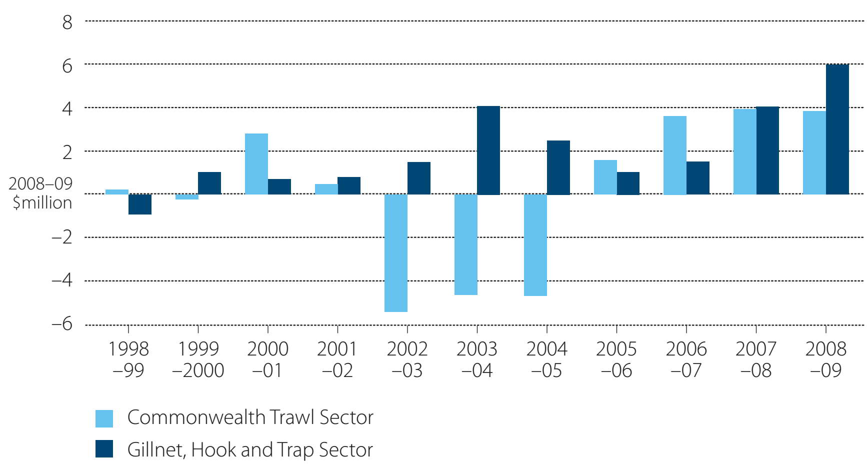
Management of both sectors is predominantly based on output controls in the form of individual transferable quotas and total allowable catches. These were first introduced in the Commonwealth Trawl Sector for gemfish and orange roughy in 1988 and 1990, respectively. In 1992, quota management in the sector was further expanded to a total of 16 target species, partly in response to deteriorating economic conditions across the sector (Smith and Wayte 2004). Quota management was then expanded to key scalefish species in the Gillnet, Hook and Trap Sector in 1998. Quota management of all quota managed species in the Commonwealth Trawl Sector was then expanded to the Gillnet, Hook and Trap Sector when global total allowable catches were set across both sectors in 2001. Currently, 34 species are managed under global total allowable catches that apply to all sectors in the Southern and Eastern Scalefish and Shark Fishery (Stobutzki et al. 2010a).

In 2005, a harvest strategy framework was adopted for the fishery to provide a more strategic approach for determining allowable catches. This predated the *Commonwealth Fisheries Harvest Strategy Policy* released in 2007, and formed the basis for the policy. The framework identifies how allowable catches should be altered when a stock falls below or rises above predetermined levels subject to a target of MEY. The rules that guide the setting of allowable catches have been designed to incorporate more precaution when there is increased uncertainty about stock status. The framework also improves the transparency of the catch-setting process. The harvest strategy framework has been continuously revised and altered in response to a number of shortcomings identified since it was implemented (Larcombe and McLoughlin 2007).

Vessel numbers in both sectors have been declining steadily over the past decade. The recent government-funded vessel buyback further reduced the number of active vessels in the fishery. The scheme aimed to reduce excess effort in fisheries subject to overfishing or at significant risk of overfishing. A total of $150 million was set aside for the buyback component, which was run as a voluntary tender process (DAFF 2006). The buyback resulted in a 46 per cent reduction in the number of fishing permits in the fishery. The overall economic impact of the buyback was assessed in Vieira et al. (2010) as being positive on each sector's profitability.

Survey-based estimates of net economic returns for both sectors reveal that the two sectors have faced different operating environments over the past decade (figure a). For the Commonwealth Trawl Sector, net economic returns were generally close to zero or negative between 1998–99 and 2004–05. Net economic returns then became positive in 2005–06 and have remained positive since then. Net economic returns were $3.8 million in 2008–09, or 7 per cent of the sector's gross value in the same year. In comparison, net economic returns in the Gillnet, Hook and Trap Sector have generally been positive over the past decade, with the exception of 1998–99. As in the Commonwealth Trawl Sector, net economic returns in the Gillnet, Hook and Trap Sector increased substantially in the three years leading up to 2008–09 and were $6 million in 2008–09—equivalent to 20 per cent of the sector's gross value in the same year (Perks and Vieira 2010).

a Real net economic returns in the Commonwealth Trawl Sector and the Gillnet, Hook and Trap Sector, 1998–99 to 2008–09



ABARES assesses the economic performance of all Commonwealth-managed fisheries in its *Fishery Status Reports* series (see Wilson et al. 2010). Qualitative interpretations of the changes in net economic returns for the two sectors assessed here have been made in this report series. However, no attempt has been made to quantify the relative contribution of various drivers to recent profitability improvements in each sector. The index number profit decomposition method described below is used to do this.

3 Methodology

The use of the index number profit decomposition method follows previous applications of the decomposition approach to fisheries. Fox et al. (2003) were the first to apply the method to a fishery (the British Columbia halibut fishery). Dupont et al. (2005) applied the method to a multi-species fishery. Both Fox et al. (2006) and Grafton and Kompas (2007) undertook a decomposition of the Commonwealth Trawl Sector (previously referred to as the South East Trawl Fishery). More recently, Kompas et al. (2009) assessed the Eastern Tuna and Billfish Fishery and used the technique to show how stock depletion had contributed to reduced vessel profitability. The approach has also been applied to the telecommunications sector (Lawrence et al. 2006) to decompose growth in domestic product in an open economy (Diewert and Morrison 1986; Fox and Kohli 1998) and to decompose estimates of the output gap in a country (Fox et al. 2002). The approach and its theoretical robustness is demonstrated in significant detail in Kirkley et al. (2002) and Fox et al. (2003). In the following section, the index number profit decomposition approach is described and details on the application of the approach to the two sectors assessed here are then provided.

The index number profit decomposition approach

The index number profit decomposition approach uses index numbers to quantify the contribution of a variable (output prices, variable input prices, productivity and stocks) to a firm's profit. It does this in terms relative to the contribution of that variable to the profitability of some other firm (a reference firm) using index numbers. The choice of reference firm is normally based on which firm is most profitable (Fox et al. 2006), although Kompas (2009) used the average firm for the most profitable year (Kompas 2009). By choosing the most profitable firm (or year), comparison of each vessel's performance can be made against what is deemed as a more desirable level of performance. Therefore, conclusions can be drawn about what an individual firm would need to change to increase its profit. Furthermore, the comparison against best performance is conceptually consistent with other economic-based frontier approaches to productivity and efficiency analysis, such as stochastic frontier analysis and data envelopment analysis (Fox et al. 2003).

The first stage of the decomposition involves estimating the profits of all vessels and adjusting them for differences in the size of fish stocks over the period of analysis. This allows the contribution of fish stocks to profit to be determined. The next stage involves decomposing differences in the profit index into contributions from prices, fixed inputs and fish stock adjusted productivity.

The first stage involves calculating the variable (excluding fixed input costs), non-zero profit of each firm by summing the product of all defined netputs and their respective prices. Netputs refer to both the outputs and variable inputs that are produced and used by a firm, where a variable input is a netput that has a negative value and an output is a netput that has a positive value. For N netputs, the variable non-zero profit, π, for a given firm in a given period is defined as:

$$\pi = \sum_n^N (p_n . q_n) \quad (1)$$

Once each firm's variable profit has been calculated, a reference firm can be selected (or calculated if using the average firm from a given year). However, in the case of a fishery, it is normally the firm with the highest stock-adjusted profit, πs, that is selected where

$$\pi s = \pi / S \quad (2)$$

where S is a measure of the fishery's stock abundance in the relevant period.

Once the reference firm (firm a) has been selected, the decomposition can begin. The variable profit of an arbitrary firm b, π^b, is first defined relative to the variable profit of the reference firm a, π^a, using an index:

$$\theta^{a,b} \equiv \frac{\pi^b}{\pi^a}. \quad (3)$$

An aggregated price index, $P^{a,b}$, is then defined, which compares the prices of all netputs between firm a and firm b. Similarly, $Q^{a,b}$ is defined as a quantity index that compares the quantities of all netputs between firms a and b. As outlined by Fox et al. (2003), the 'weak factor reversal test' of Fisher (1922) requires that:

$$\theta^{a,b} \equiv P^{a,b} . Q^{a,b} \quad (4)$$

This shows that by using netputs for the construction of the profit index, the profit (or value) index should equal the product of the price and quantity indexes. If this condition is not satisfied by a particular choice of index number for the price or quantity index (for example, Tornqvist index), then either the price or quantity index can be defined directly, and the other index is defined indirectly. If $P^{a,b}$ is defined directly (for example, to ensure that equation 4 is satisfied), $Q^{a,b}$ can be defined as:

$$Q^{a,b} \equiv \theta^{a,b} / P^{a,b} \quad (5)$$

Accordingly, $Q^{a,b}$ is referred to as an 'implicit' index (Allen and Diewert 1981) given it is derived implicitly from the 'direct' definition of $P^{a,b}$.

The definition of the implicit quantity index allows a productivity index to be derived. Put simply, productivity can be defined as some measure of the quantity of output that is produced from a given level of inputs. It therefore follows that a productivity index between two firms can be derived by taking an index of the output produced by each firm and dividing it by an index of the inputs used by each firm. The measure of productivity used here uses the implicit quantity index $Q^{a,b}$ as the output index. The input index is based on each firm's relative use of a fixed input K (capital). Therefore, the productivity index $R^{a,b}$ between the same two firms is defined as:

$$R^{a,b} \equiv Q^{a,b} / K^{a,b} \tag{6}$$

There are many ways to measure productivity, and the productivity index derived using this approach is interpreted slightly differently to more standard measures of productivity. The productivity index here represents the difference in the output quantity index between two firms that cannot be explained by differences in utilisation of the fixed input K by the same two firms. As noted by Lawrence et al. (2006), this concept of productivity is based on an implicit index of output quantity formed using a 'value-added' or 'gross-operating surplus' approach. Therefore, it differs to that of standard total factor productivity measures that use a 'gross-output approach' and are based on a direct output quantity index. Balk (2003) provides a comparison of the two approaches. Lawrence et al. (2006) distinguish between the two types of productivity measures by referring to the measure based on the index number profit decomposition approach as capital total factor productivity. They also note that, since the input base for the latter is generally smaller than a gross-output based measure of total factor productivity, growth in the former measure will tend to be much greater than growth in the latter.

The capital total factor productivity measure in equation 6 can be redefined given equation 5 as:

$$R^{a,b} = (\theta^{a,b} / P^{a,b})/ K^{a,b} \tag{7}$$

Which, once rearranged, defines the overall profit decomposition as:

$$\theta^{a,b} = P^{a,b}.\ R^{a,b}.\ \ K^{a,b} \tag{8}$$

Using equation 8, the profits of vessel b can be defined in terms of the contributions of netput prices ($P^{a,b}$), productivity ($R^{a,b}$) and the fixed input ($K^{a,b}$) to variable profit compared with the contributions of the same variables to the variable profit of vessel a.

A stock-adjusted productivity index between vessels a and b, $R_s^{a,b}$, can also be calculated by multiplying the productivity index by the ratio of stocks observed for vessels a and b:

$$R_s^{a,b} = R^{a,b}\ .\ (S_a / S_b) \tag{9}$$

where S_a and S_b are the fish stocks that each harvests from, respectively.

The aggregate price index ($P^{a,b}$) and the fixed input or capital index ($K^{a,b}$) in equation 8 can be further decomposed into indexes that show the contribution of each netput's price and each capital input's price to variable profit relative to the reference firm. The construction of these two indexes demonstrates how this can be done and is outlined below.

Construction of the aggregated price and capital indexes

To undertake the above decomposition, both an aggregate price index for all relevant netputs and an aggregate capital index for all fixed inputs must be calculated. Derivation of the aggregated price index is based on a price vector of netput prices specified for N variable netputs for vessel b, defined as:

$$p^b = (p_1^b, \ldots, p_N^b) \quad (10)$$

where the quantities of netputs is denoted in the following netput vector:

$$y^b = (y_1^b, \ldots, y_N^b). \quad (11)$$

As was noted earlier, if $y^b > 0$ a netput represents an output, but if $y^b < 0$ a netput represents a variable input. Further, the price vector (equation 10) satisfies the requirement that each element is positive (Fox et al. 2006).

As shown by Fox et al. (2003), the Törnqvist index has a number of useful properties for constructing the price indexes described in equation 8. Using the Törnqvist index, $P^{a,b}$ can be denoted as netput price and quantity indexes and is defined by:

$$lnP^{a,b} = \sum_{n=1}^{N} \frac{1}{2} (s_n^b + s_n^a) ln(p_n^b / p_n^a) \quad (12)$$

where $s_n = (p_n y_n) / (\sum p_n y_n)$ is the profit share of netput n.

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:

$$P^{a,b} = \prod^N P_n^{a,b} \quad (13)$$

where the index for each netput n is itself a Törnqvist index.

The fixed input or capital index, $K^{a,b}$, can be derived in the same fashion as $P^{a,b}$ where there are M fixed inputs which, for firm b, have an associated price vector k^b and quantity vector q^b of netput prices. The aggregate price index for the fixed input can be derived using equation 12 by substituting in the fixed input prices and the profit shares of each fixed input. However, the application of the method to fisheries in previous works has assumed that there is only a single fixed input, so that profits are all attributed to that one single fixed input (that is, that fixed input's profit share is unity). Therefore, calculation of the fixed input index is simplified and reduces to:

$$K^{a,b} = k^b / k^a \quad (14)$$

With the derivation of both the aggregated price index and the fixed input index, the profit decomposition described in equation 8 can be broken down further. Assuming that three key netputs have been defined for the decomposition—a single output (O), a fuel input (F) and a labour input (L)—and, in the case of a fishery, it's stock abundance (S) is known, the decomposition can be redefined as follows:

$$\theta^{a,b} = PO^{a,b} \,.\, PF^{a,b} \,.\, PL^{a,b} \,.\, R^{a,b} .\; K^{a,b} . \frac{S_a}{S_b} \tag{15}$$

The performance of vessel a relative to vessel b is decomposed into differences due to productivity ($R^{a,b}$), output prices ($PO^{a,b}$), labour prices ($PL^{a,b}$), fuel prices ($PF^{a,b}$) and vessel capital ($K^{a,b}$). S_a and S_b are fish stock indexes for vessels a and b. The decomposition provides measures of relative profits over time and the contributions to relative profits from input and output prices, capital, productivity and stocks.

Aggregating stocks in a multi-species fishery

The calculation of the stock index, $S^{a,b}$, requires that stocks be aggregated into a single stock abundance estimate for all years being analysed. For a fishery that catches multiple species, an aggregate measure of the fishery's total stock abundance over time is complicated by two things. First, the abundances of different species will move in different directions and magnitude in a given period. Second, the relationship that exists between a given species' stock abundance and vessel profitability will vary across species. However, the key drivers of a species' contribution to vessel profit are likely to be the catch of a given species and its price.

Accordingly, an aggregated measure of stock abundance can be computed from each key species' stock assessment abundance data, by weighting each species' contribution to the aggregated abundance according to the quantity of catch and the average price received for each species in each year. As shown by Kompas et al. (2009), aggregated stock abundance, S_t, can be defined as:

$$S_t \equiv \sum_{i=1}^{n} S_t^i \frac{p_t^i h_t^i}{\sum_{i=1}^{n} p_t^i h_t^i} \tag{16}$$

where S_t^i is the stock abundance for species i in time period t, p_t^i is its relevant price and h_t^i is the quantity caught in that time period.

Although an aggregated stock index relevant to each vessel would be ideal, such an approach is problematic because catch differences would not necessarily reflect variations in catchability across vessels (Fox et al. 2006). An alternative approach is to construct stock indexes for vessels that employ the same gear in a given year.

4 Application of the method

Data

Data for both the Commonwealth Trawl Sector and the Gillnet, Hook and Trap Sector draw on ABARES economic survey data for the financial years 1998–99 to 2008–09, including revenue and cost data for sampled vessels. These data are combined with logbook catch and effort data and catch disposal record data on vessel departure and arrival time, both supplied by the Australian Fisheries Management Authority. ABARES fisheries statistics data, including average unit prices for key fishery species, were also used to determine prices received by vessels for individual species in each year.

The Commonwealth Trawl Sector is typically divided into three operation types: otter trawlers, Danish seiners and factory trawlers. Only four factory trawlers operated in the sector between 1998–99 and 2008–09 and no survey data exists for these vessels. Therefore, this sector could not be included in the analysis. Otter trawlers can be further categorised according to whether their operations focus on inshore or offshore waters. Offshore trawlers typically target orange roughy. However, reductions in total allowable catches of orange roughy over the past decade to address sustainability concerns have resulted in a substantial decline in the number of offshore trawlers. Consequently, offshore trawlers were also excluded from the analysis.

Therefore, the analysis focuses on inshore trawl vessels (referred to as trawl vessels from here on) and Danish seine vessels. A total of 43 trawl and six Danish seine vessels were removed from the analysis because of data inconsistencies. These inconsistencies particularly related to the price adjustment that was undertaken to allow for the multi-output analysis (explained later). This left 189 trawl vessels and 69 Danish seine vessels in the sample dataset. Tables 1 and 2 contain the sample and population of the trawl sector and Danish seine sector, respectively, along with key summary statistics. The four key species caught by vessels in the trawl sample were blue grenadier, tiger flathead, pink ling and silver warehou. On average, these species accounted for 49 per cent of the average catch per boat. The average Danish seine vessel caught mainly tiger flathead and whiting. These two species accounted for an average of 90 per cent of total catch.

The Gillnet, Hook and Trap Sector, as its name suggests, includes a number of fishing methods. The method analysed here is the gillnet method, which takes around 60 per cent of the sector's catch, the majority of which is gummy shark. The sample, population and key characteristics of sampled gillnet vessels are presented in table 3. The two key species taken by gillnet are gummy shark and school shark, which accounted for 80 per cent of the average sampled vessel's catch over the period of analysis.

1 Sample population and characteristics of sampled trawl vessels (mean per vessel), by financial year

financial year	trawl sample number	trawl population number	mean days at sea	mean boat length (m)	mean blue grenadier catch (kg)	mean tiger flathead catch (kg)	mean pink ling catch (kg)	mean silver warehou catch (kg)	mean catch of other species (kg)
1998–99	20	69	183	20.8	29 488	21 357	26 243	29 552	134 201
1999–00	21	72	185	21.6	36 436	26 415	24 682	35 746	120 634
2000–01	23	73	183	19.6	9 739	29 334	14 256	27 189	111 861
2001–02	25	67	167	19.8	11 115	30 933	10 778	32 380	98 590
2002–03	15	74	166	19.1	6 499	41 544	8 668	24 766	100 881
2003–04	14	75	170	19.2	19 469	53 856	10 998	28 466	91 410
2004–05	15	72	167	20.3	20 499	31 217	8 176	24 615	92 694
2005–06	13	64	179	19.0	24 277	31 328	11 519	27 472	104 736
2006–07	11	62	163	19.8	29 998	38 881	12 719	30 968	105 876
2007–08	6	38	191	20.6	34 744	45 902	18 482	32 668	104 156
2008–09	7	38	210	22.7	43 144	47 746	14 869	41 875	128 158

2 Sample population and characteristics of sampled Danish seine vessels (mean per vessel), by financial year

financial year	Danish seine sample number	Danish seine population number	mean days at sea	mean boat length (m)	mean tiger flathead catch (kg)	mean whiting catch (kg)	mean catch of other species (kg)
1998–99	10	21	138	16.7	106 021	27 956	11 960
1999–00	10	23	120	16.7	92 931	24 031	10 490
2000–01	4	21	135	16.2	46 899	41 159	8 858
2001–02	6	19	113	16.3	46 682	27 430	8 520
2002–03	4	20	126	16.5	76 197	19 771	8 651
2003–04	6	19	121	16.7	76 494	29 021	8 680
2004–05	7	18	124	16.5	83 425	18 074	12 041
2005–06	5	18	90	17.2	43 218	22 098	8 369
2006–07	4	15	94	17.6	64 189	34 335	8 099
2007–08	7	13	113	17.0	95 235	20 917	18 118
2008–09	6	13	96	16.9	81 157	23 918	13 284

3 Sample population and characteristics of sampled gillnet vessels (mean per vessel), by financial year

financial year	sample number	population number	mean gillnet haul time (hours)	mean boat length (m)	mean gummy shark catch (kg)	mean school shark catch (kg)	mean catch of other species (kg)
1998–99	11	92	594	17.5	30 339	10 007	14 409
1999–00	9	88	696	17.1	50 897	8 364	19 009
2000–01	12	86	608	17.0	44 858	5 167	14 308
2001–02	9	82	534	16.5	37 480	9 615	12 252
2002–03	12	84	530	16.6	36 005	6 401	11 121
2003–04	6	85	428	15.6	32 331	1 788	8 494
2004–05	6	78	505	15.6	34 872	1 100	9 509
2005–06	8	63	392	16.9	31 798	1 726	10 076
2006–07	9	59	516	16.6	40 789	2 656	7 315
2007–08	7	46	643	16.7	68 720	4 279	10 005
2008–09	7	47	573	16.7	54 917	3 893	10 184

Definition of netputs, fixed inputs and the reference firm

To undertake the decomposition for both sectors, fuel and labour were defined as the key negative netputs (inputs). Fuel expenditure data were taken from ABARES survey data and combined with ABARES time series data on the average off-road diesel price in Australia, which was adjusted to an on-road price. Fuel quantity was then derived by dividing each vessel's fuel cost by the relevant diesel price.

Labour quantity was calculated based on the product of the average crew per vessel (collected in ABARES surveys) and an indicator of labour time in each of the sectors. For the Commonwealth Trawl Sector, previous index number profit decompositions by Grafton and Kompas (2007) and Fox et al. (2006) have used trawl-hour data (that is, time spent pulling a trawl net through the water) to indicate labour time. However, the current paper uses estimates of fishing days. Such an indicator more accurately reflects the total time that crew spend working on the vessel and the lost opportunities for employment elsewhere for crew. It is also a more relevant measure for the Danish seine sector, which does not use the trawl method. An estimate of fishing days was not available for the full time period of analysis for the Gillnet Sector, so a measure of gear haul time (time spent hauling gear into the boat) was used. A wage rate based on the national pastoral award rates for agricultural labour was used for labour price.

Previous decompositions of the Commonwealth Trawl Sector by Fox et al. (2006) and Grafton and Kompas (2007) have assumed a single positive netput (output) because of a lack of vessel-level price data for individual species. This has limited the analysis because it does not reveal which species are most important in improving a vessel's profitability. The current study extends the approach to multiple species (outputs) by using ABARES average unit price data available for key fishery species, given that species-level revenue data are not available for boats in the ABARES survey dataset. This use of average price data differs to the multi-species analysis of Dupont et al. (2005), who take a more direct approach given the availability of species-level revenue and catch data by vessel.

The multi-species analysis required a calculation using 'major species' and 'non-major species'. Those species that make up the major proportion of revenue for the sample dataset were identified as major species. For the Commonwealth Trawl Sector, 32 major species were selected and for the Gillnet Sector, 11 major species were selected. Prices from ABARES average price data for these species were matched to each vessel's catch of these species. For non-major species, an aggregate price was derived and matched with each vessel's sum of catch of these species. Using this combined dataset, a proxy fishing revenue was calculated that showed a vessel's revenue assuming it received the average prices contained in the ABARES price dataset and given its species-level catch. A revenue ratio was then taken of each vessel's proxy revenue to its actual revenue reported in the ABARES survey data. Each vessel's major species price and the aggregate non-major species price were then adjusted in proportion to its revenue ratio. If a vessel's price adjustment was deemed too large, vessels were removed from the sample dataset.

Key species to be included as netputs in the decomposition were identified according to their contribution to revenue. For the Commonwealth Trawl Sector, these species included blue grenadier, tiger flathead, pink ling and silver warehou. For the Gillnet Sector, gummy shark and school shark were included. An 'other species' netput price and quantity was then derived for each vessel for all remaining species.

To maintain consistency with previous decompositions, the results also include a treatment of output in the single-output sense. Single-output results are presented first, followed by the multiple-output results. Derivation of the output price in the single-output case simply involves dividing each vessel's survey-based revenue by its total catch.

As has been done in previous decompositions of the Commonwealth Trawl Sector, the measure of fixed input quantity used was boat length. This was also applied in the Gillnet Sector.

With the above definition of netputs, the profit decomposition can be rewritten. For trawl vessels in the Commonwealth Trawl Sector the decomposition is:

$$\theta_{CTS}^{a,b} = P_{BG}^{a,b} \,.\, P_{TF}^{a,b} .\, P_{PL}^{a,b} \,.\, P_{SW}^{a,b} \,.P_{Oth}^{a,b} \,.P_{F}^{a,b} \,.\, P_{L}^{a,b} \,.\, R^{a,b} .\; K^{a,b} .\frac{S_a}{S_b} \qquad (17)$$

where $P_{BG}^{a,b}$ is the price of blue grenadier, $P_{TF}^{a,b}$ is the price of tiger flathead, $P_{PL}^{a,b}$ is the price of pink ling, $P_{SW}^{a,b}$ is the price of silver warehou, $P_{Oth}^{a,b}$ is the price of all other species and all other variables are as defined in equation 14.

For Danish seine vessels in the Commonwealth Trawl Sector, the decomposition is presented as:

$$\theta_{CTS}^{a,b} = P_{TF}^{a,b} .\, P_{W}^{a,b} \,.P_{Oth}^{a,b} \,.P_{F}^{a,b} \,.\, P_{L}^{a,b} \,.\, R^{a,b} .\; K^{a,b} .\frac{S_a}{S_b} \qquad (18)$$

where $P_{W}^{a,b}$ is the price of whiting.

For the Gillnet, Hook and Trap Sector the decomposition is as follows:

$$\theta_{CTS}^{a,b} = P_{G}^{a,b} \,.\, P_{S}^{a,b} .\, P_{Oth}^{a,b} \,.P_{F}^{a,b} \,.\, P_{L}^{a,b} \,.\, R^{a,b} .\; K^{a,b} .\frac{S_a}{S_b} \qquad (19)$$

where $P_{G}^{a,b}$ is the price of gummy shark and $P_{S}^{a,b}$ is the price of school shark.

Stock abundance calculation

The aggregated stock abundance was calculated following equation 16 using the following species for the Commonwealth Trawl Sector: orange roughy, blue grenadier, tiger flathead, blue warehou, silver warehou, school whiting, jackass morwong, ling, and gemfish. These species generally accounted for around 80 per cent of the sector's total catch and value. A separate trawl sector stock abundance was calculated by combining trawl catches for all of the above species with their stock abundances. A separate Danish seine sector stock abundance was also calculated using the same data for tiger flathead and whiting. These two species account for 90 per cent of Danish seine catches. For the Gillnet Sector, the stock abundances and gillnet harvests of gummy shark and school shark were used to calculate the aggregated stock abundance. These species, on average, account for around 80 per cent of the gillnet catch. The stock biomass estimates for these individual species were calculated by the CSIRO and were sourced from G Tuck and J Day (pers. comm., June 2010).

5 Results

Each sector's decomposition is presented as a table that lists the geometric mean of each index across all vessels in a given financial year. All indexes relate to the relevant reference vessel and provide information on how the characteristics of the average vessel in a year affected profitability relative to the performance of the most profitable reference vessel.

When comparing index values, if an index takes a value greater (less) than one, it implies that that index expands (contracts) the profit ratio. For netput indexes more specifically:

- an index < 1 indicates that the positive contribution of that netput's price to profit is less than what occurs in the reference firm
- an index > 1 indicates that the positive contribution of the output price to profit is greater than what occurs in the reference firm.

In the case of an output, an index greater than one might suggest that prices received for that output were higher (and therefore, more favourable) than what the reference firm was paid. In the case of an input, an index greater than one might suggest that prices paid for that input were less (and therefore, more favourable) than what occurred for the reference firm.

However, it should be noted that the degree to which a netput price index differs from a value of one reflects not only a firm's relative price for that netput (relative to the reference firm) but the share of that netput in the firm's variable profit. That is, an output price index that is less than one (indicating a lower price) will be smaller the greater that output's share in that firm's total output (or variable profit). Likewise, if an input price is greater than the reference firm's, its input price index will be further below one the greater its share in the total costs of the firm (or the larger the negative contribution it makes to variable profit). This interpretation is consistent with the concept that an output or input's relative importance to a firm's profitability depends not only on its relative price but its relative quantity. When a netput price index is equal to one, it indicates that the contribution of that netput to profit was similar to that of the reference firm.

Commonwealth Trawl Sector results

The most profitable Commonwealth Trawl Sector firm (after stock adjustment) that was selected as the reference firm was a trawl vessel sampled in 2008–09. The average index decomposition of all firms in a given year in the fishery are displayed in table 4. A single output is assumed and a combined stock abundance for both methods is used for the calculation of the stock index (S). In all years, the input price indexes for labour (P_L) and (P_F) are close to one, while the output price indexes (P_O) vary substantially over the period, between 0.27 and 0.58. This reflects less variation in input prices, particularly for labour, and, more importantly, the larger contribution to variable profit of outputs relative to inputs.

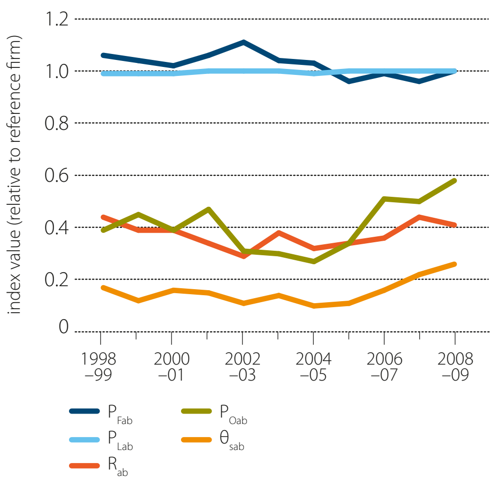
Figure b shows more clearly the change in profit over the period of analysis and the relative importance of the different drivers of profit. Stock-adjusted profit (θ_s) for the average vessel moves closer to that of the reference firm between 2005–06 and 2008–09. This is consistent with ABARES survey-based estimates of net economic returns to the sector. Once again, the two input indexes are shown to be close to one for the full time series, although the fuel price index does move from being greater than one to less than one after 2005–06. This suggests that, relative to the fuel prices experienced by the reference firm in 2008–09, lower fuel prices were more favourable and contributed positively to vessel profitability before 2005–06.

4 Index number profit decomposition results for the Commonwealth Trawl Sector average by year

financial year	no.	θ_s	θ	P	P_O	P_L	P_F	K	R	S
1998–99	30	0.17	0.20	0.42	0.39	0.99	1.06	1.09	0.44	1.17
1999–00	31	0.12	0.20	0.46	0.45	0.99	1.04	1.12	0.39	1.64
2000–01	27	0.16	0.17	0.40	0.39	0.99	1.02	1.08	0.39	1.07
2001–02	31	0.15	0.18	0.49	0.47	1.00	1.06	1.08	0.34	1.24
2002–03	19	0.11	0.10	0.34	0.31	1.00	1.11	1.04	0.29	0.93
2003–04	20	0.14	0.12	0.31	0.30	1.00	1.04	1.04	0.38	0.87
2004–05	22	0.10	0.10	0.28	0.27	0.99	1.03	1.07	0.32	0.98
2005–06	18	0.11	0.12	0.33	0.34	1.00	0.96	1.04	0.34	1.03
2006–07	15	0.16	0.20	0.50	0.51	1.00	0.99	1.08	0.36	1.26
2007–08	13	0.22	0.22	0.48	0.50	1.00	0.96	1.05	0.44	1.00
2008–09	13	0.26	0.26	0.58	0.58	1.00	1.00	1.11	0.41	1.00

Note: The geometric mean is used to average over the indexes. For any one vessel the profit decomposition 'adds up' across each index (equation (1) holds). In this table, this property will not hold as an average of the vessel indexes is shown. The reference vessel occurs in 2008–09.

b Key indexes for the Commonwealth Trawl Sector
average for all vessels by financial year



The two key factors behind the lower profits of all firms relative to the reference firm are the price of output (P_O) and the productivity index (R)—the two indexes that are the furthest from one and also show the greatest variability. The productivity index follows a slightly declining trend from 1998–99 to 2002–03, decreasing from 0.44 to 0.29, but then follows a slightly increasing trend, reaching to 0.44 in 2007–08, before declining slightly to 0.41 in 2008–09. These changes correspond with two significant periods for the sector. The first was a period in which total allowable catches in the sector were largely non-binding, which, as discussed by Elliston et al. (2004), promotes lower efficiency in a fishery managed with individual transferrable quotas. At the same time, and partly as a consequence of the latter, stocks were relatively low and catches were more difficult and costly to make as a result. The second period corresponds with significant regulatory and structural change, associated with reductions in the total allowable catches for key species in the sector (see Vieira et al. (2010) for further details) and the government-funded vessel buyback, which concluded in 2006–07. A key change in the productivity index was the immediate jump in the index after the buyback, from 0.36 in 2006–07 to 0.44 in 2007–08—an increase of 22 per cent.

The primary driver of the increase in the profit index is the change in the output price index. This is consistent with the aggregate price index in table 4 largely following movements in the output price index. After the output price index declined to 0.27 in 2004–05, the index followed a strong increasing trend and peaked in 2008–09 at 0.58. Given that 2008–09 is the same year in which the reference firm occurs, it suggests that most firms benefited to some degree from higher prices in 2008–09.

The decomposition of the output price index into its key components can provide greater insight into which species' prices have made an increasing contribution to profitability over time. However, given the different catch compositions associated with the two methods, separate species-level decompositions are presented for each method in the Commonwealth Trawl Sector in the following sections.

Trawl method

The same reference firm that was used in the aggregated decomposition was used for the trawl vessel decomposition. However, a separate trawl stock abundance was calculated and used for the stock index. The trawl decomposition results are displayed in table 5 and include indexes for the five key outputs: tiger flathead (P_{TF}), blue grenadier (P_{BG}), pink ling (P_{PL}), silver warehou (P_{SW}) and other species (P_{Oth}). The results reveal that the reference firm's higher profit was driven by the contribution of tiger flathead and other species to its profitability. Pink ling, blue grenadier and silver warehou (in order of importance) made far lower contributions to the vessel's profit.

C Stock-adjusted profit index and key output indexes for trawl vessels in the Commonwealth Trawl Sector
average per vessel by financial year

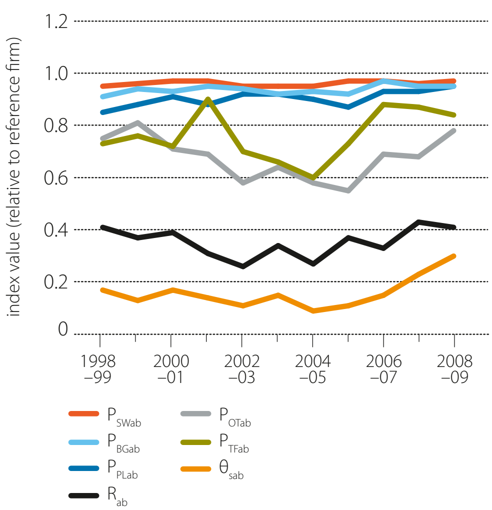


Figure c shows that the change in the stock-adjusted profit index and productivity index for trawl method vessels closely approximates that of the entire Commonwealth Trawl Sector sample shown in figure b. This reflects the larger number of trawl vessels relative to Danish seiners. Once again, the productivity index followed an increasing trend for trawl method vessels after 2004–05, increasing from 0.27 in 2004–05 to 0.41 in 2008–09.

The stock-adjusted profit index for the average vessel was at its lowest value (0.09) in 2004–05. In the same year, the price index for

5 Index number profit decomposition results for trawl vessels in the Commonwealth Trawl Sector

average by year

financial year	no.	θ	θ_s	P	P_{TF}	P_{BG}	P_{PL}	P_{SW}	P_{Oth}	P_L	P_F	K	R	S
1998–99	20	0.21	0.17	0.43	0.73	0.91	0.85	0.95	0.75	0.99	1.07	1.17	0.41	1.24
1999–00	21	0.22	0.13	0.50	0.76	0.94	0.88	0.96	0.81	0.99	1.05	1.21	0.37	1.77
2000–01	23	0.18	0.17	0.42	0.72	0.93	0.91	0.97	0.71	0.99	1.03	1.10	0.39	1.09
2001–02	25	0.19	0.14	0.54	0.90	0.95	0.88	0.97	0.69	1.00	1.06	1.12	0.31	1.31
2002–03	15	0.11	0.11	0.37	0.70	0.94	0.92	0.95	0.58	1.00	1.12	1.07	0.26	0.94
2003–04	14	0.13	0.15	0.35	0.66	0.92	0.92	0.95	0.64	1.00	1.05	1.08	0.34	0.86
2004–05	15	0.09	0.09	0.29	0.60	0.93	0.90	0.95	0.58	0.99	1.04	1.14	0.27	0.98
2005–06	13	0.12	0.11	0.30	0.73	0.92	0.87	0.97	0.55	1.00	0.96	1.06	0.37	1.02
2006–07	11	0.19	0.15	0.52	0.88	0.97	0.93	0.97	0.69	1.00	0.99	1.12	0.33	1.31
2007–08	6	0.23	0.23	0.47	0.87	0.95	0.93	0.96	0.68	0.99	0.94	1.16	0.43	1.00
2008–09	7	0.30	0.30	0.57	0.84	0.95	0.95	0.97	0.78	1.00	1.00	1.25	0.41	1.00

Note: The geometric mean is used to average over the indexes. For any one vessel the profit decomposition 'adds up' across each index (equation (1) holds). In this table, this property will not hold as an average of the vessel indexes is shown. The reference vessel occurs in 2008–09.

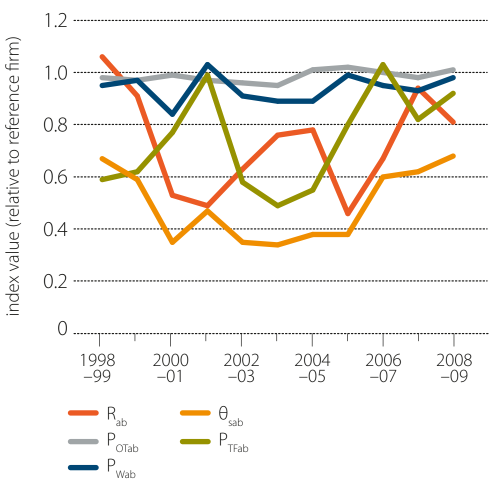
tiger flathead was also at its lowest value (0.60) and at its second lowest value for other species (0.58). This compares with the much higher values of 0.84 and 0.78 that occurred for each species in 2008–09, respectively. This represents a 40 per cent increase for the tiger flathead price index and a 34 per cent increase for the other species price index. The price index for pink ling also increased over four years, from 0.87 in 2005–06 to 0.95 in 2008–09 (a 9 per cent increase). However, this index had relatively lower influence on the profit index, as indicated by it being relatively closer to one. Accordingly, the blue grenadier and silver warehou price indexes remained close to one, which suggests a relatively small contribution to profit by these species.

Danish seine method

For the Danish seine decomposition, a new Danish seine reference vessel had to be selected given that the aggregated Commonwealth Trawl decomposition used an otter trawler as a reference firm. The most profitable Danish seine vessel was selected as the reference firm and operated in 2008–09. Table 6 contains the decomposition results, where the index of output prices has been decomposed into price indexes for tiger flathead (P_{TF}), whiting (P_W) and other species (P_{Oth}).

The index numbers reveal that the key netput that affected profitability was tiger flathead (P_{TF}), while productivity (R) was also an important driver. The stock (S) index for Danish seiners also increased substantially over the period, from 0.80 in 1998–99 to 1.00 in 2008–09, although this followed a peak of 1.05 in 2007–08. The impact of stocks on profit is represented by the difference between the indexes for profit (θ) and stock-adjusted variable profit (θs). For example, in 1998–99 the average variable profit index was 0.54, but once stock-adjusted, the index takes a value of 0.67.

d Key indexes for Danish seine vessels
average per vessel by financial year



The stock-adjusted profit index followed a declining trend before 2002–03 then stabilised between 2002–03 and 2005–06 (figure d). A 58 per cent increase then occurred between 2005–06 and 2006–07, from 0.38 to 0.60, followed by two smaller increases in 2007–08 and 2008–09. A key observation is that peaks in the productivity index (R) occur with troughs in the tiger flathead price index and vice versa. Whether this is evidence of productivity increases as a result of the response of vessel operators to lower tiger flathead prices cannot be tested here, particularly given the low annual sample sizes that make interpretation of the average indicators problematic.

6 Index number profit decomposition results for Danish Seine vessels average by year

financial year	no.	θ	θ_s	P	P_{TF}	P_W	P_{Oth}	P_L	P_F	K	R	S
1998–99	10	0.54	0.67	0.55	0.59	0.95	0.98	0.99	1.02	0.91	1.06	0.80
1999–00	10	0.49	0.59	0.59	0.62	0.97	0.97	0.99	1.01	0.91	0.91	0.82
2000–01	4	0.30	0.35	0.65	0.77	0.84	0.99	1.00	1.01	0.89	0.53	0.87
2001–02	6	0.44	0.47	1.01	0.99	1.03	0.97	1.00	1.02	0.89	0.49	0.93
2002–03	4	0.30	0.35	0.53	0.58	0.91	0.96	1.00	1.04	0.91	0.63	0.87
2003–04	6	0.30	0.34	0.42	0.49	0.89	0.95	1.00	1.02	0.92	0.76	0.87
2004–05	7	0.35	0.38	0.50	0.55	0.89	1.01	1.00	1.01	0.91	0.78	0.93
2005–06	5	0.34	0.38	0.80	0.80	0.99	1.02	1.00	0.99	0.94	0.46	0.90
2006–07	4	0.63	0.60	0.97	1.03	0.95	1.00	1.00	1.00	0.97	0.67	1.04
2007–08	7	0.64	0.62	0.73	0.82	0.93	0.98	1.00	0.98	0.94	0.94	1.05
2008–09	6	0.68	0.68	0.91	0.92	0.98	1.01	1.00	1.00	0.93	0.81	1.00

Note: The geometric mean is used to average over the indexes. For any one vessel the profit decomposition 'adds up' across each index (equation (1) holds). In this table, this property will not hold as an average of the vessel indexes is shown. The reference vessel occurs in 2008–09.

There was a jump in the productivity index between 2006–07 and 2007–08 immediately following the buyback. However, when compared with other movements in the productivity index over the period of analysis, and given the small sample sizes, it is difficult to conclude whether there has been an effect on productivity from the buyback. Danish seine vessel numbers declined only slightly between 2006–07 and 2007–08, from 17 to 16, so any immediate effect would have been relatively minor.

Gillnet Sector results

The most profitable (after stock adjustment) gillnet vessel was sampled in 2008–09 and was selected as the reference firm for the Gillnet, Hook and Trap Sector decomposition. The decomposition results are displayed in table 7 as the geometric mean of all indexes across all vessels sampled in each financial year. Although the most profitable firm was sampled in 2008–09, the most profitable year for the average vessel sampled was 1999–2000, when the stock-adjusted profit index was 0.44. The least profitable year for the average sampled vessel was 2005–06, when the stock-adjusted profit index had a value of 0.18.

7 Stock-adjusted profit index and key output indexes for the Gillnet Sector

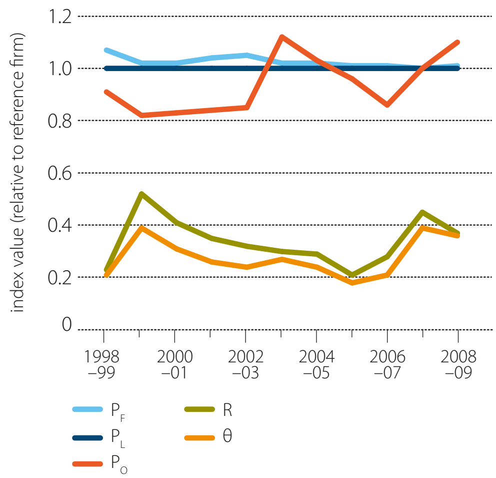
average for all vessels by financial year

financial year	no.	θ_s	θ	P	p_O	p_L	p_F	K	R	S	R_s
1998–99	11	0.23	0.21	0.98	0.91	1.00	1.07	0.92	0.23	0.88	0.26
1999–00	9	0.44	0.39	0.83	0.82	1.00	1.02	0.9	0.52	0.90	0.59
2000–01	12	0.33	0.31	0.84	0.83	1.00	1.02	0.89	0.41	0.95	0.43
2001–02	9	0.27	0.26	0.87	0.84	1.00	1.04	0.85	0.35	0.96	0.37
2002–03	12	0.24	0.24	0.89	0.85	1.00	1.05	0.85	0.32	1.00	0.32
2003–04	6	0.27	0.27	1.14	1.12	1.00	1.02	0.79	0.30	1.03	0.3.0
2004–05	6	0.24	0.24	1.05	1.03	1.00	1.02	0.79	0.29	1.04	0.28
2005–06	8	0.18	0.18	0.97	0.96	1.00	1.01	0.89	0.21	1.02	0.2.0
2006–07	9	0.21	0.21	0.87	0.86	1.00	1.01	0.87	0.28	1.01	0.27
2007–08	7	0.39	0.39	1.00	1.00	1.00	1.00	0.87	0.45	1.00	0.45
2008–09	7	0.37	0.36	1.12	1.10	1.00	1.01	0.87	0.37	0.97	0.38

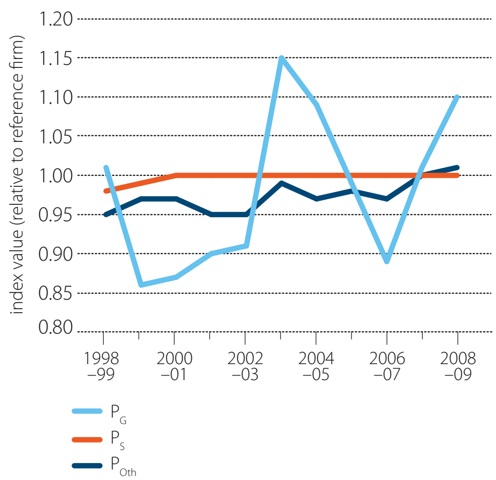
Once again, output is the main contributing netput to profitability, with fuel and labour having indexes close to or equal to one. However, when compared with the two fishing methods in the Commonwealth Trawl Sector, the output price index is relatively closer to one in the Gillnet Sector. Additionally, in four years (2003–04, 2004–05, 2007–08 and 2008–09) the average vessel's output prices made a contribution to profitability that was equal or greater than what occurred for the reference firm, as indicated by an index value of one or greater. In the Commonwealth Trawl Sector, the output price index always had a value less than one.

Given the relatively lower contribution of output prices to profitability, the major driver of profitability changes over the period of analysis was the productivity index—movements in profitability appear to largely follow movements in the productivity index (figure e). It should

e Stock-adjusted profit index and key output indexes for the Gillnet Sector
average for all vessels by financial year



f Decomposed output price indexes for the Gillnet Sector
average for all vessels by financial year



also be noted that the contribution of productivity to the reference firm's profit relative to other vessels sampled was substantially higher, as indicated by the productivity index always having a value considerably less than one—it averaged 0.33 over the 10-year period.

The Gillnet Sector and Commonwealth Trawl Sector both saw a sharp increase in the productivity index following the buyback, from 0.28 in 2006–07 to 0.45 in 2007–08—an increase of 61 per cent. The major effects of a vessel buyback that are likely to have an immediate effect on vessel-level performance are: an increase in average efficiency with the removal of less-efficient vessels leaving fewer, more efficient vessels to harvest the resource; and an improvement in catch rates with the rebuilding of depleted stocks (Vieira et al. 2010). The relatively constant stock index is consistent with stable catches and total allowable catches in the sector and suggests that the buyback has not had an effect on stocks in the Gillnet Sector. Therefore, it is likely that the key reason behind the vessel-level productivity improvement shown here is fewer vessels competing for the same resources.

Although it has already been noted that output prices contributed less to profitability in the Gillnet Sector than in the Commonwealth Trawl Sector, the decomposition of the output price index into key outputs can provide more information on the sector's drivers of profit (figure f). Given the dominance of gummy shark in the sector's total catch, gummy shark price fluctuations are the most important determinant of profitability, with school shark and other species having a relatively minor influence.

6 Discussion and conclusions

Some limitations

The index number profit decomposition approach is a relatively new method that offers a way of assessing a fishery's economic performance. As has been demonstrated, its usefulness lies in its ability to represent the relative importance of key drivers to changes in profitability over time. However, there are some issues associated with the way the method has been used here.

The choice of reference firm is a fundamental component of the analysis and has a major bearing on the usability of the results. The approach taken here was to use the most profitable firm as the reference firm. This was problematic in the case of the multi-species analysis of the trawl method in the Commonwealth Trawl Sector, as the reference firm was a largely specialised firm, focusing on tiger flathead. Therefore, the analysis was limited by not being able to represent the key drivers of profitability for a vessel that specialised in other key species. Additionally, ABARES data suggest that blue grenadier prices have increased in a similar proportion to tiger flathead over the same period, but this was not revealed in the analysis given that the reference firm caught little blue grenadier. The choice of reference vessel automatically defines and/or restricts what the decomposition can show. For this reason, use of the average vessel in the most profitable year—particularly in the multi-species context—may be better. This would allow firm-level comparisons to be made using a reference firm that is more representative of all vessels in the sector and not just relevant to firms that have similar output compositions.

Another issue is the measure of capital used to calculate the fixed input index and, further, its effect on the productivity index. Previous authors have assumed a single fixed input, the quantity of which is measured by vessel length. While the assumption of a single capital input simplifies the decomposition to some degree, the link between boat size and its effect on a vessel's harvest production is disputable. ABARES survey data for both fishery sectors include estimates of the market value of the boat, the year of manufacture and the replacement cost of capital items on the vessel. Applying a capital price index to these data could be a more relevant approach for incorporating the fixed input into the decomposition and, more importantly, the productivity index. However, the author acknowledges issues with measuring capital that have been discussed by previous authors (Griliches 1963; Jorgensen 1996; Diewert and Lawrence 2000).

Furthermore, analysis of the productivity indexes in the boat-level decomposition data reveals that vessels that spent a relatively small amount of time operating in a given year had substantially lower levels of productivity, while only high levels of productivity were attained by vessels that spent more time fishing per year. Such a finding indicates that there may be an issue with vessel scale (in terms of each vessel's time input into the fishery) that affects a vessel's productivity index value.

Fox et al. (2006) discuss the issues with assuming a single price for a multi-output sector, which has been the most common approach when applying the index number profit decomposition method to fisheries. The approach taken here has provided both a single output decomposition and a multi output decomposition using average price data for the relevant sector and making adjustments given each vessel's catch (by key species group) and total reported revenue. This approach captures both the relative price differences between firms (also shown in the single output analysis) but also captures the price differences between different outputs (species) over time. The relevance and theoretical validity of using average price data to decompose output price changes into key output categories needs further investigation. However, the values of all other indexes as well as the aggregated netput price index remain unchanged in the multi-output context relative to the single-output case. This demonstrates that the actual results do not change in the multi-output context, just the detail at which the results are reported changes. The greater level of detail presented in the multi-species analysis here has provided greater insights.

Excluding some inputs and applying generic price data series to fuel costs and labour costs means the method tends to provide information that can be described as output and productivity biased, with limited information on the input side of a firm's production process. Indeed, the share of revenue in a profitable firm's variable profit is always going to be greater than its costs. Therefore, the contribution of output price fluctuations to profit will always be represented as having a stronger influence on profit given the nature of the index calculation. Anecdotal evidence and ABARES survey-based estimates of financial performance for the Commonwealth Trawl Sector (Perks and Vieira 2010) suggest that increases in fuel prices had a major effect on vessel profits in 2007–08. However, the negative contribution of fuel to variable profit is difficult to discern from the decomposition results for both sectors.

One option to improve the representativeness of the boat-level decomposition data for fuel is to apply regional fuel price data series according to where a vessel operates. This approach was taken by Fox et al. (2003). This provides a clearer picture of how fuel prices paid by vessels may vary throughout the fleet. For labour, most crew and skippers in both fishery sectors are paid a share of revenue. This means that if a price of labour was derived from a vessel's revenue share payment to crew (total labour payment divided by labour quantity) it would exhibit a positive linear relationship with revenue. It is likely that share payments to labour show some variation across firms and over time. This means that labour payments could vary across firms, which may influence the consistency of the profit measure over firms and time. Therefore, the approach taken to apply an average wage to each vessel's measure of labour quantity is preferred.

There may also be a question over the stock biomass estimates used in the analysis and their relevance to the performance of vessels in the fishery. The stock assessment data available for Commonwealth Trawl Sector species was only in the form of total biomass estimates (which was used) and spawning biomass, while for the Gillnet Sector it was in the form of biomass of fish aged greater than one year. Ideally, for the purpose of determining the contribution of stock biomass to a vessel's profitability, the biomass of fish that fall within the population or size parameters caught by the relevant gear is required. The relevance of the biomass estimates used in each sector to the population that is actually targeted and caught is likely to vary across species. For example, eastern school whiting, which are caught in the Commonwealth Trawl Sector, recruit into the fishery at between 2 and 3 years of age, while orange roughy recruits into the fishery at between 24 and 42 years of age (Stobutzki et al. 2010b). This demonstrates that the relevance of biomass estimates used in the analysis will depend on the age a species recruits into the fishery and the age cohort structure of the biomass estimate that is being used. In the absence of any other data about stocks, the data that were available and used provide more information about the basis of changes in profitability than would otherwise be possible.

Comparisons with previous results

Different approaches to dealing with the issues outlined above can affect the final results of a given decomposition. For this reason, comparisons with previous results can be difficult to interpret, but can still be insightful. The results presented in Fox et al. (2006) and Grafton and Kompas (2007) for the Commonwealth Trawl Sector bear both similarities and differences to the results presented here.

Fox et al. (2006) analysed the Danish seine sector, otter trawl sector and the offshore trawl sector, which is excluded here. Their analysis period is from 1997 to 2000, which only overlaps with two years of the current results. This, combined with the inclusion of the offshore trawl sector, limits the comparisons that can be made. However, one key similarity between the two papers is that in both cases productivity is shown to increase following a vessel buyback (in the Fox et al. (2006) case, a buyback occurred in 1997). They also show that productivity and the price of output are key contributors to profit, as is shown here.

A major difference is that Fox et al. (2006) estimate that the labour price index is the major contributor to the most profitable reference firm's high profit—the labour index averages 3.95 over the four years. This contrasts with the current results, where the labour index is always close to one given the use of an average wage series that results in labour always having a small profit share. Fox et al. (2006) in comparison use the share payments made to crew reported in ABARES survey data to determine the labour price.

ABARES survey data on labour include both a dollar amount paid to the skipper and crew as well as an imputed cost for any unpaid work undertaken by vessel owners and their family members. It is possible that Fox et al. (2006) have excluded this imputed cost and that the reference firm has a low labour price as a result. Indeed, their estimated labour price index for individual boat-level decompositions reaches as high as 51.2 (Fox et al. 2006, p. 197). Another possibility is that their assumed reference firm is an offshore trawler, which may have very different labour characteristics relative to the vessels focused on here. Whatever the case, the dramatic difference between the contribution of the labour index to profit between the two sets of results means that the relative contributions of other profit drivers will also be inconsistent.

Grafton and Kompas (2007) took the decomposition results from Fox et al. (2006) for the period 1997 to 2000 and added new results up to 2005. Their results for the period that overlaps with Fox et al. (2006) are identical and were not updated. Given that Grafton and Kompas (2007) exclude the offshore trawl sector and also assume the average vessel in 2000 as the reference firm (and not the most profitable vessel in 2000 assumed by Fox et al. (2006)), interpreting their full time series of results may be problematic. Ignoring this, with the exception of the labour price index, which once again takes a high value (ranging between 3 and 3.3 from 2001 to 2005), all other trends between 2001 and 2005 are consistent with the results presented here. The output price index declines and the productivity and profit indexes are stable but relatively low.

Concluding remarks

The method used here has provided some important insights into the key driving factors behind profit changes for both sectors. For example, the recent buyback appears to be a major driver behind increased profits since 2006–07 in both fisheries. This has been realised through an improvement in vessel productivity, with fewer, more efficient vessels remaining after the buyback. These vessels continue to harvest similar resources and, therefore, are able to achieve higher output from the inputs they invest in the fishery. This improvement in productivity in the post-buyback period is consistent with productivity improvements in the same two sectors observed by Vieira et al. (2010) and Perks and Curtotti (2011). For the Commonwealth Trawl Sector, the results were also able to demonstrate how average vessel productivity (and profitability as a result) were lower in a period when the management instrument (output controls in the form of individual transferable quotas) was not being used in conjunction with appropriate management settings. That is, total allowable catches were set too high and were non-binding.

For the Commonwealth Trawl Sector, the two key factors behind the lower profits for all firms, other than the reference firm in 2008–09, were the price of output (P_O) and the productivity index (R). At the sub-sector level, tiger flathead price changes were the key contributor (other than productivity) to changes in profitability. For the trawl method, it was also shown that the other species output category was a key influence on vessel-level profit.

Observations about the MEY objective can also be made for recent years. For the Commonwealth Trawl Sector, substantial profit improvements have occurred since 2005–06. The key drivers of these improvements have been output price increases and increases in vessel-level productivity, particularly since the buyback. At the same time, stocks are higher than what they were in low profit years (2002–03 to 2005–06). This has occurred with a large reduction in the amount of capital (vessels) invested in the fishery through the exit of vessels before the buyback (largely in response to low returns) and then through the buyback. Although price increases have been a major factor behind the improvement in profitability, the above factors suggest that, since 2005–06, the sector has been moving toward rather than away from MEY.

For the Gillnet Sector such an interpretation is made more difficult by the sector experiencing positive net economic returns for the past nine financial years. However, given that the improvement in vessel-level profitability since 2005–06 has occurred in conjunction with increases in vessel-level productivity, a reduction in vessel numbers and a subdued impact from output prices, it may be the case that this sector is also moving closer to MEY.

As has been shown, the index number profit decomposition approach is suited to providing information about the historical performance of vessels in a fishery. It can also be used to show how under different scenarios—for example, with higher stock levels—vessel profitability could vary (Kompas et al. 2009). However, the approach is not able to fulfil the role of a bioeconomic model whereby a given harvest level can be determined that is most likely to result in the fishery achieving MEY. Despite this, and in the absence of a bioeconomic model, it can provide decision-makers with more information about whether a fishery's current operating environment is conducive to relatively high profits. When used together with other indicators of a fishery's economic performance, the approach provides policymakers with more information about the effect of previous decisions and how current decisions will affect the future profitability of managed fisheries.

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