Industrial Organisation in the South African Deep Sea Hake Trawl Sector: A Taxonomy

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This paper presents a taxonomy of industrial organisation in the South African deep sea hake trawl sector. The primary sources of economies of scale and scope in the sector are identified and modelled. These multiple sources combine in the hake trawl industry to make large-scale, vertically integrated and diversified production beneficial. Policy implications of this industrial organisation are considered. In particular, whilst competition amongst many smaller firms typically has prima facie *appeal, this is unlikely to be beneficial in hake trawling, given the risks faced by small firms and the efficiency gains made possible by large-scale and vertically integrated operations. A further implication is that if further transformation is to be achieved within the sector, it should come from within established firms rather than through the fragmentation of existing quota shares.*

Introduction

The South African deep sea hake trawl sector provides domestic and international markets with a wide variety of fish products. These products include fresh and frozen hake – processed and packaged in a variety of forms – and other value-add products such as fish meal and animal feed (Benguela Current Large Marine Ecosystem [BCLME] Project LMR/SE/03/02, 2006). The extensive product choice given to consumers is made possible by the presence of large, industrial firms that are able to exploit the economies of scope and scale that exist in deep sea hake trawling, processing, and distribution. These complex and interrelated production and distribution processes which characterise this sector are the subject of this paper. This paper investigates and models the benefits and costs of scale, vertical integration, and diversification which are present in the industry.

The main findings of this paper are as follows. Hake trawling is inherently risky, particularly in South Africa. The economic risk is particularly acute for small operators. As a result, companies have found various ways to diversify operations to lower this risk. These diversification strategies include

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increasing fleet size, having multiple vessel types, expanding product range, and supplying to both foreign and domestic markets. Large companies are in the best position to diversify their operations across these dimensions. A further finding is that there are extensive scale and scope economies in deep sea hake trawling. The sophisticated catching and processing operations necessary to supply reliably and competitively, especially in retail markets, require extensive investment in capital and knowledge. Further, the production techniques for many hake products require similar skills and capital, and so there are cost savings available to firms which produce a number of related products. The implications of these findings is that a given total allowable catch (TAC) is able to generate more value and result in greater economic development if the industry is freely and securely able exploit these economies of scale and scope and diversification benefits over time. The presence of these underlying industrial forces also explains the tendency of the industry to consolidate, despite recent attempts by policymakers to fragment quota shares.

These findings are demonstrated formally by modelling the important industrial processes in the sector. These models demonstrate how large, vertically integrated, and diversified firms are better able to spread risk and add more value to quota. Whilst the existing literature has often accepted these *conclusions* – although this is not universal – few attempts have been made to describe *formally* these industrial forces underlying the industry's operations. That is the niche this paper fills. This theoretical analysis is supported by the existing evidence. Although data with which to test these models are limited, the models have been made to align as closely as possible with (i) available evidence in the literature, and (ii) evidence provided through interviews with individuals in the deep sea hake trawl industry.[2]

Before proceeding, it is worth making a comment about the scope of this paper. This paper focuses only on the *deep sea hake trawl* sector, for three reasons: (i) the hake sector is South Africa's most important fishery, accounting for about 50% of the value of South Africa's fish market; (ii) deep sea trawling accounts for between 80% and 90% of the hake sector; and (iii) there is a large degree of heterogeneity (in methods, industrial organisation, and markets) across different sectors within the fishing industry (Cooper *et al*., 2014; BCLME Project LMR/SE/03/02, 2006). Thus, general statements about the fishing industry as a whole are unlikely to be specific enough to be true of any individual sector within the industry. By narrowing the scope, a more careful and informative analysis is made possible. Importantly, this implies that findings of this paper are *not* representative of the South African fishing industry as a whole.

This paper proceeds as follows. Section 1 offers a history of the hake trawl sector and a summary of the sector today. Section 2 models the primary ways in which hake trawl firms spread risk through diversification and scale. Section 3 lists and discusses the most important sources of scale economies. Section 4 considers other consequences of concentration. Section 5 discusses policy implications, before concluding remarks are offered.

[2]See Appendix A for details of interviews conducted.

1. Historical Context and Recent Trends

1.1. A brief history of deep sea hake trawling in South Africa

The following discussion draws heavily on Bross's (1998) comprehensive history of the deep sea hake trawl sector. Where other accounts are used, these are cited explicitly. The South African hake trawl industry emerged at the beginning of the 20th century, when Irvin and Johnson – first separately, but later in a reluctant partnership – began trawling operations off the Cape coast. The trawling sector sprang up quickly, in modern industrial form, under the guidance of Irvin and Johnson. Irvin and Johnson (I&J) became a *de facto* monopoly, and remained so until 1960.

Hake stocks remained relatively underexploited during this time. New firms did attempt to enter the sector, but invariably either failed or were absorbed into I&J's operations. I&J was able to maintain its monopoly position largely because of economic conditions specific to South African fishing; in particular, (i) the high risk of operations (I&J faced near-bankruptcy on a number of occasions), and (ii) the large-scale capital investment necessary to profitably process and distribute hake. South Africa's local market was relatively small, and most of the market was located inland, at the Witwatersrand mines. This meant that getting a perishable product like hake to market necessitated extensive capital investment, and required large volumes to spread the associated overheads. These factors made it somewhat inevitable that a large-scale, industrial, and concentrated industry emerged from the earliest years.

During the 1960s and 1970s the industry changed dramatically. Foreign trawlers entered South African waters to trawl the relatively underexploited fishing grounds (Ponte & Van Sittert, 2007). New domestic firms entered the industry, particularly spurred by advances in processing and distribution. Hake stocks (and, correspondingly, catch per unit effort) declined, and overseas markets previously dominated by South African product were disrupted by foreign firms.

In response to these challenges, in 1977 the government declared an Exclusive Economic Zone (EEZ) extending 200 miles offshore, in which only South African firms could fish (Ponte & Van Sittert, 2007). Further, in 1979 the South African government introduced managed fishing rights for the first time (Ponte & Van Sittert, 2007). They did so by deciding on an annual Total Allowable Catch (TAC), and then allocating each firm a proportion of this TAC (i.e. a quota). At the time of the first quota allocation in 1979, I&J and Sea Harvest together controlled 81.2% of the market, as measured by their joint share of the TAC. The level of concentration declined in the industry between the initial quota issue and 1990, as at least eleven new firms were granted fishing rights during this period.

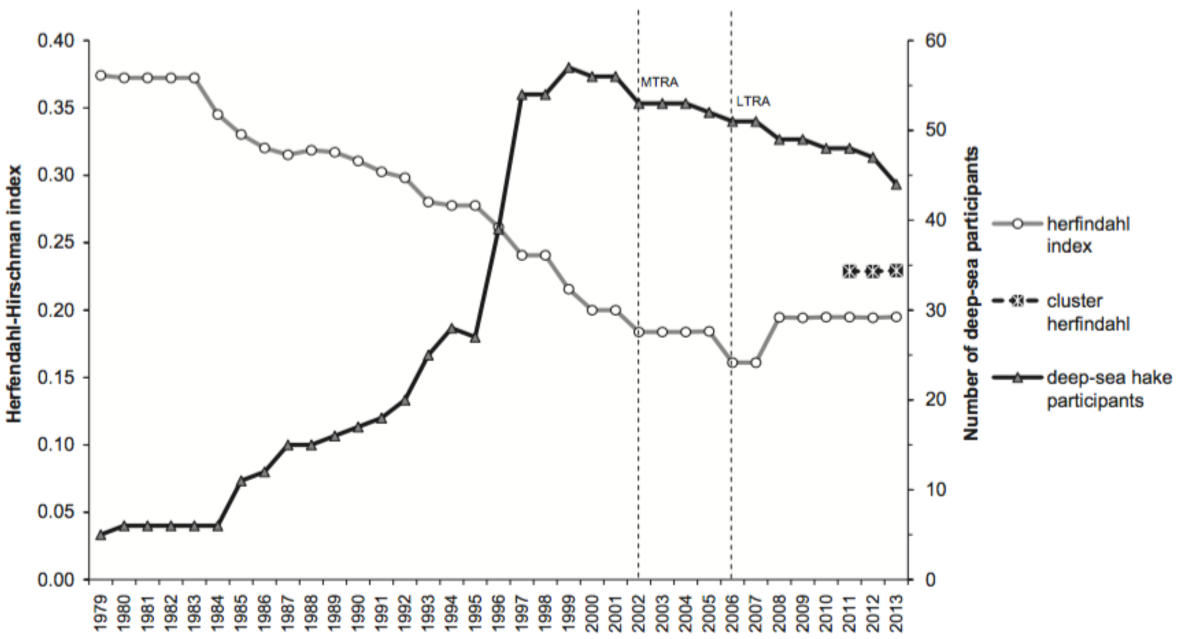
From 1990 to 1998, the Quota Board oversaw quota allocations, and during this time the trend of deconcentration continued. After the first democratic elections in 1994, transformation of the hake industry became an important policy topic. Initially, through the Reconstruction and Development Programme (RDP), new small firms owned by historically disadvantaged individuals (HDIs) were introduced (Isaacs *et al*., 2007). From 1996, the Growth, Employment and Redistribution (GEAR) framework focused more on market-oriented economic policy for export-led growth (Isaacs *et al*., 2007). For hake fisheries, this meant that transformation of established companies through incentive schemes, rather than transformation through the introduction of small HDI-owned firms, became the favoured policy position (Isaacs *et al*., 2007).

In recent years, however, there have been some attempts to shift policy towards back towards external transformation (i.e. transformation through the introduction of small HDI-owned firms). In 2005, before the first issue of long-term fishing rights, Marine and Coastal Management (MCM) announced a plan to allocate at least 10% of the quota to small firms, and a further 10% according to transformation scores (Van Sittert *et al*., 2007). This plan was later watered down, but further talk of external transformation has followed. More recently, Mnisi and Lekezwa (2014) argue that the hake fishing industry should be fragmented further when long-term rights are reissued in 2020, to allow for transformation and increased competition. It is within this context that section 6 of this paper addresses policy issues within the industry.

1.2. The Deep Sea Hake Trawl Sector Today

The hake trawl sector contributes over 50% of the value of South African fisheries, 64% of which was exported in 2013 (Cooper *et al*., 2014; South African Deep Sea Trawling Industry Association [SADSTIA], 2013a). Figure 1 traces the changes in the number of deep sea hake trawl firms and the concentration levels in the sector. In 2012, 49 entities held rights to extract deep sea hake having risen from 21 rights-holders in 1990 (Cooper *et al*., 2014). In 1992, the 5 largest quota holders controlled 92% of the quota, but by 2002 this had fallen to under 74% (Nielsen & Hara, 2006). This suggests that there has been a tendency – driven by quota allocation policy – to fragment the sector. In 2013 the Herfindahl-Hirschman Index (HHI)[3] at the rights-holder level was 0.20 (Cooper *et al*., 2014).

Figure 1 – Participants and concentration in the deep sea hake trawl sector, 1979-2013. Source: Cooper *et al.* (2014).



[3] HHI is a measure of industry concentration obtained by summing squared market shares across all firms. Algebraically, for n firms in the hake trawl sector, each having a quota share of Q_i:

$$HHI = \sum_{i=1}^{n} Q_i^2$$

If the sector is a monopoly, then HHI=1. If the sector consists of many firms, each having a very small share of the TAC, HHI will be close to zero.

However, coupled with this fragmentation at the quota level, there has been a slow but steady tendency for the deep sea hake trawl sector to consolidate into bigger operating *clusters*. Cooper *et al*. (2014) found that rights-holders had consolidated into 9 operating clusters. These clusters were formed both horizontally and vertically. In 2013 the largest 5 clusters controlled about 75% of the market (Cooper *et al*., 2014), and the HHI at the cluster level is 0.23 (as opposed to 0.20 at the rights-holder level). The industry today is thus more concentrated than the rights-holder numbers suggest. Despite the trend of deconcentration at the level of rights-holders, what remains important from an economic perspective is the *de facto* operational size – and here there has been a tendency to consolidate rather than fragment. It is the 9 operational clusters that are of particular interest in this paper's analysis, since a cluster operating as single economic unit is able to exploit economies of scale and scope, irrespective of the number of rights-holders underlying this cluster.

Although relatively few clusters are in operation, heterogeneity in business models does exist. These can be broadly separated into three categories. First, there are smaller firms which operate as catch-and-sell fishers, mainly (if not entirely) supplying the domestic market with minimally processed hake. Second, medium-sized firms operate as wholesalers, serving both domestic and international markets. For these firms, processing is limited, and is used largely as a value-add for leftover catch not suitable for selling in wholesale form. Third, large firms (two exist in the industry, and account for more than 60% of the volume) have sophisticated and vertically integrated operations which process hake mainly for retail markets in South Africa and abroad (Cooper *et al*., 2014).

This discussion may be summarised as follows. The hake trawl industry has historically been concentrated. Despite recent attempts to fragment quota, there has been a tendency to consolidate into larger operating clusters. The industry today is still dominated by a few large players, but has become relatively less concentrated. The analysis that follows attempts to classify industrial organisation in a way consistent with these historical and contemporary trends.

2. Modelling Risk in Deep Sea Hake Trawling

In this section, two theoretical models are outlined, each of which demonstrates that diversification and scale allows firms to lower their exposure to the risk inherent in hake trawling. The first model is a statistical model, and the second is an adaptation of modern portfolio theory. Evidence in support of these models is provided, and plausible ranges of parameter values in each model are discussed.

2.1. Catch Variability

There is a high degree of variability in daily catch in deep sea hake trawling, even after controlling for vessel size and type, and crew characteristics (Sauer *et al*., 2003). The most important determinants of catch variability identified by industry participants are weather conditions, maintenance levels, and fluctuating stock concentrations in trawl grounds. This section develops a model which demonstrates formally two related conclusions resulting from this natural variability in catch: (i) the catch variability in trawling creates risk for trawling firms, which can be costly or lead to failure; and (ii) this catch variability can be mitigated by scale: as fleet size increases within a given company, the average variability of catch *per trawler* declines.

Suppose that a firm operates one trawler, and that this trawler can only make one trip per period. Further, suppose the total cost per trip is a constant (i.e. not a function of catch):

$$TC = z \tag{1}$$

This trawler catches an average tonnage of hake per trip, *f*, but there is variation about this average:

$$Catch = f + u \tag{2}$$

where

$$u \sim N(0, \sigma^2) \tag{3}$$

Thus, *u* is a stochastic term which encapsulates the variation in catch during a given trip.[4] Assume for the present that the market price per ton of landed hake is constant and equal to *P*. Then total revenue is given by:

$$TR = P(f + u) \tag{4}$$

By (1) and (4), total profit is given by:

$$\Pi_1 = P(f + u) - z \tag{5}$$

Taking the variance of both sides, we get the variance in the company's profit stream:

$$\text{var}(\Pi) = P^2\sigma^2 \tag{6}$$

Thus, an individual trawler can expect profits to vary, where this variance is a function of the market price and the variation in catch.

Now, in contrast to this, suppose a company or partnership has *n* trawlers, where for comparability each of these trawlers is identical to the trawler previously discussed. If we assume again a trawler can make one trip per period and that total cost per trip is a constant, then the total cost of operating these *n* trawlers is:

$$TC = \sum_{i=1}^{n} z = nz \tag{7}$$

Assuming this company faces the same market price, *P*, we have total revenue as follows:

$$TR = \sum_{i=1}^{n} P(f + u_i) = nPf + P\sum_{i=1}^{n} u_i \tag{8}$$

where each of the u_i are independent and identically distributed (iid):

$$u_i \sim N(0, \sigma^2), \quad i \in \{1, 2, ..., n\} \tag{9}$$

By (7) and (8), total profit is given by:

$$\Pi_n = nPf + P\sum_{i=1}^{n} u_i - nz \tag{10}$$

Dividing by *n* on both sides, so that we are dealing with the average profit *per trawler* (and thus making our expression comparable to (5)), and taking the variance of both sides, we have:

[4] The assumption of normally distributed catches is not crucial, but is plausible in the case of fishing. The results of this model are robust to *any* distribution with a well defined mean and variance.

$$\text{var}(\frac{\Pi_n}{n}) = P^2\ \text{var}(\frac{\sum_{i=1}^{n} u_i}{n}) \tag{11}$$

Simplifying, and using that the u_i's are iid, we get:

$$\text{var}(\frac{\Pi_n}{n}) = \frac{P^2\sigma^2}{n} \tag{12}$$

Comparing (12) and (6), note that the variance term in (12) is necessarily smaller than the variance term in (6), when n is greater than 1. That is:

$$\frac{P^2\sigma^2}{n} < P^2\sigma^2\ , \quad \forall n > 1 \tag{13}$$

Further, as n increases – i.e. a firm increases fleet size – this variance declines. Indeed, in the limit this variance tends to zero. Thus, although firms face risk due to variable catch, all of this risk can (in theory) be mitigated by scale. In the context of the South African system of quota allocations, these two results imply that sharing quota amongst fewer participants allows a given TAC to produce a more stable flow of value to individual shareholders, with lower risk of company failure. This is an important finding in the context of current policy debates. The policy implications of this are dealt with in greater detail (and synthesised with other considerations) in section 5.

Three additional issues can be added to this conclusion, which reinforce the result that scale is beneficial in the catching phase of deep sea trawling. First, the costs of owning and maintaining vessels are a major barrier to entry and expansion. Small operators tend to have older and less well maintained boats. This is likely to exacerbate the variance in catch experienced by small operators. In the model above, this can be incorporated as a higher σ^2 term for the one-trawler operator. Second, small operators are unlikely to face a constant market price, which was assumed. In fact, small-scale sellers are likely to experience relatively higher variation in the price their product fetches, for three reasons: (i) they are likely to sell more of their catch fresh, and fresh hake is perishable, (ii) small-scale producers are largely unable to process and store their catch, and so cannot smooth revenues with efficient working capital management, and (iii) small-scale producers do not have the sophisticated supply chains which bring stable volumes and prices. The third issue which makes being a small operator relatively more difficult is that the catch variability discussed above is not limited to short-term (i.e. per trip) catch variability. Hake stocks tend to vary over the longer-term (in roughly 10 year cycles), and so firms face catch risk over this longer time period as well. These three factors drive a further wedge between the risk faced by the small-scale operator relative to the large-scale operator, and so reinforce the conclusions reached above.[5]

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[5] One technical comment about the form of the above model is in order. It was assumed that trawlers incur a given *cost* in order to catch a variable *quantity* of hake. However, a different form of this model is possible. It could be assumed that trawlers look to catch a given quantity of hake, and incur a variable cost in doing so. In this form, when conditions are adverse, trawlers may incur a relatively high cost to fill their holds. Here, variability would be on the cost side (rather than the quantity side), and it is this variable cost that results in profit variability. This is the dual form to the problem presented above, but the results are robust to the model being presented in the dual form: the variability of profit streams diminishes with scale.

2.2. Diversification across Vessel Type, Product Range, and Market

Not only can scale be used to diminish risk in hake trawling, as was shown above. Hake production can also be *diversified* across a number of dimensions, further allowing the spreading of risk. This section models these diversification benefits, and discusses the three most important diversification opportunities firms have: vessel type, the number of products produced, and the market targeted. Firms are modelled as constrained profit maximisers that balance risk and profitability considerations, subject to (i) meeting their quota allocation and (ii) the exogenous conditions prevailing in operations and markers at the time.

Hake is typically trawled by two vessel types: wetfish trawlers and freezer trawlers. In 2013, 25 freezer trawlers and 27 wetfish trawlers were active in the sector (SADSTIA, 2013b). Wetfish trawlers store catch on ice, and leave hake unprocessed on the vessel. Hake caught by wetfish trawlers is processed on-shore before being distributed to market. Freezer trawlers process hake on the vessel, although the product range is limited relative to on-shore processing capabilities (BCLME Project LMR/SE/03/02, 2006). Freezer trawlers are advantageous in that extracted quota can be delivered to market relatively quickly upon the vessels' return to shore. Having both freezer and wetfish trawlers allows a company greater working capital flexibility, and expands the range of products into which landed hake can be processed.

Further, wetfish and freezer trawlers tend to be associated with different cost and revenue structures, and so incorporating both techniques into production allows the risk in each production technique to be mitigated. Firms diversified across vessel type are thus exposed to an additional decision variable through which to optimise trawling activities, subject to the prevailing operating environment.

The importance of firms being able to spread risk and lower costs through diversifying across trawler types was illustrated in the Namibian hake trawl sector in the first decade of this century. Quota were allocated separately for each type of trawling (wetfish or freezer). Wetfish trawling was relatively unprofitable at that time, and so firms allocated wetfish quota operated inefficiently relative to firms allocated freezer quota (BCLME Project LMR/SE/03/02, 2006). Further, the differences in profitability were substantial: Japp and Steenkamp (2004) estimated that the profit per ton for wetfish-trawled hake was N$-2580 and for freezer-trawled hake was N$380. This relative profitability is determined by exogenous factors such as the fuel price, labour costs, electricity costs, and the exchange rate. Thus, giving firms a decision variable through which they can adjust production given these exogenous shocks is important in maximising the efficiency with which a given TAC is extracted.

Processing landed hake into a number of different *products* is the second method of diversification. Generally, the best quality wetfish-trawled hake is sold fresh, although in large companies this is relatively low volume. In large and vertically integrated companies, remaining hake is processed and made into a variety of frozen hake products (between 100 and 150 products, in the case of the largest companies). Hake not fit for consumer products is processed into fish meal and other value-add products (BCLME Project LMR/SE/03/02, 2006). In this way, wastage is minimised through processing.

The benefits that accrue to firms from the processing described above take on at least three forms. First, transforming the one input into a variety of products allows the risks associated with each market to be somewhat mitigated. Second, having a large number of products into which hake can be processed (and having control over the volume of each product produced) provides firms with another decision variable through which production can be optimised: ratios of products produced can be adjusted depending on the relative market conditions prevailing in each individual market. Third, the production techniques used in processing are often similar, and involve similar capital and labour inputs. Thus, the production of multiple products is associated with economies of scope: producing multiple goods means that each individual good is produced at a lower average cost than it would be if it was produced alone (this is discussed in greater detail in section 3.1).

The third dimension of diversification is market location. Firms are able to optimise returns and spread risk by selling a given product range into markets with relatively favourable conditions. Executives from large companies confirmed that, whilst some contracts are fixed, many are flexible, and firms tend have more buyers than they can satisfy (i.e. the market is supply-constrained). Whilst this can put strain on relationships with buyers, it does give firms the ability to optimise the marketing of its portfolio of hake products. The export market provides a particularly important opportunity for diversification: the amount of hake exported can be optimised depending on the exchange rate and prevailing world prices for hake. However, given the large volumes necessary for export contracts, small firms are unlikely to be able to access international markets, and thus are less likely to be able to be able to diversify along this dimension.

The following model, which is an adaptation of modern portfolio theory, demonstrates the benefits in terms of profitability and risk reduction accruing to firms able to diversify across the three dimensions discussed above. Suppose that a trawling firm has the potential to transform hake quota into n different products. The range of products which the firm produces can be considered a *portfolio*. Let each potential hake product i, $i \in \{1,2,\ldots,n\}$, have a profit level per ton produced (π_i), and a standard deviation of this profit level (σ_i). Let the (exogenously determined) quota allocated to the firm equal Q_0, and let the quantity of hake the firm allocates into the i^{th} market equal q_i (endogenously determined), so that:

$$\sum_{i=1}^{n} q_i = Q_0 \tag{14}$$

The expected profit level of the firm from allocating q_i into the ith market (across all n markets) is given by:

$$E(profit) = \sum_{i=1}^{n} q_i E(\pi_i) \tag{15}$$

This is a weighted average of the profits generated in each of the n markets (weighted according to how much hake is sold in each market). The variance in the total profit of this firm is given as follows:

$$Var(profit) \equiv \sigma_{portfolio}{}^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} q_i q_j \operatorname{cov}(\pi_i \pi_j) = \sum_{i=1}^{n} q_i{}^2 \sigma_j{}^2 + 2\sum_{i=1}^{n}\sum_{j\neq i}^{n} q_i q_j \sigma_i \sigma_j \rho_{i,j} \tag{16}$$

Where $\rho_{i,j}$ is the correlation coefficient between the markets for products i and j ($i \neq j$).[6] It can be shown that as long as the the profit levels in the markets are not perfectly positively correlated, then the

[6] The correlation coefficient measures the strength of the linear relationship between two variables. The correlation coefficient is always between -1 and 1 (inclusive). A value of 1 indicates a perfect *positive* correlation, a value of 0 indicates linear independence, and a value of -1 indicates a perfect *negative* correlation.

standard deviation of the profits accruing from the *portfolio* of products is lower than the weighted sum of the standard deviations of the profit levels for each individual product (Alexander, 2008). Symbolically this is given as follows:

$$\sigma_{portfolio} = \sqrt{\sum_{i=1}^{n} q_i^2 \sigma_j^2 + 2\sum_{i=1}^{n}\sum_{j\neq i}^{n} q_i q_j \sigma_i \sigma_j \rho_{i,j}} < \sum_{i=1}^{n} q_i \sigma_i \,, \quad \rho_{i,j} \neq 1 \qquad (17)$$

Inequality (17) shows that a firm with a given quota can reduce the variability in its profit streams by selling hake across multiple markets, relative to the weighted sum of the variability of each individual market. Thus, firms able to diversify their production can lower their exposure to risk, provided the profit levels between the product markets are not perfectly correlated. However, there is a limit to the benefits of diversification: some non-diversifiable risk is likely to exist, and will be determined by the extent to which profit levels across the various products vary together. The more closely positively correlated are average prices, the less risk can be diversified away.

The above model evaluates only the *risk* facing a firm. However, firms do not simply minimise risk when making production decisions. The optimisation problem they solve will balance both risk *and* profitability considerations. The maximisation problem can be stated in a general form as follows:

Maximise $$E(profit) = \sum_{i=1}^{n} q_i \pi_i \qquad (18)$$

subject to $$\sigma_{portfolio} < v_0 \qquad (19)$$

$$\sum_{i=1}^{n} q_i = Q_0 \qquad (20)$$

In (19), v_0 is the pre-determined maximum level of risk (as measured by a standard deviation) a company is willing to accept. Other variables and parameters are defined as before. The exact form the above maximisation problem takes will depend on how strongly the company values stable profits (i.e. low risk) relative to average profit levels, via its choice of v_0.

Whilst the major *reasons* for the presence of diversification benefits was discussed previously, no mention has yet been made of the *extent* of these factors in the deep sea hake trawl sector. In particular, firms' ability to lower risk and maximise returns through diversification will depend on the values of three sets of parameters: (i) the extent to which individual product markets are unrelated (the $\rho_{i,j}$), (ii) the variability of profit levels in individual product markets (the σ_i), and (iii) the expected profitability of individual product markets (the $E(\pi_i)$). Data available to quantify these factors are limited; nonetheless, there is in most cases good qualitative evidence available to provide indications of the likely range of parameter values.

First, how closely related are the markets for different hake products? In other words, what are the values of the $\rho_{i,j}$ in (16)? This, clearly, will vary depending on the two products being compared (i.e. the values of *i* and *j*). It may be hypothesised that the various hake product markets would be very closely related, since they each have similar products. However, there are three main reasons – provided by interviewees within the industry – for why markets for hake products are in fact *not* particularly closely related. First, many products are specifically *designed* to appeal to different consumer groups, with different incomes and preferences. Second, markets are often located in diverse geographic regions, each subject their own conditions and shocks. This is particularly true in the case of export markets, where different regions tend to favour different products. Because different products are being shipped to geographically distinct markets, the markets are likely to behave relatively independently. Third, the products into which landed hake can be transformed are themselves diverse. Some are relatively unprocessed commodities (such as fresh or frozen whole hakes), whilst others are highly processed (such as frozen hake products sold to retailers). Others are mere value-adds (such as fishmeal, which is not sold for human consumption). These three reasons provide *prima facie* evidence that the correlation across markets may be close to zero in some cases. Whilst some products may be similar enough to have high correlations, within the overall range of potential products to be produced, there are likely to be enough products that do not vary similarly for diversification to be beneficial.

The second set of parameters to be considered are the σ_i, each of which quantify the variability in profit levels in market i. Different products are subject to different levels of variability in profits. For example, fresh hake is highly perishable, and so prices tend to fluctuate relatively more. On the other hand, frozen hake products can be stored and released onto market at the best time, and supplier relationships and volumes tend to be more stable. Thus, for these products there is likely to be less variability in profit levels. Profit levels in export markets, which are subject to exchange rate variability, are more variable than equivalent domestic markets, all else equal.

The third set of parameters of interest is the set of average profitabilities across each of the n products – that is, the set of $E(\pi_i)$. Given the different costs and revenue structures for hake products, it is important not simply to compare profit *margins*. Different hake products may generate similar margins, but in *absolute* terms the profits will differ depending on the costs incurred in processing and distributing these different hake products. The $E(\pi_i)$ are thus to be measured in Rand terms, per ton of landed hake. Generally, the profit *margins* on processed products may not be substantially higher than for less processed products. Indeed, profit margins on processed hake products sold in the retail space may be *lower* than margins on relatively unprocessed hake products. However, because value is added through processing, in absolute terms the profit earned per ton of *landed* hake is higher for processed products. This increase in absolute profitability through processing is enhanced by scale and scope economies (discussed in section 3, below), and the ability of large firms to export product. The expected values of the π_i for processed products are thus likely to be higher than for relatively unprocessed products.

The conclusions of this model may thus be summarised as follows. Diversification is beneficial for firms because it allows firms to lower their exposure to market risk. Further, insofar as diversification takes place *up* the value chain, absolute profitability is likely to be higher. Small operators, with lower volumes and a product that is more likely to be subject to commodity cycles, are likely to have more variable profit streams. Further, the diversification opportunities available to large firms enable these large firms to solve the optimisation problem in (18)-(20) on an *on-going* basis, so as to smooth profit streams dynamically. If these findings are correct, they provide evidence in favour of maintaining a level of concentration in the industry sufficient to support this diversification.

3. Other Sources of Scale and Scope Economies in Deep Sea Hake Trawling

On top of benefits of diversification, there are benefits to *scale* in deep sea hake trawling. Whilst some scale benefits were mentioned previously, this section more carefully elucidates the sources of any scale and scope economies in deep sea hake trawling.

3.1. Capital- and Knowledge-Intensity

Deep sea hake trawling requires extensive capital investment, both in the catching and processing phases. In the catching phase, vessels need to be purchased and maintained. Vessels are large, capital intensive, and thus expensive. A second hand wetfish trawler costs about R45 million, and a second hand freezer trawler costs about R100 million (2015 prices). In 2013, SADSTIA (2013c) estimates that fixed investment in the industry totals R6 billion (with a replacement cost of R16 billion). Further, even once initial capital investments are made, extensive capital expenditure is required to maintain operating efficiency.

Similarly, the processing phase of deep sea hake trawling is capital intensive. Processing plants can cost in the billions of Rands, and the associated overheads (even once plants are built) are substantial. To make these investments worthwhile, volume needs to be sufficiently large, so that the overheads are spread as thin as possible. These entry costs – and the ongoing overheads – provide both a substantial barrier to entry, and extensive economies of scale within the industry. For small firms, the average costs of operating sophisticated trawl and processing equipment would be prohibitively high. However, by having large-scale operations, average costs can be lowered sufficiently for sophisticated catching and processing techniques to be profitable. It is only within the context of firms having a large and secure quota that this degree of capital expenditure is undertaken.

Qualitative evidence from interviews supports this. One large hake trawling operator confirmed that their plants cost in the region of R1 billion to build, and that a further 20% decrease in quota (relative to current levels) would result in the facility becoming unprofitable. An executive from a different trawling company argued that this capital expenditure would not be undertaken today, given the quota shrinkage which established companies have experienced.

A further benefit of processing hake are the economies of scope it generates. Due to the fact that an homogenous input (landed hake) is used, and similar skills and capital are required to process this hake into marketable products, the average cost of producing related hake products is lower when these products are produced together. Having one processing plant, rather than separate processing plants, producing multiple products means that the overheads of that plant are spread across multiple products. There are, then, synergy benefits to producing related hake products within one firm. These synergy benefits take the form of lower average costs for individual products, when these individual products are produced together.

Hake trawling is also *knowledge* intensive. It requires extensive industry-specific expertise and skills, from sea-going crew, engineering teams, to management and scientists. Large firms are able to employ skilled management, engineers, and scientists to optimise operations (including maintaining vessels and processing facilities), mitigate risk, and ensure environmental compliance within the firm. This expertise lowers average costs for the large trawling operation by more than the direct cost of obtaining this expertise. As a result, this expertise is a source of economies of scale: as scale increases, average costs fall for a firm able to employ this expertise and generate knowledge.

3.2. Coastline Indentation

South Africa has a relatively unindented coastline, with few natural harbours and often difficult weather conditions. South Africa's geographic features provide one reason why the deep sea hake trawl industry sprang up in an already-industrialised form (see section 1.1): no slow scaling up from traditional fishing methods was possible, simply because small boats and traditional methods were not profitable or prudent in the conditions specific to South Africa (Bross, 1998).

The lack of natural harbours, dangerous conditions, and relatively unindented coastline have implications for the industrial organisation in hake trawling. These factors bring greater risk to operations, and this risk is mitigated through sophisticated and capital-intensive operations, and extensive use of the few natural harbours. For example, large protective quays and advanced vessels capable of handling strong seas are used to ensure that fish can be caught consistently and safely. Further, given limited docking space, firms are forced to economise on space, and this is more successfully achieved when operations occur through a limited number of firms.

These geographic constraints are a source of scale economies specific to the South African hake trawl sector: as scale increases, firms are better able to negotiate these geographic difficulties, and economise on docking space, and thus can lower their average cost of landing hake. All else being equal, a group of small quota holders with collective quota equivalent to a large firm would be unable to streamline their operations to the same extent, dockside space would likely be used less efficiently, and the associated average costs would thus be higher.

3.3. Distribution Networks and Supplier Relationships

Large firms are able to build networks of suppliers, and successfully market their product under particular brands. A large volume of product is a necessary condition for being able to develop relationships with suppliers higher up the value chain. This is particularly true in (i) the retail space, where relatively low-margin but high-volume produce is targeted, and (ii) in the export space, where the fixed costs of logistics and supply chain management necessitate relatively large volumes being traded.

The implications of these factors are two-fold. First, small firms are very unlikely to be able to supply the export and retail markets, given their limited volumes. Second, the development of distribution networks represents a source of economies of scale for large firms. Established relationships with suppliers allow the average cost of transactions and contracting to fall. Thus, the average cost of a large firm getting product to market is lower than in a small firm, all else equal. There are, then, scale economies to be exploited in distribution, and doing so allows for the more efficient moving to market of an existing TAC.

4. Other Effects of Concentration in Deep Sea Hake Trawling

Not only are there factors specific to *firms* which justify concentration (as discussed in sections 2 and 3), but there are also *external* effects of having a concentrated deep sea hake trawl sector. This section outlines these external effects of concentration.

4.1. Co-management, Coordination Failure, and Protection of the Commons

Fisheries management in South Africa depends on a complex network of government and industry interaction. The Department of Agriculture, Forestry and Fisheries (DAFF) is responsible for allocating quota, setting the TAC each year, and managing the regulatory framework applicable to the sector. The operators in deep sea hake trawling are organised into the South African Deep Sea Trawling Association (SADSTIA). Together, these organisations depend critically on scientific and management expertise, and research output, to co-manage the industry in a sustainable and efficient manner (Hutton *et al.*, 1999).

The very existence of SADSTIA, its research, and its cooperation with government in managing the hake trawl industry is due to the existence of large firms with a commitment to the sustainability of the industry. This is, above all, a coordination problem: whilst a large number of small firms could, theoretically, organise themselves into an industry association like SADSTIA, a number of problems would be faced. First, no individual firm would see the direct benefits of membership and active participation. This effect is noted by Nielsen and Hara (2006), who found that new entrants thought they lacked experience and expertise, and thus did not see the benefit of, or feel comfortable attending, meetings with other industry stakeholders. Second, reaching industry-wide agreement and successfully managing the hake stock together with regulators would prove difficult, if not impossible. Third, compliance with regulations would likely be lower, as individual operator incentives would not be aligned with the sustainability of the whole resource. When the resource is owned (through quota allocations) by few players in the industry, and this ownership is largely secure in the long-term, then firms will act to maximise the stream of discounted future value flowing from the resource, rather than looking to make short-term gains at the expense of the long-term sustainability of the resource. These factors mean that scale has positive externalities associated with it for the industry as a whole, and for the state of the natural resource.

Two prominent examples of coordination failure are given by high-grading and high levels of by-catch. There is strong evidence to suggest that large companies have lower levels of by-catch, and are less likely to engage in high-grading. Sauer *et al.* (2003) found average by-catch rates amongst the three largest quota-holders to be between 8 and 9%, but amongst remaining quota holders by-catch was between 35% and 40%. This difference shows the extent to which large companies are incentivised to act in accordance with the long-term interests of the resource, and the negative externalities that can be associated with having many small operators in the industry.

4.2. Pricing Power

An important argument against industry concentration – not only in hake trawling, but in industrial organisation more generally – is that a concentrated industry may give firms in that industry a degree of price control. This would allow these firms to extract rents from consumers, relative to firms in a more competitive environment. This section discusses whether concentration in deep sea hake trawling is likely to have this effect on firms' pricing power. Interestingly, the existing literature on pricing in deep sea hake trawling is limited (most of the literature focuses on the environment, policy, and the value chain). For this reason, this section draws heavily on interviews conducted with those inside the industry.

For a firm to have pricing power in the short-run, it must face a downward-sloping demand curve. The firm must be able to set its prices by adjusting quantity in the market – or by setting a price and then supplying a market-clearing quantity. It is worth dividing the hake product market into two broad categories for the purpose of this discussion: the domestic hake market, and the foreign hake market.

In the export market (where 64% of South African hake is sold), South African firms contribute only 1% of all whitefish (and 2% of all wild-caught groundfish) (SADSTIA, 2013a). Given the relative insignificance of South African supply, domestic firms are price-takers on the international market. However, insofar as South African firms' brands and eco-labelling (including Marine Stewardship Council [MSC] certification) are respected on the international market, South African firms may be able to extract a premium price. However, a BCLME study found that price premia resulting from MSC certification have been minimal so far (BCLME Project LMR/SE/03/02, 2005). In this sense, then, the ability of branding to create pricing power in the export market appears somewhat limited.

The domestic market is likely to be less competitive, and firms do have some pricing power. However, even here, executives stressed that margins tend to be low, and there are a large number of substitutes with which hake must compete (for example, beef, chicken, other fish species, etc). Thus, despite the two biggest companies dominating the hake range in retailers, these firms have not been able to set high prices. Indeed, one company estimated the price elasticity of demand for its retail-sold hake products to be close to 15: a 20% increase in price entailing a 300% decrease in quantity demanded. Whilst more evidence would be required to verify the precise value of price elasticity (and the associated level of pricing power), the relatively high price elasticity of hake products is uncontroversial amongst operators within the industry: these operators are not free to increase prices without suffering severe setbacks to quantities demanded.

One restriction to firms' pricing power, which applies across both the international and domestic markets, is the fact that the buyers of large companies' products tend to be retailers, and not final consumers. In most cases, these retailers are themselves large companies that enjoy relatively powerful positions in the market. Further, retailer business models tend to be geared around extracting as much as possible from suppliers, at tight margins. This, then, limits the extent to which even the largest companies in hake trawling are able to set their own prices.

There is evidence, then, that firms do not enjoy the level of pricing power that may be assumed to exist if one looks merely at the level of concentration in the industry. Three reasons support this claim: (i) trawling firms supply competitive retailers, (ii) trawling firms sell the majority of hake on a competitive international market, and (iii) hake products compete with many other foods.

5. Policy Implications

5.1. Fragmentation of Quota Share

Policy surrounding quota allocation has been a controversial subject since at least the 1990s. On the one hand, some have argued that the power of established companies should be lessened by fragmenting quota – i.e. allocating quota to a larger number of rights-holders, each of whom would enjoy a relatively smaller share of the TAC. On the other hand, established companies and others have tended to oppose this, arguing that the promotion of competition in the industry would not be beneficial given the circumstances which prevail in deep sea hake trawling. Nonetheless, the largest companies have experienced quota decline since the 1990s (Cooper *et al*., 2014). There are ongoing calls for policymakers to further diminish the quotas of established companies to make room for new entrants in the industry. A recent call for fragmentation came from economists Mnisi and Lekezwa (2014) in a paper presented at a Competition Commission conference.

What are the likely effects of a fragmentation policy on industry-wide economic and environmental outcomes? Sections 2-4 of this paper provide evidence that the implications of further fragmentation would not be beneficial for the industry. The arguments elucidated in this paper suggest that fragmentation, and the corresponding shrinking of average company size, would result in a number of negative outcomes, namely (i) higher average costs, (ii) a narrower range of products, (iii) lower levels of value added to a given TAC, (iv) lower exports (and thus less foreign exchange generated), (v) higher risk for shareholders and employees within the industry, and (vi) less alignment between the sustainability of the resource and the interests of operators in the sector. Further, this would be achieved without any comparable benefit in lowering pricing power, since it was argued that even large firms have only limited pricing power. Importantly, then, the economic and environmental consequences appear to be unambiguously in favour of at least some level of concentration being maintained.

Policymakers in favour of fragmentation may respond by arguing that the industry can be fragmented at the *catching* stage, but that concentration can be maintained at the *processing* and *distribution* stages, so that the benefits of concentration at these levels can still be achieved. In such a case, these smaller quota holders at the catching level would then either (i) sell fresh or freezer-trawled hake directly to market (largely unprocessed), or (ii) sell their catch to on-shore plants for further processing. In the first case (selling hake directly to market), small operators are likely to have difficulty developing formal and stable contracts for their catch. Further, given the perishability of hake, and the catch variability in trawling, there is likely to be substantial risk faced by these operators. It is not clear why policymakers should want to expose rights-holders to these risks, when they can be mitigated through vertical integration and scale.

In the second case (selling hake to processing plants), formal contracts with a stable quantity and price agreements are far more likely to exist – thus reducing the uncertainties involved in small operations. Nonetheless, in these transactions there would be room for the exploitation of small trawl operators by processing plants, since these processing plants would enjoy monopsonistic positions in the market. Insofar as this is true, these processing plants will be able to buy hake from small operators at relatively low prices. Now, if one also takes into account the risks inherent in *catching* hake, previously described, a relatively low margin accruing to small operators is likely to be particularly harmful to these operators. In the long-run, if the TAC is given to relatively small firms, and processing happens through relatively few plants, prices paid to the small operators will be just sufficient to induce them to fish, but likely to be associated with high risk and financial hardship. This is one of the regrettable truths in hake fishing: remaining a small operator condemns a firm to lower and more risky returns. Removing vertical integration from the industry is likely to add to this, rather than detract from it. Overall, then, the policy of fragmentation appears to have little evidence in its favour.

5.2. Disentangling Transformation and Fragmentation

Section 5.1 argued that fragmentation is unlikely to be beneficial for the industry and the environment. However, the fragmentation debate has often been coupled with another item on the policy agenda: that of transformation. Two main types of transformation have been focused on in the literature: *internal* and *external* transformation (these are not, however, strictly mutually exclusive). Internal transformation takes place when existing companies in the industry become transformed, largely through changing the demographic profile of employees, shareholders, and other stakeholders.

External transformation occurs when new firms – composed largely or entirely of historically disadvantaged individuals (HDIs) are allocated quota.

Sauer *et al*. (2003) found that 92% of individuals employed in hake trawling were previously disadvantaged individuals, and 40% of employees were female. Black participation in the industry has been rising at all levels, and 86% of the industry payroll goes to previously disadvantaged individuals. In 2007, 75% of vessel skippers were historically disadvantaged individuals. In terms of ownership, by 2002 74% of companies were majority-owned by previously disadvantaged individuals (Nielsen & Hara, 2006). This declined to 59% after the 2006 long-term rights allocation (Ponte & Van Sittert, 2007). Nonetheless, the overall proportion of quota owned by previously disadvantaged individuals rose slightly from 59% in 2002 to 61% in 2006 (Ponte & Van Sittert, 2007). Both of these percentages started from a base of zero percent in 1992 (Ponte & Van Sittert, 2007). As of 2015, one of the two largest companies in the hake trawl sector was 84% owned by HDIs.

These employment and shareholder data suggest that there is still room for further transformation, and it is likely for precisely this reason that the subject remains an important policy topic. Nonetheless, the degree of transformation even by this point does appear to have been substantial in deep sea hake trawling. It is within this context that current policy discussions are taking place.

Some authors argue for greater and more inclusive transformation. For example, Isaacs *et al*. (2007), and Isaacs (2006) argue for a number of related conclusions: (i) that government should do more for historically disadvantaged communities reliant on fishing, (ii) that government should pursue external transformation in industrial fisheries, (iii) that internal transformation thus far has been "cosmetic", and (iv) that government should take a more active role in supporting small businesses. Similarly, Mnisi and Lekezwa (2014) argued that transformation should be coupled with increases in competition through external transformation: the fragmenting of existing quota and allocation to new firms, owned and run by HDIs. These authors, then, argue in favour of achieving transformation *through* fragmentation. Other authors point out that transformation has already been remarkably successful, and that industrial fisheries offer the least scope for external transformation, and thus that internal transformation should be favoured (Branch & Clark, 2007; Van Sittert *et al*., 2006).

This paper's findings suggest that fragmentation would be damaging to the industry, all else being equal (see 5.1 above). Now, given that alternative *forms* of transformation exist – in particular, internal transformation – which can be achieved without fragmentation, transformation need not bear the costs of fragmentation. Only external transformation would bear these costs. In fact, assuming that both transformation *and* efficiency are desirable, then internal transformation is a strict Pareto improvement over external transformation: both achieve transformation in the sector, but only *internal* transformation is able to exploit the efficiency gains associated with scale, vertical integration and diversification. If this paper's finding are true, then Mnisi and Lekezwa's (2014) conclusion that competition and transformation should be coupled together has little evidence in support of it. It is possible – and preferable – to disentangle competition and transformation, and for transformation to be achieved *without* the costs associated with fragmentation.

Concluding Remarks

This paper provided a taxonomy of the most important industrial forces present in the South African deep sea hake trawling industry. In particular, the major reasons for the existence of scale and scope economies and diversification benefits, and the consequences of these factors, were modelled and analysed. The findings of this paper are as follows. Natural variability in catch and variability in the markets for individual hake products allows diversified, vertically integrated and large-scale firms to experience relatively stable profit streams. Further, the capital- and knowledge- intensity of producing hake products, as well as the advantages of developed distribution networks, allows large firms to produce more efficiently. Pricing power of large firms in the industry is limited, despite the scale of these firms. Having fewer firms in the hake trawl sector is likely to enhance the sustainability of the resource and produce a more cooperative relationship between firms and regulators.

Policy implications of these findings were considered. Fragmentation – the dividing of the TAC amongst a larger number of participants – is likely to lead to inefficiencies, coordination failures, greater risk for operators within the industry, and thus set back the economic development that could be achieved in the industry. Further, because transformation can be disentangled from fragmentation, it was argued that transformation objectives can still be pursued and achieved within the context of a relatively concentrated industry.

This paper's analysis and conclusions are subject to important limitations, and this opens up room for further research. First, much of the analysis was qualitative, given a lack of available data. This means that the analysis proceeded with a certain degree of imprecision. If sufficiently detailed data can be obtained, the models and theoretical predictions made in this paper can be tested and quantified to a greater extent, and an overall model of the South African hake trawl sector could be developed.

A further limitation of this paper's analysis is the use of interviews with individuals inside the industry. Whilst every effort was made to avoid bias occurring in the interviews, individuals interviewed may (even subconsciously) have been subject to a self-serving bias, and thus provided information supporting their positions. Given that interviews were conducted within large and established companies, any self-serving bias would mean that the conclusions of this paper are stated with greater strength than is warranted. However, it is worth pointing out that many of the factors this paper identified were pointed out *unprompted* by interviewees, and are supported by the academic literature, and so the author holds that these factors are real and present in the industry.

Appendix A: Interviews Conducted

Individual(s) Interviewed†	**Role**	**Organisation**	**Date of interview**
Rory Williams *Also present:* Anthony Leiman (UCT School of Economics)	Financial Director	Viking Fishing	8 September 2015
Felix Ratheb *Also present:* Madoda Khumalo (Sea Harvest) Johann Augustyn (SADSTIA)	Chief Executive Officer	Sea Harvest	8 September 2015
Brendon Lucke	Financial Director	Irvin & Johnson	10 September 2015

†*Note: Lists of questions and corresponding minutes for all interviews are available from the author on request (with provision that sensitive company-specific information may be omitted).*

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