Review of the NSW Commercial Fisheries Exit Grant Proposal

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Executive Summary

The structural adjustment component of the commercial fisheries reform program aims to improve the long-term economic viability of the NSW commercial fishing industry by linking fishing rights (i.e. shares) to resource access and by providing opportunities for ongoing autonomous adjustment. A voluntary exit grant package of $15.5 million has been made available to facilitate movement of shares from inactive to active, viable fishers and minimize any negative impacts on those intending to remain in the industry.

The competitive tender process that is an integral part of the current exit grant proposal is an important improvement over earlier suggestions such as straight buy outs. The existing market for shares is full of uncertainty with highly variable prices for access rights. Without running a competitive process there is no way to robustly determine correct share prices and value entitlements in a fishing business. Buy outs would lead to an inefficient allocation of shares across the industry and result in poor use of the assistance package in a way that does not meet key objectives of the reform program.

However, there are a number of ways in which the current proposal can be improved. First, it involves a two-stage process that separates the commitment to dispose of shares from the actual trading (or surrendering) of shares. While commitments to dispose are obtained through a centralized tender process, share trading is decentralized as fishing businesses have to find their own trading partners. Such decentralized search is costly, causes delays, and agreed trades may be reneged upon when the selling party is not successful in the exit grant tender (or those successful in the tender may opt not to collect exit grant money if no trade partner is found). The proposed two-stage process exacerbates uncertainty, which could be avoided by combining the two elements – commitment to dispose and share trading – into a single mechanism.

Second, while the description and rules of the current proposal seem straightforward, the strategic situation fishing businesses face is complex. Fishing businesses will want to base their decision to exit the industry or buy additional shares on the prices that unfold in the market. A buyer will want guarantees that it obtains enough shares in a certain share class if it purchases any at all. An exiting firm will want to make sure it sells all shares and not just its high-value ones. Different sellers within the same share class should be paid the same share price. These features are not only desirable (from the industry's viewpoint), they are necessary to avoid fishing businesses ending up with fragmented and unviable share portfolios. Yet, they are not part of the current proposal, which puts all objective and strategic risk on the shoulders of the fishers, adding further uncertainty.

A two-sided *combinatorial market* offers the desired features and presents a significant improvement over the current proposal. It allows fishing businesses to submit flexible offers, e.g. "all-or-nothing" sell offers, buy offers that specify minimum or maximum share amounts, consolidating offers to sell shares in one share class only if shares in another share class can be purchased, or mutually exclusive offers to stay or exit that are contingent on market prices. By running the combinatorial market for multiple rounds (possibly including some "mock" trials) important price feedback can be provided, resulting in better-informed decisions and a more efficient allocation of shares. These multiple rounds could be conducted over the course of a single day, with the entire industry participating in a single clearinghouse thereby greatly reducing delays and search costs.

To summarize, a multi-round combinatorial market shifts all complexities from the participants to the tender's organizer. In doing so it greatly reduces uncertainty and

1. Avoids unnecessary delays and transactions costs, and reduces uncertainty about trade opportunities by including both buyers and sellers in a centralized "clearinghouse."

2. Avoids fragmented and unviable share portfolios by allowing for more flexible (contingent) offers.

3. Ensures equity across sellers via the use of uniform prices.

4. Reduces uncertainty about share values through price feedback in an iterative process (including, possibly, the use of "mock" trials).

5. Allows for a transparent inclusion of additional constraints specified by the Department.

6. Allows for a more effective and transparent allocation of the $15.5 million subsidy.

Software needs to be developed to conduct the combinatorial market and decisions need to be made regarding the format and nature of the submission forms (web, phone, Fax) as well as the timing and duration of the tender process (single shot, repeated rounds during a single day, or over the course of days/weeks). A team should be hired that can develop the software and collaborate closely with the Department, SARC, and industry representatives, to reach consensus regarding important details that feed back into the software. It is a substantial project and it is imperative that this team starts soon for the tender process to be conducted this year.

1. Background

Commercial fishing is an important primary industry in New South Wales (NSW), harvesting annually around 15,000 tonnes of fish and prawns worth about $80 million at point of first sale. There are over 1,100 commercial fishing businesses in NSW who have an entitlement to catch fresh, locally caught fish for the community to enjoy. The industry has recognised the challenges in making fisheries sustainable and supported many of the regulatory, policy and practice changes introduced over time to improve environmental performance. The NSW commercial fishing industry is primarily made up of small businesses that rely on high levels of local knowledge and skills learnt over many generations. The industry has a diverse demographic profile, with fishers from different ethnicities and cultural backgrounds, differing levels of literacy and is dispersed across regional coastal towns from Eden to Tweed Heads.

Commercial fisheries are managed in accordance with the principles of Ecologically Sustainable Development (ESD) and are subject to a range of regulations, fisheries management strategies, management plans and policies. Commercial fisheries in NSW are currently going through a critical period of change to improve long term security and viability of the industry as a whole. This follows the May 2012 Independent Review of NSW Commercial Fisheries Policy, Management and Administration and the subsequent announcement in November 2012 of the Commercial Fisheries Reform Program by the Government.

Three key areas for reform include:

1. A comprehensive structural adjustment program to address the problem of poorly defined fishing rights;
2. Reform of governance processes to achieve a proper balance of responsibilities and accountabilities within Government and industry to restore confidence in decision making,and;
3. Reform of consultation processes to provide effective processes and structures to facilitate co-ordinated advice, communication and feedback between Government and industry.

This report concerns only the fist point, i.e. the problem of poorly defined and allocated fishing rights. To address this issue, a voluntary exit grant package of up to $15.5 million has been proposed. The exit grant is intended to best facilitate movement of shares from inactive to active fishers (or those intending to remain in the industry), and minimise negative impacts on active, viable fishers. This report reviews the proposed exit grant.

2. Details of the Current Exit Grant Proposal

The exit grant was proposed to subsidize shareholders willing to transfer their shares to other shareholders or to surrender them for cancellation. The exit grant process should result in the consolidation of shares within the industry and act as an indirect subsidy for existing shareholders who wish to acquire additional shares.

Once decisions have been made on share linkage and total catch/effort levels, all shareholders would know the level of access that shares provide and how access will be controlled in the future. The tender process is then conducted whereby shareholders are able to submit formal tender bids for an exit grant (payment) in return for transferring or surrendering the shares that they nominate. At the end of the tender period, all bids received will be ranked in terms of their "value for money." Successful tenderers would then be required to transfer or surrender shares in order to receive payment from the government.

It was expected that tender bids for an exit grant could be made for the:

1. Transfer or surrender of all shares in a fishing business, at which point the fishing business is revoked. If the fishing business has a southern fish trawl endorsement, that endorsement must be surrendered (not transferred).
2. Transfer or surrender of all shares in a particular fishery (e.g. transfer all Ocean Trap & Line shares from a business but retain the Estuary General shares).
3. Transfer or surrender of all shares in a particular share class, where possible.

Each tender would be ranked based on the type and number of shares offered and the overall tender price. The rankings would be calculated in a way that considers:

- whether the tender involves the removal of a fishing business (i.e. tenders that result in the removal of a fishing business will be weighted higher than those that do not);
- the value of total catch in each share class (i.e. the higher the overall value of production the higher the weighting);
- the difference ('distortion') between those who hold the shares versus those who catch the fish, e.g. a share class involving lots of shareholders where only a few businesses take most of the catch is very distorted and will be given higher weighting.

The ranking allows tender bids from businesses with different shareholdings to be compared. An overall ranking based on the above factors would result in those ranking highest being accepted first. Tender bids would be accepted based on ranking until all of the $15.5 million in available funding is committed or payments no longer represented value for money.

3. Evaluation of the Current Exit Grant Proposal

The competitive tender process that is an integral part of the current exit grant proposal is an important improvement over earlier suggestions such as straight buy outs. Without running a competitive process there is no robust way to determine correct share prices and, therefore, generate value from expenditure of government and private funds. And without share prices it is impossible to value the entitlements in a fishing business, let alone approximately 1,100 fishing businesses with varying share portfolios. Not only would the price not be right, there would be no guarantee that the correct businesses, i.e. those with lowest values for their shares, would be bought out. In other words, the buy out process would lead to an inefficient allocation of shares across the industry. This would result in poor use of the assistance package in a way that does not meet key objectives of the reform program.

A competitive tender process allows for share prices to be set by the market and to identify the businesses that given those prices prefer to exit or purchase additional shares. Care must be taken with respect to the design of the tender, though, since also competitive processes can fail. Indeed, the current proposal has a number of shortcomings. In particular, it misses out on several features that are not only desirable (from the industry's viewpoint) but that are essential to ensure an efficient allocation of shares.

Before going into detail we provide a summary of features that are currently missing and that need to be included to guarantee that key objectives of the reform program are met:

1. Avoid unnecessary delays and transactions costs, and reduce uncertainty about trade opportunities by including both buyers and sellers in a centralized "clearinghouse."

2. Avoid fragmented and unviable share portfolios by allowing for more flexible (contingent) offers.

3. Ensure equity across sellers via the use of uniform prices.

4. Reduce uncertainty about share values through price feedback in an iterative process (including, possibly, the use of "mock" trials).

5. Allow for a transparent inclusion of additional constraints specified by the Department.

6. Allow for a more effective and transparent allocation of the $15.5 million subsidy.

While these features pertain to different aspects of the tender process they have in common that they reduce the uncertainty and strategic complexity for those participating in the tender.

3.1. Include both sides of the market in a centralized claringhouse

The current exit grant proposal involves a two-stage process that separates the commitment to dispose of shares from the actual trading (or surrendering) of shares. One reason is that the Department seeks to avoid acting as an intermediary that holds shares (first buying them from exiting businesses and subsequently selling them to those that stay), but it can buy commitments to no longer use shares.

While commitments to dispose are obtained through a centralized tender process, share trading is decentralized as fishing businesses have to find their own trading partners. Such decentralized search is costly, causes delays, and can lead to inefficient outcomes. Suppose, for instance, that there are four businesses: one wants to buy a share at \$10, two want to sell a share at \$0, and a fourth wants to either sell a share at \$8 or buy a share at \$3. In a decentralized market it may happen that only one trade occurs: the fourth business sells a share to the high-value buyer. Even though a more efficient allocation exist, i.e. the two zero-value sellers trade their shares.

Moreover, the two-stage process creates additional uncertainty. Some businesses might be successful with their tender bids *and* in finding a trade partner in the three months following the tender (or before). Others may be successful in the tender but may have to surrender their shares afterwards because of lack of demand or market imperfections. Yet others may have found a trading partner beforehand but then be unsuccessful in the tender. The risk of missing out on one of the two elements, being successful in the tender and in finding a trade partner, will undoubtedly be recognized as a problem by the industry and affect their behavior. First, deals may be broken – those that are successful in the tender may opt not to collect their exit grant money when no trade partner is found and those that are unsuccessful in the tender may renege on agreed trades. More generally, the possibility to trade shares separately from the tender process will affect the tender's functioning.

To illustrate, consider the very standard supply-and-demand graph in the top-left panel of Figure 1. The downward-sloping curve reflects buyers' share values and indicates how many shares (shown on the horizontal axis) are being demanded at each price (shown on the vertical axis). Likewise, the upward-sloping curve reflects sellers' share values and indicates how many shares are being offered for sale at each price. Under standard assumptions, the outcome of a *centralized* market would be that 5 shares are traded at a uniform share price of \$5.

Suppose the Department has a budget of \$16 to buy commitments to dispose of shares. Under the current exit grant rules, those successful in the tender are paid what they asked for – so called "discriminatory" prices as different sellers are paid different amounts for the same shares. The use of discriminatory prices creates strategic difficulties in that raising one's ask price is beneficial if it continues to win but not if it turns a winning offer into a losing one. This is another shortcoming of the current proposal, which we'll address in a later section. To highlight the inefficiencies caused by separating the tender from the actual trading of shares we can ignore this flaw and simply assume that fishing business use a rule of thumb, e.g. they add a markup of 60% to what the share is worth to themselves (their use values). With a budget of $16 this implies that those with use values less than four win and each receives a price equal to 160% of the use value (since $1.6 \times (1 + 2 + 3 + 4) = 16$).

How does the tender affect market trading? Winners in the tender commit themselves to no longer use their own shares. In other words, these winners now have zero use values as indicated by the flat part of the supply curve in the top-right panel of Figure 1. The resulting market-clearing price is still $5 and 5 shares are traded: four come from the auction winners, who receive a market price of $5 plus 160% of their use value, and another from an auction loser, who receives only $5.

Obviously, sellers will want to avoid having found a trade partner and not being successful in the tender by strategically lowering their ask prices. Indeed, if five sellers *know* they will sell their shares, then they *should* make sure they are also successful in the tender. Suppose each of the five sellers simply asks $3.2 for its share. Then the auction has five winners and each receives $3.2. The resulting supply in the market is then given by the bottom-left panel of Figure 1. All those with an exit grant and a share sale option receive $8.2 in total.

The story of "strategically lowering one's ask price to get a share of the exit grant money" does not end here though. Some of the "marginal" losers, i.e. those with values just above 5, also have an incentive to lower their bids. Indeed, suppose that in the auction 6.3 shares get committed at a price of $2.6 each. In the market these 6.3 shares then trade at a price of $3.7. This outcome, shown in the bottom-right panel of Figure 1, is the one that is predicted to occur ("in equilibrium"). As it is the only outcome in which no one can gain from lowering/raising their ask prices.[1]

The point of the above example is not to blindly believe in its mathematically precise predictions. For starters, fishers may not have the strategic sophistication presumed. More importantly, they are unlikely to know the exact parameters of demand and supply, which were needed to carry out the above calculations. The point is that strategic behavior of whatever form or shape is likely to occur when $15.5 million is on the table. And the consequences of such strategic behavior may be worse precisely because fishers don't all have the same information or the same level of sophistication. In this sense, the above example probably sketches a best-case scenario.

An additional concern is how the $15.5 million subsidy is distributed across the industry. In particular, how much of it will go to those selling (and exiting the industry) and to those buying (and staying in the industry). For the above example, if we believe that the scenario in the

[1]Notice that the marginal winner has an opportunity cost of $6.3 for the share, which is just recouped by receiving $2.6 in the auction and $3.7 in the market.

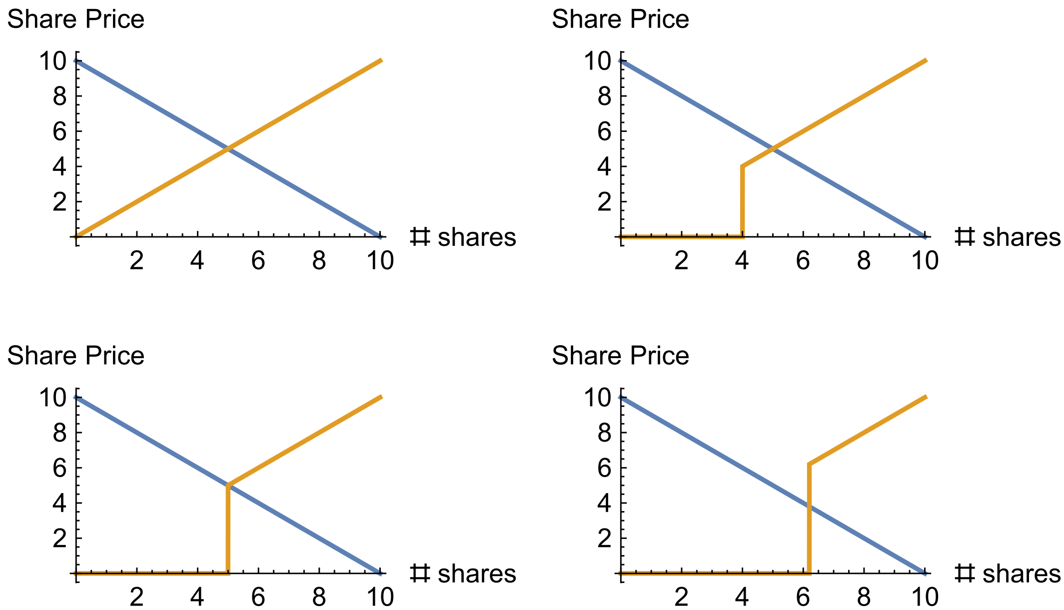

Figure 1. The upper-left panel shows supply and demand in the market for shares without an exit grant. The upper-right panel shows how market supply changes when an efficient exit grant tender is conducted. The lower panels depict cases where businesses partly (left panel) or fully (right panel) adapt their behavior so as to get their part of the exit grant money.

bottom-right panel will unfold, the \$16 subsidy led to an increase in shares traded (from 5 to 6.3) and reduced the market price (from 5 to 3.7). So existing shareholders who wish to acquire additional shares also benefit from the tender process.

But if the outcome in the bottom-right panel were the desired one then there are simpler ways of implementing it. Suppose the department offers a \$1.3 subsidy, for both buyers and sellers. This shifts the demand and supply curve outwards as shown by the solid lines in Figure 2 (the dashed lines correspond to the original configuration). The new market equilibrium is that 6.3 units are traded at a price of price of \$5 and the total subsidy cost is \$16.

To summarize, the two-stage nature of the current exit grant proposal has the following shortcomings: (i) the trading of shares is decentralized, causing delays, search costs, and trade inefficiencies, (ii) separating the trading of shares from commitments to dispose will cause deals to be broken and (iii) result in strategic behavior in the tender. These shortcomings exacerbate the uncertainty that fishing businesses face, which can be avoided by letting both buyers and sellers participate in a centralized clearinghouse mechanism. This has important additional advantages, e.g. it would would reduce delays and transaction costs, sellers would be paid once for their shares (and not have to worry about being successful in the tender and in the market), and it would allow for better control over the \$15.5 million subsidy, e.g. by directly rewarding both the buy and sell side of any transaction.

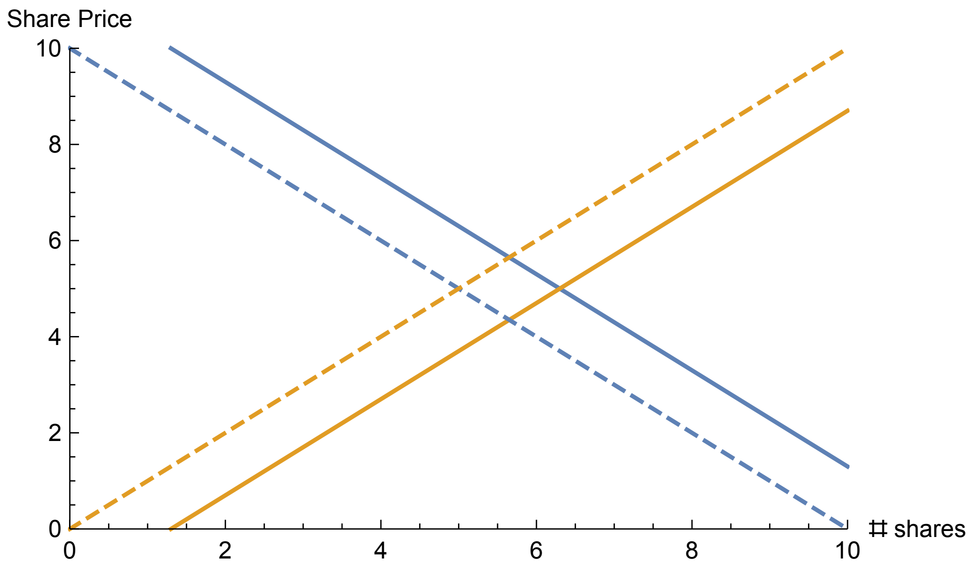

Figure 2. Implementing the same outcome as in the lower-right panel of Figure 1 with a simple subsidy to the buyer and the seller.

3.2. Allow for more expressive bids and asks

The current proposal suggests that more weight will be given to businesses that exit the industry (by giving up all their businesses and shares), although it does not make explicit how this will be done. A careful handling of "all-or-nothing" tender offers is important to avoid that a business sells off its more profitable shares and is stuck with the low-value ones. In the economics literature, this is known as the *exposure problem* to reflect the fact that participating businesses are exposed to outcomes that make them worse off when aggressively trying to sell all their shares, businesses may lose money in the process if they are successful in only selling part of their share holdings.

A very inefficient and undesirable outcome of the exit grant process would be if afterwards there are many fragmented businesses left whose shareholdings do not allow for viable business plans. Furthermore, businesses that plan to stay in the industry and buy shares often need a minimum number of them. Also in this case it would be undesirable if businesses started buying shares (possibly in a share class where they previously did not own any shares) to end up with less than the required amount. Finally, there will be a number of businesses that want to consolidate rather than exit, i.e. they want to buy in one share class and sell in another.

To avoid fragmentation and less-than-minimally-required share holdings, as well as to allow for consolidation, the tender process should allow for more expressive bids. Fishing businesses interested in exiting the industry should be allowed to state all-or-nothing asks, e.g. one price for all shares they hold but only if all shares are sold (and not some subset). Similarly, those buying should be allowed to state an all-or-nothing offer, e.g. one price for a specified number of shares.

(These all-or-nothing bids and asks are optional and do not preclude businesses from quoting simple per-unit prices for their shares if they wish; e.g. a business with 10 shares might simply quote a per-unit price for each of them with the understanding that it may sell any number between 1 and 10 shares at that price.)

Also consolidating offers could be allowed to take a conditional form, i.e. a business may want to expand its share holdings in a certain share class only if it is able to sell all its shares in another share class. Finally, some businesses may be on the fence whether to exit the industry by selling all their shares or to stay and purchase additional shares. In such cases, it would be helpful if businesses could express this via so-called XOR bids, which means that they can submit both an offer to sell their current shares and an offer to buy additional shares knowing that at most one of these two offers will be successful.

3.3. Explicate and incorporate constraints imposed by the Department

Currently, the Department has some implicit restrictions in mind about how the $15.5 million subsidy should be allocated across different share classes. For instance, share classes that generate less value should receive less subsidy, as should share classes that are less distorted (i.e. where share holdings better reflect desired/current fishing activities).

Making the Department's preferences explicit increases the transparency of the tender process, which allows fishing businesses to develop a more informed strategy. For example, the Department could announce upfront that only a certain dollar amount or a certain percentage of the total subsidy will be spent on a specific share class. Moreover, the Department may set targets for the total number of shareholders in a given fishery, or the percentage of shares that a fishing business is allowed to hold within a particular share class. Finally, the outcomes of the tender will have to meet the Department's current transfer rules. One major advantage of the solution proposed below is that all these constraints can be included in, and may even expedite, the optimization routine.

3.4. Reduce uncertainty through iterative process

There is likely to be substantial uncertainty: about the value of shares, about the (strategic) behaviour of others, about how the tender process translates offers received into a final outcome (i.e. how "winners" are picked).

For example, the "value of a share" could mean its use value, i.e. how much profit its owner generates from using the share. (In a separate project, these use values are being estimated by AgEconPlus). Alternatively, the value of a share could mean its resale value, i.e. at what price can the share be sold to others given what they can do with it. In the economics literature, use value is also known as the share's *private value* (reflecting that it is specific to the owner) while resale value would be called *common value* (reflecting that it is the same for all owners). It is well known that tenders where both private and common values play a role can generate inefficient outcomes because of the increased uncertainty. A business with low use values may demand higher prices for its shares than a rival with high use values simply because it has more optimistic expectations about the resale value of its shares. The adverse effects of differences in expectations about resale values can be mitigated using an iterative tender process where businesses receive feedback over multiple rounds and can learn from others' behaviour.

An iterative tender process that provides feedback has the additional important advantage that it protects against poor outcomes stemming from serious misjudgements: of the market environment, others' behaviour, or the tender process itself. Indeed, it seems strenuous to assume that all fishing businesses will enter the process with the same (and correct) expectations about what market prices will be and with full understanding of the rules. More likely, at least some will be confused or have wrong expectations about resale values and initially submit uncompetitive offers as a result. One measure would be to run "mock" or trial versions of the combinatorial market in the weeks or months leading up to the tender. While this requires significant engagement, it would help to alleviate concerns the industry might have about the tender process and would undoubtedly improve performance of the mechanism at the time of the actual tender. With some prior experience the actual tender could then be run during a single day. An iterative process would still be required – to provide important feedback to fishing businesses that start out with unrealistic expectations and guide them towards more realistic offers.

4. An Alternative Proposal for the Exit Grant Process

It is useful to summarize the shortcomings of the current exit grant proposal as follows: the rules and description of the process are relatively straightforward but the strategic situation that fishing businesses face is incredibly complex. There is considerable uncertainty about the (private and common) value of shares, about whether there will be an auction payment and a payment in the market afterwards, how subsidies will be allocated across the industry, etc. Moreover, fishing businesses face a severe exposure problem when they sell only part of their share holdings, purchase less than the minimum-required amount of shares, or when their plans for consolidation are only partly successful.

Instead of having simple rules that induce a complex strategic environment, a better solution would be to make participation as simple as possible for the fishing businesses and shift all complexities to the tender's organizer, which could be an independent company. This company would not act as a middle man but rather be the organizer of a clearing house where shares change hands from one fishing business to another. What should this clearing house look like?

The ideal format for the exit grant tender would be a multi-round combinatorial market if it can be made practically feasible.

To explain these terms:

- *Multi-round* refers to the fact that fishing businesses would be able to submit tender offers during a series of rounds, receiving feedback about the outcomes after each round. There could be fixed number of rounds, which makes the length of the process clear upfront but has the disadvantage that it could trigger "sniping," i.e. tender offers are not serious until the final round. Alternatively, the process could have a "soft close," i.e. it ends after a round in which there were no substantial changes in the outcome (relative to the outcome of the previous round). Or some kind of activity rule that forces participants to be active from the start could be imposed.
- *Combinatorial* captures the idea that expressive offers are allowed, e.g. an all-or-nothing buy offer of the type "I am willing to pay $X for x number shares but only if I get all x of them" or a consolidating offer of the type "I am willing to pay $X if I get x shares in one share class and sell all my shares in another share class." The fact that offers typically contain combinations of shares explains the adjective combinatorial.
- *Market* (rather than auction) indicates that both buyers and sellers participate in a single process.

Under the current proposal, exiting businesses incur the financial and practical burden of finding partners to transact with. This is not the case for the clearing house method proposed here. All buy and sell offers are submitted into the system, which then clears in an "anonymous" manner. No business will know who they bought their shares from or whom they sold to. Restrictions on which transactions can occur ("transfer rules") can be implemented into the clearing mechanism so that they are automatically satisfied.

4.1. Details of the combinatorial market

A combinatorial market involves the following steps: (i) participants submit offers to buy and sell, (ii) an algorithm takes these offers to maximize a well-defined *objective* subject to *constraints*, and (iii) participants are informed how many shares and cash they will receive or have to deliver to the clearing house. Net of the subsidy, the algorithm is budget balanced, i.e. the clearing takes as much money as it gives. As explained below, the optimal solution might involve the clearing house taking more shares than it gives, in which case the excess shares are retired (for cancellation or later use).

A commonly used objective is cash *surplus*. To illustrate, suppose there is only a single buyer, who has no shares, and a single seller, who owns a single share. Suppose the seller asks \$10 and the buyer offers \$15 then trade should occur and the surplus is \$5. In contrast, if the seller asks more than the buyer then trade would involve a negative surplus and, hence, should not occur. This can be formulated as a maximization exercise as follows. Denote the sell offer as (s, q), where s is the amount of money demanded and $q = 1$ the quantity offered. Likewise, denote the buy offer as (b, y), where b is the amount of cash offered and $y = 1$ the quantity demanded. The optimization routine takes the form:

$$\begin{aligned} \max_{\beta,\sigma} \quad & b\,\beta - s\,\sigma \\ \text{s.t.} \quad & \beta = \sigma \\ & \beta, \sigma \in \{0, 1\} \end{aligned}$$

Here β and σ are internal parameters chosen by the program. We say that the buy (sell) offer is successful or "winning" when $\beta = 1$ ($\sigma = 1$) and it is "losing" when $\beta = 0$ (σ=0). The constraint that $\beta = \sigma$ reflects that supply has to equal demand. The above problem is easy to solve by hand: $\beta = \sigma = 1$ when $b \geq s$ and $\beta = \sigma = 0$ otherwise.

Next, suppose the seller has many shares, say q of them. Let's first interpret a sell offer (s, q) to mean that the seller is willing to sell any number of shares up to a total of q at a per-unit price of s. Similarly, the buy offer (b, y) means the buyer is willing to buy up to y shares at a per-unit price of b. Then the relevant problem is:

$$\begin{aligned} \max_{\beta,\sigma} \quad & b\,\beta - s\,\sigma \\ \text{s.t.} \quad & \beta = \sigma \\ & 0 \leq \beta \leq y \\ & 0 \leq \sigma \leq q \end{aligned}$$

Also this problem is easy to solve: $\beta = \sigma = \min(q, y)$ when $b \geq s$ and $\beta = \sigma = 0$ otherwise.

Alternatively, the sell offer (s, q) could be interpreted as an "all-or-nothing" offer, i.e. the seller only wants to either sell all shares or none of them. Then the problem becomes:

$$\begin{aligned} \max_{\beta,\sigma} \quad & b\,\beta - s\,\sigma \\ \text{s.t.} \quad & \beta = \sigma q \\ & 0 \leq \beta \leq y \\ & \sigma \in \{0, 1\} \end{aligned}$$

Now $\beta = q$ and $\sigma = 1$ if $b \geq s$ and $y \geq q$, otherwise $\beta = \sigma = 0$.

With all-or-nothing offers, the demand-equals-supply restriction is often to restrictive in that profitable trades might exist where some shares are retired. For example, suppose the seller offers

10 shares (all-or-nothing) at a total price of 80 while the buyer is willing to buy up to 9 shares at a per-unit-price of 10. Then giving 9 shares to the buyer and retiring one unit is a transaction with positive surplus. We can incorporate such cases by requiring that demand *does not exceed* supply (rather than demand *equals* supply).

Finally, the buy offer (b, y) could also be interpreted differently, e.g. to mean that the buyer wants *at least* y shares. Of course, there is still an upper bound to the number of shares the buyer can get, $q^{\max}$, which is either the total number of shares in the share class or some maximum number that the Department imposes. Under this interpretation of the buy offer the maximization problem becomes

$$\begin{array}{ll} \max_{\beta,\sigma,\zeta} & b\,\beta - s\,\sigma \\ \text{s.t.} & \beta \,\leq\, \sigma q \\ & \beta \,\leq\, q^{\max}\zeta \\ & q\zeta \,\leq\, \beta \\ & \sigma, \zeta \in \{0, 1\} \end{array}$$

Notice that the demand-supply constrained has been relaxed. The binary ζ variable implements a solution where the buyer gets nothing, $\beta = 0$ when $\zeta = 0$, or some number of shares between the minimum quantity demanded and the maximum number of shares, $y \leq \beta \leq q^{\max}$ when $\zeta = 0$.

As the different cases illustrate, an important role is played by the *bidding language*, i.e. what is the precise interpretation of the submitted buy and sell offers. The bidding language should be tailored to the problem and make submission of offers intuitive and protect businesses from ending up with fragmented and unprofitable share portfolios. In the rest of this section, it is assumed that sellers are best protected by being able to submit all-or-nothing offers and that buyers are best protected by being able to submit offers specifying a minimum quantity.

While it is not known upfront how many fishing businesses will be buyers or sellers, there will mostly be more than one of each so we need some further notation. Let $\mathcal{S} = \{1, \ldots, S\}$ denote the set of all S sellers, $\mathcal{B} = \{1, \ldots, B\}$ the set of all B buyers, and $\mathcal{L} = \{1, \ldots, L\}$ the set of all L share classes. An all-or-nothing offer from seller $i \in \mathcal{S}$ takes the form $(s^i; q^i_1, \ldots, q^i_L)$ where s^i is the total ask price and q^i_l for $l = 1, \ldots, L$ represents the quantity being offered in share class l. Typically, fishing businesses own shares in only a few share classes so many of the q^i_l will be zero. Buyers submit separate offers for the different share classes. An offer from buyer $j \in \mathcal{B}$ for shares in share class l would take the form (b^j_l, y^j_l) where b^j_l is the per-unit price the buyer is willing to pay for any number of shares between y^j_l and $q^{\max}_l$.

The optimization problem becomes:

$$
\begin{aligned}
\max_{\sigma^i,\beta_l^j,\zeta_l^j} \quad & \sum_{j=1}^{B}\sum_{l=1}^{L} b_l^j \beta_l^j - \sum_{i=1}^{S} s^i \sigma^i \\
\text{s.t.} \quad & \sum_{j=1}^{B} \beta_l^j \le \sum_{i=1}^{S} q_l^i \sigma^i && \forall\, l \in \mathcal{L} \\
& \beta_l^j \le q_l^{\max} \zeta_l^j && \forall\, j \in \mathcal{B},\ l \in \mathcal{L} \\
& y_l^j \zeta_l^j \le \beta_l^j && \forall\, j \in \mathcal{B},\ l \in \mathcal{L} \\
& \sigma^i, \zeta_l^j \in \{0,1\} && \forall\, i \in \mathcal{S},\ j \in \mathcal{B},\ l \in \mathcal{L}
\end{aligned}
$$

This optimization problem may appear rather complex to solve (and, as discussed in the Section 4.4, in some sense it is) but that does not mean the tender is complex to participate in. Fishing businesses should not have to be concerned how the algorithm actually finds the surplus-maximizing solution. They only have to think about what offers to submit and with the right bidding language this should be simple and provide maximum protection against bad outcomes.

Furthermore, now that the tender has been formulated as a maximization problem subject to constraints, it is easy to add further constraints. Additional constraints limit the set of possible solutions, and as such, can make the algorithm complete faster. For example, one interesting option that adds further flexibility to fishing businesses is the possibility of submitting both buy and sell offers with the understanding that either the buy or the sell offers can be winning, but not both. Such offers are commonly referred to as "XOR" offers to reflect that the offers to buy OR sell are mutually eXclusive. They can be taken into account with a single additional constraint

$$
\sum_{l=1}^{L} \beta_l^i \le (1-\sigma^i) \sum_{l=1}^{L} q_l^{\max} \qquad \forall\, i \in \mathcal{S} \cap \mathcal{B}
$$

The intuition is that if sell offer is winning ($\sigma^i = 1$) then the buy quantities β_l^i are put to zero. While if the sell offer is losing there is no further restriction on the buy quantities other than those in the maximization problem above. Importantly, additional constraints can introduced such as the Department's **transfer rules** or the Department's preferences over **subsidy allocations** across share classes, as we discuss next.

4.2. Incorporating the subsidy

The $\Delta =$ \$15.5 million subsidy can be used in a variety of ways to stimulate share trading. An obvious approach would be to use the subsidy to cover trades with negative surplus. For instance, if a seller offers a share at \$15 but the buyer only wants to pay \$10 then subsidizing, say, the buyer with \$5 covers the negative surplus of the trade. More generally this approach would take the form:

$$
\begin{aligned}
\max_{\sigma^i,\beta_l^j,\zeta_l^j,\delta_l} \quad & \sum_{j=1}^{B}\sum_{l=1}^{L}(b_l^j+\delta_l)\beta_l^j - \sum_{i=1}^{S} s^i\sigma^i \\
\text{s.t.} \quad & \sum_{j=1}^{B}\sum_{l=1}^{L}\delta_l\beta_l^j \le \Delta \\
& \sum_{j=1}^{B}\beta_l^j \le \sum_{i=1}^{S} q_l^i\sigma^i && \forall\, l\in\mathcal{L} \\
& \beta_l^j \le q_l^{\max}\zeta_l^j && \forall\, j\in\mathcal{B},\ l\in\mathcal{L} \\
& y_l^j\zeta_l^j \le \beta_l^j && \forall\, j\in\mathcal{B},\ l\in\mathcal{L} \\
& \sum_{l=1}^{L}\beta_l^i \le (1-\sigma^i)\sum_{l=1}^{L} q_l^{\max} && \forall\, i\in\mathcal{S}\cap\mathcal{B} \\
& \sigma^i,\zeta_l^j\in\{0,1\} && \forall\, i\in\mathcal{S},\ j\in\mathcal{B},\ l\in\mathcal{L}
\end{aligned}
$$

where the objective is surplus inclusive of buyer subsidy and the first constraint makes sure that the clearing house does not overspend. But this is by no means the only way the subsidy could be used. Indeed, if the interest were in getting as many shares to those that remain in the industry then the subsidy could be used as follows:

$$
\begin{aligned}
\max_{\sigma^i,\beta_l^j,\zeta_l^j} \quad & \sum_{l=1}^{L}\sum_{j=1}^{B}\beta_l^j \\
\text{s.t.} \quad & \sum_{i=1}^{S} s^i\sigma^i - \sum_{j=1}^{B}\sum_{l=1}^{L} b_l^j\beta_l^j \le \Delta \\
& \sum_{j=1}^{B}\beta_l^j \le \sum_{i=1}^{S} q_l^i\sigma^i && \forall\, l\in\mathcal{L} \\
& \beta_l^j \le q_l^{\max}\zeta_l^j && \forall\, j\in\mathcal{B},\ l\in\mathcal{L} \\
& y_l^j\zeta_l^j \le \beta_l^j && \forall\, j\in\mathcal{B},\ l\in\mathcal{L} \\
& \sum_{l=1}^{L}\beta_l^i \le (1-\sigma^i)\sum_{l=1}^{L} q_l^{\max} && \forall\, i\in\mathcal{S}\cap\mathcal{B} \\
& \sigma^i,\zeta_l^j\in\{0,1\} && \forall\, i\in\mathcal{S},\ j\in\mathcal{B},\ l\in\mathcal{L}
\end{aligned}
$$

The objective is now total quantity bought across all share classes and the first constraint makes sure that the clearing house does not spend more than the total subsidy.

Importantly, as these examples illustrate, there are a number of ways the subsidy can be incorporated. To determine the "best" way one has to consider both economic factors (efficiency of the resulting share allocations) as well as key objectives of the reform program. As such, the implementation of the subsidy program is something that should be worked out between the Department and the company it hires to develop the combinatorial market (if the approach would be adopted).

4.3. Uniform prices

A combinatorial market mechanism not only determines the transfer of shares it also determines share prices. An important distinction is whether such prices are "discriminatory" or "uniform" across participants. For example, suppose a seller is willing to sell two shares at a per-unit price of \$2 and one buyer is willing to pay \$4 and another \$10. If the seller struck separate deals with the buyers, the resulting prices might be halfway at \$3 and \$6 respectively. This would be an example of discriminatory prices. Under uniform pricing, both buyers would pay the same, \$3 if the lowest buyer and the seller meet each other halfway. Importantly, the use of uniform prices avoids envy across buyers and sellers interested in the same share class.

The example also hints at the following in general that are many "market clearing" prices, e.g. when the seller asks \$2 and the buyer offers \$4 then *any* price between \$2 and \$4 clear the market, and going halfway is only one of the possible choices. More generally, let $\mathcal{B}_l^W = \{j \in \mathcal{B} | \beta_l^j > 0\}$ denote the set of buyers who win some shares in share class l and let $\mathcal{S}^W = \{i \in \mathcal{S} | \sigma_i = 1\}$ denote the set of winning sellers. Then we demand that market-clearing prices satisfy:[2]

$$p_l \leq b_l^j \qquad \forall\, j \in \mathcal{B}_l^W$$

for the buyers and

$$\sum_{l=1}^{L} q_l^i p_l \geq s^i \qquad \forall\, i \in \mathcal{S}^W$$

for the sellers. Note that both sides of the market can get better deals than they were asking for: the buyer pays a price lower, or equal, than the per-unit price offered, and the seller receives a total price higher, or equal, to the amount requested. It would be easy to include a subsidy into the inequalities, e.g. with a buyer subsidy the above constraint changes to $p_l \leq b_l^j + \delta_l$ for all $j \in \mathcal{B}_l^W$.

As in the above example there are typically many prices that solve these inequalities. Sellers would like higher prices, which could be obtained as follows

$$\begin{aligned} \max_{p_l} \quad & \sum_{l=1}^{L} p_l \\ \text{s.t.} \quad & p_l \leq b_l^j \qquad \forall\, j \in \mathcal{B}_l^W \\ & \sum_{l=1}^{L} q_l^i p_l \geq s^i \quad \forall\, i \in \mathcal{S}^W \end{aligned}$$

[2] In principle, we could also take losing offers into account. For example, suppose a single seller offers 1 share at \$2 and two buyers offer to pay \$9 and \$10 respectively. Then instead of going halfway between the winning buyer's offer and the seller's ask, which would result in a price of \$6, it makes sense to set the price at \$9 to keep the other buyer out of the market. However, with combinatorial offers, there do not always exist linear prices that satisfy all the market-clearing constraints imposed by losing and winning offers. For this reason, we simply focus on the market-clearing constraints imposed by the winning bids.

Conversely, buyers would lower prices, which follow from a similar program

$$\begin{aligned} \min_{p_l} \quad & \sum_{l=1}^{L} p_l \\ \text{s.t.} \quad & p_l \le b_l^j \qquad \forall\, j \in \mathcal{B}_l^W \\ & \sum_{l=1}^{L} q_l^i p_l \ge s^i \quad \forall\, i \in \mathcal{S}^W \end{aligned}$$

A weighted average of the two sets of prices could be used to clear the combinatorial market.

4.4. Practical difficulties

In this section, I address two questions that might affect the performance of the combinatorial market in practice:

Q1. Is the combinatorial market computationally too complex for the organizer to solve?

Q2. Are there difficulties in conducting a multi-round process (on a single day)?

Together with a computer science group in Munich, I have started to explore Q1 with simulations. The simulations are based on industry information we received from the Department and employ the bid language of Section 4.1. In particular, every business that intends to retire or sell its shares can propose an all-or-nothing offer that includes all current holdings in various share classes. The bid has a single ask price for the entire set of shares, see Figure 3 for an example.

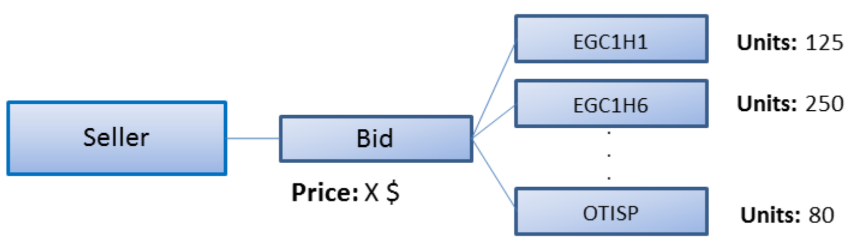

Figure 3. An example of an all-or-nothing sell offer.

Buyers may want to purchase shares from several share classes and, hence, we allow buyers to make bids that involve multiple share classes (but are not combinatorial in nature). Buyers can specify a range for the quantity desired and a bid price per share, see the example in Figure 4. In addition we allow for offers where a business sells its shares *only if* it gets some other desired shares instead. In a next iteration, we will include the XOR offers discussed in Section 4.1.

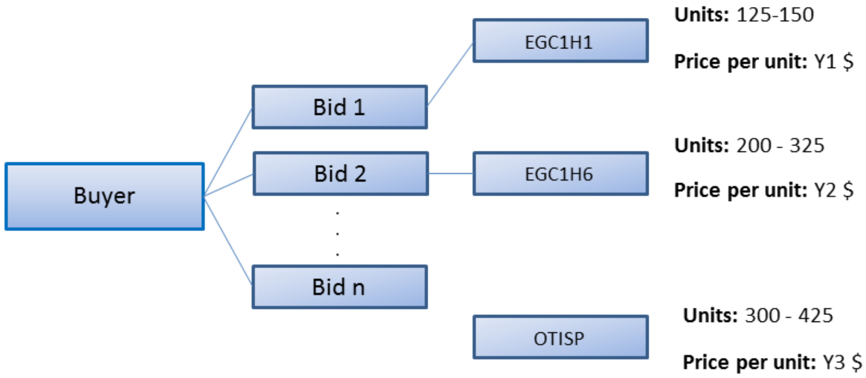

Figure 4. An example of a buy offer.

We implemented an initial version of an offer generator which creates artificial bids based on the data about current holdings of fishing businesses. The offer generator follows simple decision rules based on current holdings to decide whether a fishing business wants to buy or sell shares or submit combined buy and sell offers . We generate sell offers if a fishing business:

1. is not profitable and wants to sell all its shares
2. has some unused shares, which it wants to sell
3. wants to change its fishing type/zone by selling some of its shares but only if it can purchase new ones

We generate buy offers to simulate when a fishing business:

1. wants to increase their shares in efficiently used endorsements
2. wants to get shares for a new endorsement in the same region

The generator iterates over all fishing businesses and randomly chooses whether it participates as a buyer or seller (or not at all), with the probability of being a buyer being increasing in the business' GVP. For each seller, one of the strategies goals above is then selected and a corresponding bid package is created. For each buyer, we consider the endorsements it actively uses to predict the shares it wants to buy. We create several offers for each buyer.

The prices specified in the offers are based on the average GVP in each endorsement and the scarcity of shares. First, we determine a common value for each share class and then let each business randomly deviate from this common value, i.e. the business may underestimate or overestimate the value.

An example of a simulation had the following characteristics:

1. Total number of participants: 1039
2. Total number of bids: 1070
3. Buyers: 517, number of bids: 548
4. Sellers: 522, number of (package) bids: 522

When we executed the constrained-maximization program of Section 4.1 using this setup, the program solved in seconds or minutes. This indicates that with the bidding language proposed in Section 4.1, the approach is highly feasible.

The answer to Q2 is that over the next months steps need to be taken to ensure industry engagement, possibly in the form of running "mock" trials. Decisions will need to be made regarding the format and nature of the submission forms. A multi-round process conducted over the course of a single day would typically require web-based participation. Ignoring for the moment whether all fishers are Internet savvy, there undoubtedly would be technical problems when trying to conduct a large-scale market on the web with hundreds of participants, scattered over a large geographic area (with some in very remote locations). For starters, there would be a number of them who would not have the right version of the browser or JAVA installed, and it would be ludicrous to expect fishers to know how to resolve such issues on their own.

Having said that, a solution could be to make the process less web dependent. For instance, fishers could possibly call in or fax their offers and the web would be used only to show results (in which case the web-page could be much simpler and involve only basic HTML to avoid any software-version problems). If also the phone or fax are considered too technologically advanced, only paper submission is a possibility. This would preclude running multiple rounds in one day, but maybe the tender process could be done over a series of days/weeks instead.

5. Conclusions and Recommendations

The current exit grant proposal constitutes an important improvement over earlier suggested approaches that were based on straight buy outs. Yet it has important shortcomings and there is considerable room for further improvement. A multi-round combinatorial market offers such improvement by greatly reducing the uncertainty and strategic complexity that fishing businesses face under the current proposal.

In particular, a multi-round combinatorial market would

(i) protect exiting businesses from being left with a fragmented and unviable share portfolio,

(ii) protect those that stay in the industry from obtaining less than the desired number of shares,

(iii) allow for consolidating tender offers,

(iv) offer the flexibility to submit mutually exclusive offers to either stay or go,

(v) reduce uncertainty about share values and others' (strategic) behavior,

(vi) allow for better allocation of the $15.5 million subsidy,

(vii) allow for the Department to impose clearly specified restrictions,

(viii) reduce delays and transaction costs.

For the practical implementation of the multi-round combinatorial market, important details will have to be settled. First, software that handles the expressive tender offers described above will have to be developed specifically for this application. Second, how this software will be built depends on the format and nature (web, phone, Fax) of the tender submission forms. Third, important decisions with respect to the timing and duration of the tender process have to be made (single shot, repeated rounds during a single day, or over the course of days/weeks).

My recommendation would be to develop a combinatorial market form along the lines sketched above. To hire a team or company that can develop the required software and who collaborate closely with the Department, SARC, and industry representatives, to decide on important details (timing, duration, submission forms and formats) that feed back into the software. It is a substantial project and it is imperative that this team starts as soon as possible for the tender process to be conducted in 2015.