Marine Policy 122 (2020) 104218

Contents lists available at ScienceDirect

Marine Policy

journal homepage: http://www.elsevier.com/locate/marpol

Full length article

Factors influencing financial performance in marine small-scale fisheries value chain in Kenya

Patrick Kimani [a,*], Andrew Wamukota [a], Julius O. Manyala [b], Chrisestom Mwatete Mlewa [a]

[a] Pwani University, P. O. Box 195, Mombasa, Kilifi, Kenya
[b] Jaramogi Oginga Odinga University of Science & Technology, P. O. Box 210, 40601, Bondo, Kenya

ARTICLE INFO

Keywords:
Structure-conduct-performance
Small-scale fisheries
Sales
Costs
Profitability

ABSTRACT

Factors influencing financial performance in marine small-scale fisheries are numerous but are scantily documented and tested, more so from the Structure-Conduct-Performance perspective. The present study empirically tested influence of structure in context value of equipment, on actors' conduct in context of price collusion, choice of products, access to market information and power to determine prices, and how these and other factors influenced performance in terms of profitability. Data was collected through field interviews targeting 403 actors (fishers, middlemen and small-scale processors) at five sites along the Kenyan coast. Binomial, multinomial, ordinary least squares regressions and regressions with instrumental variables were used in data analysis. Findings revealed that structure did not significantly influence actors conduct, while both structure and conduct influenced performance only on a few variables and actors. Instead other non-Structure-Conduct-Performance variables influenced performance across all actor groups. Increasing sales, improved profitability, while increasing variable and fixed costs decreased profitability. Results of the study provide important insights on actor behaviour that are useful for policy and value chain development interventions.

1. Introduction

Kenya's marine fisheries are dominated by Small-Scale Fisheries (SSFs), but only account for 7% of national production [1–3]. Like other SSFs globally [4,5], they are critical in food security, income and employment through activities in fishing, trading and small-scale processing. Continued maintenance of these roles requires supportive interventions that take into account operational aspects, such as actor structural positioning, competitive behaviour and how these among other factors influence financial performance [6,7]. Actors' structural positioning based on capital investments, determines their functions [8]. In SSFs, high-capitalized middlemen traditionally control decision-making, facilitate fishing and coordinate distribution and marketing of fish, while low-capitalized middlemen and fish processors, retail and process fish [9,10].

Structural positioning also influences actions taken by actors to maintain market command, for example collusion to set prices, choice of products, access to market information and power to determine prices [12–14]. These ultimately determines actors' financial performance. This causal relationship, referred to as the Structure-Conduct-Performance (S–C–P) paradigm in industrial organization was advanced by Mason (1939) and Bain (1959). In the S–C–P paradigm, actor positioning is referred to as structure, while actor behaviour is referred to as conduct.

In fisheries, several conduct variables have been studied for example the choice of fish grade and products, hinged on size, species, quality and gear used [16,17]. Different fish grades attract differentiated prices based on buyer's capital outlay, consumer demand and preference. For example, low capital-endowed small-scale fish processors in East Africa target low-grade, low-value fish for sale to low-income consumers [10,18]. Actors' choice of fish grade hinged on structural positioning, has been scantily studied in Kenya.

Access to market information informs actors choices and negotiation power. For example, Sambuo & Kirama (2018) found that access to market information by fishers in Lake Victoria, significantly influenced their price negotiations. On the other hand, lack of information reduces transparency and worsens collusion [20–22]. Access to market information based on structural positioning and extent of collusion, have not been addressed in Kenyan marine SSFs.

Power to determine prices is dependent on structural positioning,

* Corresponding author.
E-mail address: patrick.kimani2002@gmail.com (P. Kimani).

https://doi.org/10.1016/j.marpol.2020.104218
Received 5 April 2020; Received in revised form 10 August 2020; Accepted 18 September 2020
Available online 4 October 2020
0308-597X/

where low capital-endowed actors have low capacity to determine or negotiate prices [7,11]. For example, fishers dependent on middlemen's facilitation are often forced to sell to single buyers [23]. This stifles opportunities for price negotiations and fair catch shares [24,25]. Poorly capitalized middlemen and small-scale processors also face challenges of fish access, and are discriminated by high-capitalized middlemen and fishers [10]. Such capital asymmetries and price setting mechanisms in the fishing node are well studied [26–28]. However, empirical studies addressing power asymmetries in processing and trading nodes in Kenya are scarce.

Study of performance in fisheries has traditionally focused on indicators such as sales, costs and profitability [7,29,30]. Level of sales determines the accrued profitability [31]. Costs are also an important component of profitability and vary considerably. Variable costs are usually higher than fixed costs in some fisheries [32,33], and lower in others [34]. Considerable variations in costs by gear type have also been noted [35]. There is a general inadequacy of information on costs and profitability concerning trading and processing nodes, where much emphasis has been on the fishing node.

Numerous factors influence financial profitability in fisheries value chains. In the present study we use financial profitability which refers to returns made after subtracting all costs and interests [29,30]. It is distinguished here from economic profit—which refers to returns made after subtracting all costs, interests and opportunity costs of capital and labour [29,30]. Profitability in fishing is influenced by invested capital, fish type and grade, number of days fished, fishing site, vessel type and

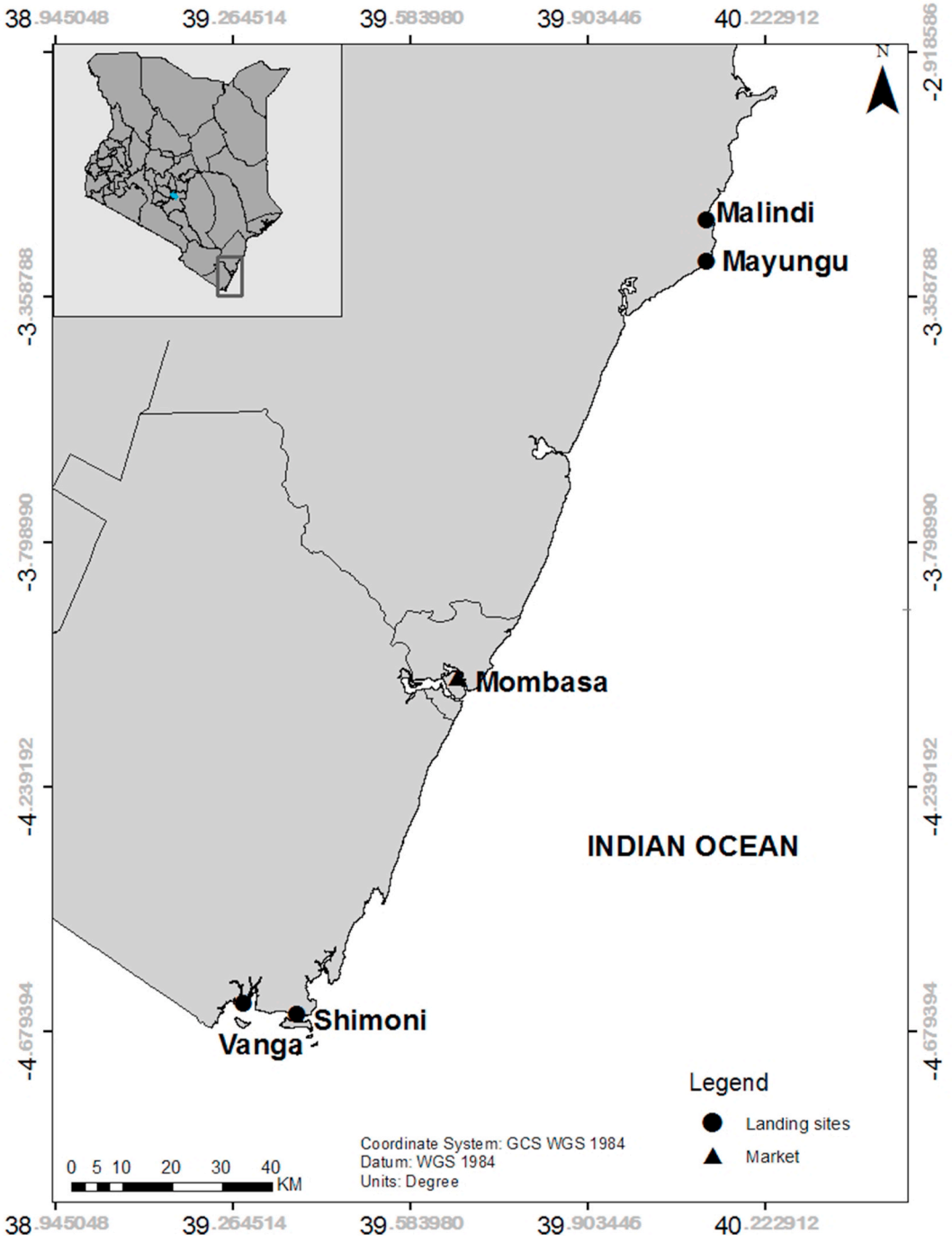

Fig. 1. A map of the Kenyan coastline showing study sites.

crew size [35–37]. In trading and processing, it is influenced by experience, level of capitalization and education [38]. In Kenya, several studies addressing some aspects of profitability have been undertaken [39,40]. Studies addressing variation in profitability and its influencing factors particularly for downstream nodes are scanty.

The present study conducted in Kenya's marine SSFs explored how structure influenced actors conduct, and how structure, conduct and other factors influenced performance in terms of profitability. Structure indicators included middlemen's and processors' value of equipment, percent ownership of equipment amongst fishers and market concentration [15,19] amongst primary middlemen. Conduct indicators included collusion to set buying and selling prices, access to fish buying and selling price information, power to determine fish prices and choice of fish grade.

2. Materials and methods

2.1. Study area

The study was conducted along Kenya's coast at Malindi and Mayungu fish landings sites in Kilifi County in the North and Shimoni and Vanga in Kwale County in the South (Fig. 1). Mombasa in Mombasa County—the largest coastal city was also included. It is a convergence fish market for the rest of the Kenyan coast. Mayungu, Shimoni and Vanga are rural, while Malindi is urban, hence a rural-urban representation and North-South dispersion. Malindi and Shimoni lie next to no-take marine protected areas, while Mayungu and Vanga have some of their fishing grounds lying within marine reserves with gear restrictions. These variations may have implications on catches and market access, and are representative of Kenya's marine SSFs.

Landing site specific data for marine fisheries in Kenya is difficult to obtain since it is aggregated at a higher level by county. However, the fisheries at the study sites are dominated by SSFs, where the main vessels in use include dugout canoes, outrigger canoes and wooden boats, using sails, poles and paddles [41]. Only a few vessels are fibre boats using engines. The fishery is multi-gear, multispecies with basket trap, gill net, hand line, spear gun and beach seine as the major gears in use. Key fish species in landings include demersals such as rabbitfishes, snappers and scavengers; pelagics such as needlefishes, tuna and mackerels; molluscs such as octopus and squid; crustaceans such as lobsters and crabs and sharks, rays and mixed species [42].

Fish trading is undertaken by middlemen at primary and secondary levels. Middlemen play a pivotal role of facilitating fishing, particularly the migrant fishers at the four landings sites of the study, by providing equipment and operational capital [43–45]. Much of the processing is undertaken by small-scale fish processors who fry fresh fish for sale, while industrial processing for marine fish is minimal. Industrial fish processors have stationed collecting agents at Malindi and Shimoni landing sites. See detailed value chain description in Ref. [46]. State of supportive infrastructure is varied. By the time of this study, Mayungu, Shimoni and Vanga had unpaved access roads. There were cold rooms at Malindi and Vanga and an ice making machine at Vanga, but all were non-functional by the time of this study. Thus, ice was supplied by private operators through company agents and middlemen.

2.2. Data collection

Data were collected from fishers' vessel captains, middlemen and processors through individual interviews between November 2014 and December 2015. Since recall data is fraught with measurement error, best average estimates were derived from the most recent recall estimates for a typical day or trip in South East Monsoon (SEM) and North East Monsoon (NEM) seasons. Most fish fishers did one trip/day, while offshore handline fishers took up to two days/trip. Respondents indicated lowest, average and highest amounts for each season, which were then averaged to create cross-sectional data. The rationale was to obtain the closest estimate between the two seasons, given that required landing site specific data is not available in government datasets.

Structure indicators recorded included cost of equipment, its ownership and age. Level of trading for middlemen was recorded as; primary (sourcing fish directly from fishers) or secondary (sourcing from other middlemen). Fishers' primary gear was also recorded.

For conduct indicators, actors recorded their tendency to collude to set prices, access to price information prior to transactions and power to determine fish prices (through dictation, negotiation or price taking). Choice of fish grade was also recorded and was based on a four-point local fish grading system (grades 1+, 1, 2 and 3). Grading is dependent on size and species, where grade 1+ attracts the highest price, and 3 the lowest.

The short run performance indicators for the SEM and NEM seasons used to calculate profitability included; costs, purchases and sales. Fish amounts were also recorded. Fishers catch share formula was also recorded to aid in financial profit calculation. Fishers' variable costs included; fuel, food, bait, hooks, sinkers, transport and porter costs. Fixed costs included; equipment repair, service and maintenance, house rent and anchorage fees for migrant fishers. Middlemen's variable costs included; transport, ice and labour, while fixed costs included; equipment repair, service and maintenance, premises rent, electricity, water and licenses. Processors' variable costs included; frying oil, energy, condiments and packaging material, while fixed costs were equipment repair and licenses. Respondents' demographic and socio-economic data were also recorded.

A total of 403 respondents were identified through systematic sampling, where every *k*th respondent by actor group was interviewed following [47]. The Slovin's formula [48,49] was used to determine the sample size. This yielded 73 middlemen, 108 processors and 222 fisher boat captains from an estimated population of 601 respondents (109 middlemen, 157 processors and 335 fishing units).

2.3. Data analysis

Structure was deduced from actor capitalization through computation of the present value of equipment, using the straight line depreciation method following [50]. Average exchange rate for year 2015 (KES 91.25 to the US dollar) was used [51]. Useful lifetime of equipment was assumed to be that of the oldest similar equipment from the dataset. Equipment in the fishery are used for long before retirement, hence a salvage value of 50% of purchase price was applied.

The present value and specialization were then used to categorize actors further. High-capitalized fishing units using engine propelled boats and fishing offshore, were categorized as offshore high-capitalized fishers. Low-capitalized, units fishing inshore using un-mechanized vessels such as canoes, were categorized as inshore low-capitalized fishers.

Middlemen, were classified using local criteria, where large-scale middlemen (locally known as *Matajiri*), typically have the following characteristics; 1) operated from own premises 2) ownership of 'critical equipment' such as fishing gear, boats, engines and storage equipment, 3) ownership of at least two types of critical equipment with a value of ≥USD 2192. Traders not meeting these criteria were classified as small-scale middlemen. Middlemen were further categorized as primary or secondary middlemen. Small-scale fish processors and restaurant operators who primarily fried fresh fish, were broadly categorized as processors.

Market concentration was determined by computing Herfindahl-Hirschman Index (HHI) based on buyers' sales volumes following [13,14,52], as expressed below:

$$HHI = \sum_{1=1}^{n} (ss)^2 \mathrm{i} \quad (1)$$

Where n is the total number of buyers per site and SS is the percentage

share of sales for buyer *i*. Competitiveness was only captured at the primary level and hence Mombasa with secondary buyers only, was omitted.

Fish grading as a conduct factor required further elaboration. To delineate the most targeted fish grades by an individual, a 65% cut-off was set. Targeting >65% of grades 1+ and 1, was considered as high-grade and grades 2 and 3 as low-grade. Targeting <65% of both high and low grade was considered as mixed grade.

Averaged indicators for the SEM and NEM seasons were used in analysis of financial profit following [36,53,54] as below.

$$Financial\ profit = GR - VC - FC - LC \quad (2)$$

Where; *GR* is gross revenue from sales, *VC* is variable cost, *FC* is fixed cost and *LC* is labour cost.

Test for significant differences in financial profit between actor groups was done using Kruskal Wallis test. The Dunn's post-hoc test for differences in pairs was also done.

Influence of structure on actors' conduct was tested using logistic regressions [55]. See structure and conduct variable description below (Table 1). R statistical software (Version 3.5.3) [56], was used in analysis, where *glm* binomial option and *mlogit* package were used for binomial and multinomial logistic regressions respectively. Assumption of linear relationship between log odds of the dependent variable and the continuous independent variables was satisfied in all models. The Hosmer-Lemeshow test for goodness of fit was done using the *generalhoslem* package in R, and all models fitted well ($p > 0.05$). Multicollinearity was checked through inspection of Variance Inflation Factors (VIF) using *vif* function and all models were satisfactory with values < 10. The Hausman-McFadden test for assumption of Independent Irrelevant Alternatives for multinomial logistic regressions, was done using the *mlogit* package, and the assumption held for all models ($p > 0.05$). The general logistic equation is stated below.

$$\mathbf{P}(\mathbf{Y}) = \frac{1}{1 + e^{-(\beta_0 + \beta_{1i}\mathbf{x}_{1i} + \cdots \beta_{ji}\mathbf{x}_{ji})}} \quad (3)$$

Where *P* is the probability of predicting *Y* dependent variable, *e* is the base of natural logarithm, while *Xs* are the independent regressors for *i* respondent.

Analysis of performance (in context of profitability) and its influencing factors (structure, conduct and other variables) was done using Ordinary Least Squares (OLS) regression in R. See variable description below (Table 1). Cook's distance was used to determine outliers, where extreme values were omitted from analysis. Non-linear continuous regressors; sales, fixed and variable costs for fishers, sales for middlemen and variable costs, sales and experience for processors were transformed using Johnson's and Box Cox transformations. The dependent variable (financial profit) violated the Shapiro-Wilks test for assumption of normality, and Johnson's and Box-Cox transformation done for fishers', middlemen's and processors' models respectively. The Breusch-Pagan Test for homoscedacity was done using *bptest* function in R, and all models held ($p > 0.05$). Multicollinearity was inspected through Variance Inflation Factors (VIF) and all models were satisfactory with values < 10. Autocorrelation was tested using the *durbinWatsonTest* function in R and all models were satisfactory ($p > 0.05$). The general linear regression equation is stated below (Equation iv).

$$\boldsymbol{P(Y)} = \boldsymbol{\beta_\theta} + \boldsymbol{\beta_{j1}x_{j1}} + \ldots + \boldsymbol{\beta_{jp}x_{jp}} + \boldsymbol{\varepsilon} \quad (4)$$

Where *P* is the probability of predicting *Y* (the dependent variable), while *Xs* are regressors for *i* respondent and $\mathcal{E}$ is the error term.

Initial regression results showed that the test of influence of structure and conduct on performance alone had only few significant influencing variables. In the fishers' S–C–P model, only fish grade and power to determine selling prices were significant. In the middlemen's S–C–P model, only fish grade and value of equipment were significant. In the processors' S–C–P model, only access to selling price information and value of equipment were significant. These variables explained little variation in the models; 0.3% for fishers, 13% for processors and 48% for middlemen. Therefore, additional variables known to influence performance were also considered in the OLS analysis [29,35–37].

In the OLS model with all variables, several regressors were suspected to be endogenous—having relationship with the dependent variable and the error term. These variables are those that seemed most likely to correlate to multiple variables not included in the model. In this case such endogenous variables result to biased estimates [57,58]. The solution to this problem is to use an Instrumental Variable (IV) *z* (see Equation v). The IV regressor should not be directly related to the dependent variable, except through the identified endogenous regressor, and should also be exogenous (not related to the error term) [57,58].

$$P(Y) = \beta_\theta + \beta_{j1}x_{j1} + \beta_{j2}z_{j2} + \ldots + \beta_{jp}x_{jp} + \varepsilon \quad (5)$$

Variable cost in the fishers' model was suspected to be endogenous, where working hours and boat propulsion were used as IVs. Longer working hours and the type of propulsion influenced variable costs but not influencing profitability directly. Sales in the middlemen's model was suspected to be endogenous, where multiplicity of buyers and actors' possession of critical equipment were used as IVs since they influenced sales volumes but not profitability directly. Variable cost in the processors' model was suspected to be endogenous, where working hours was used as IV since actors working for longer hours travelled far distances and hence incurred higher transportation costs. The regression model with IV was executed using the *ivreg* function in AER package in R. The *vcov* function in *sandwich* package was used in calculation of White's standard errors, as well as performing diagnostics. These included the Wu-Hausman test for endogeneity, the Sargan test for

Table 1
Description of variables used in regression analysis.

Description of variable	Type of variable	Variable levels
Financial profit person^{-1}day^{-1}	Continuous	NA
Sales	Continuous	NA
Fixed costs	Continuous	NA
Variable costs	Continuous	NA
Working hours	Continuous	NA
Experience in years	Continuous	NA
Percent ownership of equipment	Continuous	NA
Equipment value	Continuous	NA
Access to credit	Categorical	Yes, no
Site	Categorical	Malindi, Mayungu, Mombasa, Shimoni, Vanga
Actor type – fishers by gear	Categorical	High-capitalized handline, reef seine net, drifting gillnet, basket trap set net, low-capitalized handline
Actor type – fish buyers	Categorical	Company agent, large-scale primary middlemen, large-scale secondary middlemen, small-scale primary middlemen, small-scale secondary middlemen and processors
Power to determine buying price	Categorical	Seller, self, negotiated
Power to determine selling price	Categorical	Buyer, self, negotiated
Buyers' accesses buying price information	Categorical	Yes, no
Accesses selling price information	Categorical	Yes, no
Education level	Categorical	Not schooled, primary, secondary, tertiary
No. of buyers selling to	Categorical	Single, multiple
Training	Categorical	Yes, no
Buyers' buying collusion	Categorical	Yes, no
Selling collusion	Categorical	Yes, no
Buyers' choice of fish grade	Categorical	High grade, mixed grade, low grade

Table 2
Summary of actors' demographic and socio-economic characteristics.

Variable	Levels	Processors	Fishers	Middlemen
Experience	% experience (1–10yrs)	79	16	60
	% experience (11–20yrs)	16	36	30
	% experience (21–30yrs)	6	23	5
	% experience >30yrs	–	24	4
Education	% none	1	0	0
	% with primary education	96	93	67
	% with secondary education	2	6	28
	% with tertiary education	1	1	5
Time spent	Average number of hours worked per day	11	12	10
Gender	% Female (27% of all actors)	97	0	5
	% Male (73% of all actors)	3	100	95
Marital status	% married	59	94	84
	% divorced	19	1	7
	% single	10	5	8
	% widowed	11	0	1

validity of instruments and the test of strength of instruments.

3. Results

3.1. Demographic and socio-economic characteristics

Fish processors were the most inexperienced actors, with 79% being new entrants with less than 10 years' experience, while fishers were the most experienced (Table 2). Education level across all groups was generally low. Majority of actors were schooled to primary level, although more middlemen had secondary education.

On average, actors spent between 10 and 12 h in fisheries related activities. Processing was female-dominated, while fishing and trading were male-dominated. Forty-one percent of processors were unmarried, widowed or divorced.

3.2. Structure

Sampled actors consisted of fishers (55%), middlemen (27%) and processors (18%). Five broad classification groups emerged (Table 3). High-capitalized middlemen had the highest investments, while processors had the least. Proportionally, fishers owned 27–73% of the equipment they used, while middlemen owned the rest. Observably, two of the high-capitalized fisher categories had the least ownership.

Herfindahl-Hirschman Index (HHI) scores were 607 for Mayungu, 920 for Shimoni, 988 for Vanga and 1053 for Malindi. Therefore scores were below 1800 threshold, hence indicating low market concentration and high market competitiveness [13].

3.3. Influence of structure on actors' conduct

Influence of structure on actors' conduct was not statistically significant for any of the variables (Table 4). This suggests that structure did not influence conduct. However, some conduct variables were more correlated to certain actor groups. For example, 30% of middlemen targeted high-grade fish, 58% mixed grades and only 12% targeted low-grade fish. In contrast, only 5% of processors targeted high-grade fish, 23% targeted mixed grades and 72% targeted low-grade fish.

3.4. Performance indicators

Fish volumes dealt with by buyers and high-capitalized fishers, largely correlated with their level of capital investments (Table 5). Fish purchases and sales amongst buyers also showed similar trends, except for small-scale secondary middlemen with higher purchases and sales, due to higher secondary prices. Reef seine net fishers had the lowest per capita fish volumes and sales resulting from sharing amongst large crews of up to 18 members.

Costs, unlike other indicators showed low correlation to level of capital investments. However, high-capitalized fishers incurred comparatively higher variable costs, which were subtracted first before fishers shared catch proceeds with middlemen. Generally, high-capitalized middlemen incurred higher fixed costs associated with maintenance of their boats and equipment.

Similarly, patterns of financial profitability were mixed and showed low correlation to level of capitalization for some actor groups. Based on the profit sharing arrangement, reef seine net fishers earned the lowest profits comparatively. High-capitalized handline fishers earned the highest profits. However, Kruskal Wallis test results showed no significant differences in profitability between gears ($H = 8.605$, $df = 6$, $p = 0.233$), due to large variations within gears.

Amongst buyers, company agents earned the highest profits, while processors earned the least. Kruskal Wallis test results showed significant differences in profitability between middlemen categories ($H =$

Table 3
Actor categorization by capitalization.

Broad category	Fishers by gear	n	Average value of equipment in USD	% equipment ownership
Offshore fishers	High-capitalized handline	38	4480	27
	Drifting gillnet	11	4050	27
	Reef seine net	11	3670	73
Inshore fishers	Set net	34	1108	59
	Basket trap	78	895	58
	Low-capitalized handline	50	336	45
	Sub- total	222		
	Buyers			
High-capitalized middlemen	Company agent	3	48,258	91
	Large-scale secondary middlemen	4	9389	100
	Large-scale primary middlemen	15	9236	100
	Sub- total			
Low-capitalized middlemen	Small-scale primary middlemen	34	885	98
	Small-scale secondary middlemen	17	781	90
	Sub- total	51		
Processors	Small-scale fish processors	108	32	100
	Total	403		

Table 4
Results of influence of structure on actors' conduct from separate regressions.

Conduct variable	Levels	Odds ratio	Coefficient	Std. Error	z-value	P-value
Fishers						
Power to determine selling price	Self	0.998	0.006	0.007	0.852	0.394
	Negotiated	1.006	−0.002	0.003	−0.651	0.515
Price collusion	Colludes when selling	0.997	−0.003	0.005	−0.554	0.579
Price information	Accesses selling price information	0.999	−0.001	0.003	−0.280	0.779
Middlemen						
Power to determine buying price	Self	1.000	−0.000	0.000	−0.452	0.651
	Seller	1.000	−0.000	0.000	−1.124	0.261
Power to determine selling price	Self	1.000	0.000	0.000	0.870	1.000
	Buyer	1.000	0.000	0.000	0.222	1.000
Price collusion	Colludes when buying	1.000	0.000	0.000	0.157	0.876
	Colludes when selling	1.000	0.000	0.000	0.815	0.415
Price information	Accesses buying price information	1.000	0.000	0.000	0.468	0.640
	Accesses selling price information	1.000	0.000	0.000	0.822	0.411
Choice of fish grade	High fish grade	1.000	0.000	0.000	1.412	0.158
	Mixed fish grades	1.000	0.000	0.000	1.311	0.190
Processors						
Power to determine buying price	Self	1.000	−0.000	0.000	−0.241	0.810
	Seller	1.000	0.000	0.000	0.189	0.850
Price collusion	Colludes when buying	1.000	0.000	0.000	0.783	0.434
	Colludes when selling	1.000	−0.000	0.000	−0.806	0.420
Access to price information	Accesses buying price information	1.000	0.000	0.000	0.009	0.993
	Accesses selling price information	1.000	0.000	0.000	0.632	0.528
Choice of fish grade	Low fish grade	1.001	−0.001	0.001	−1.137	0.255
	Mixed fish grades	1.001	0.001	0.001	0.888	0.374

Table 5
Mean daily fish amounts dealt with in kg, and purchases, sales, fixed costs, variable costs and financial profit person^{-1} in USD. Actors are listed in decreasing order of capital investments.

Actor type	Fish amounts	Purchases	Sales	Variable costs	Fixed costs	Financial Profit
Fishers						
High-capitalized handline	23 ± 3	–	39.77 ± 6.04	14.73 ± 2.15	0.76 ± 0.13	15.74 ± 2.72
Drifting gillnet	12 ± 2	–	18.39 ± 4.73	3.79 ± 1.66	1.25 ± 0.35	6.76 ± 2.42
Reef seine net	7 ± 1	–	8.58 ± 2.19	2.50 ± 1.13	0.24 ± 0.05	4.95 ± 1.25
Set net	8 ± 1	–	16.99 ± 2.24	0.52 ± 0.25	0.49 ± 0.08	10.50 ± 1.58
Basket trap	8 ± 1	–	15.39 ± 1.24	1.35 ± 0.30	0.65 ± 0.10	10.37 ± 0.99
Low-capitalized handline	10 ± 1	–	14.41 ± 1.98	1.80 ± 0.65	0.22 ± 0.05	12.71 ± 1.58
Fish buyers						
Company agent	232 ± 134	469.66 ± 132.57	597.57 ± 125.11	14.31 ± 10.94	27.70 ± 11.24	85.91 ± 22.63
Large-scale secondary middlemen	178 ± 93	320.55 ± 97.45	386.31 ± 122.32	10.60 ± 2.08	14.88 ± 7.09	40.27 ± 19.90
Large-scale primary middlemen	107 ± 25	231.12 ± 48.86	331.67 ± 72.16	30.27 ± 14.46	14.29 ± 2.07	56.00 ± 12.05
Small-scale primary middlemen	61 ± 12	97.39 ± 10.21	132.93 ± 14.39	7.52 ± 1.75	2.14 ± 0.70	25.88 ± 4.21
Small-scale secondary middlemen	55 ± 6	150.87 ± 20.67	182.09 ± 23.85	8.49 ± 1.62	3.51 ± 1.23	19.22 ± 3.22
Small-scale fish processors	7 ± 1	11.85 ± 0.88	22.50 ± 1.58	4.16 ± 0.31	0.11 ± 0.03	6.45 ± 0.61

12.286, df = 4, p = 0.02). However, Dunn's post-hoc test for profitability between different groups of middlemen revealed that none of the comparisons was significant, due to large individual variations within groups.

3.5. Factors influencing actors' profitability

The all-variable regression model results presented here are based on either the selected OLS model or model with IV.

3.5.1. Fishers

The Wu-Hausman test for endogeneity revealed that the model with IV was better in estimating the regression (p = 0.021) compared to the OLS model (Table 6). Fishers' profitability increased significantly, as sales increased, but decreased as variable and fixed costs increased. Reef seine net, drifting gillnet and set net fishers earned significantly lower income compared to other groups. This was associated with higher costs and lower per capita catches (Table 5). Fishers at Shimoni earned significantly higher incomes compared to Malindi, Mayungu and Vanga. This is possibly due to lower costs associated with most of the unmechanized vessels here. Percent ownership of equipment and actors' power to determine fish prices only marginally influenced fishers' profitability. Notably, conduct factors showed no significant influence on profitability. The model with IV explained 65% of the variation.

3.5.2. Middlemen

The Wu-Hausman test revealed that OLS model was better in estimating the regression than the model with IV(p = 0.455) (Table 7). Middlemen's profitability increased significantly, as sales increased, but decreased as variable costs increased. Trained middlemen earned significantly lower income compared to untrained ones. This was associated with comparatively higher fixed and variable costs amongst untrained actors. Notably, structure and conduct factors showed no significant influence on profitability. The OLS model explained 80% of the variation.

3.5.3. Processors

The Wu-Hausman test revealed that the model with IV was better in estimating the regression (p = 0.021), compared to the OLS model (Table 8). Processors' profitability increased significantly, as sales increased, but decreased as variable costs and experience increased. More experienced processors tended to earn lower incomes than less experienced ones. This was associated with the low training and education levels amongst the more experienced persons and subsequently

Table 6
Results of factors influencing fishers' profitability from regression with IV.

Variable	Coefficient	Std. Error
(Intercept)	0.290	0.350
Percent ownership of equipment	0.002·	0.001
Accesses selling price information	0.054	0.098
Selling to single buyers	−0.075	0.096
Colludes in selling	0.090	0.135
Fish grade targeted		
High	−0.090	0.191
Mixed	−0.208	0.153
Power to determine selling price		
Negotiated	0.055	0.087
Self	0.227	0.189
Sales	1.056***	0.054
Fixed costs	−0.204**	0.065
Experience	−0.001	0.003
Fisher by gear		
Low capitalized handline	0.120	0.242
Reef seine net	−1.695***	0.277
Basket trap	0.021	0.262
Drifting gillnet	−0.742*	0.309
Set net	−0.639*	0.296
Site		
Mayungu	0.090	0.136
Shimoni	0.347**	0.129
Vanga	0.154·	0.131
Accesses credit	−0.074	0.255
Trained	0.089	0.094
	Adjusted R-squared: 0.65	
	IV diagnostics	
	Weak instruments: $p < 0.005$***	
	Wu-Hausman: $p = 0.228$*	
	Sargan: NA	

Symbols used refer to significance level; ·=0.1, * = $p < 0.05$, ** = $p < 0.005$ and *** = $p < 0.0005$.

Table 7
Results of factors influencing middlemen's profitability from OLS regression.

Variable	Coefficient	Std. Error
(Intercept)	0.978·	0.560
Value of equipment	0.175	0.126
Accesses buying price information	−0.161	0.190
Accesses selling price information	−0.210	0.243
Colludes in buying	−0.113	0.259
Colludes in selling	0.117	0.322
Fish grade targeted		
Mixed	0.232	0.291
High	−0.240	0.352
Power to determine buying price		
Negotiated	0.068	0.219
Self	0.026	0.268
Power to determine selling price		
Negotiated	−0.395	0.327
Self	−0.521·	0.299
Variable costs	−0.277*	0.114
Fixed costs	0.160	0.105
Sales	0.994***	0.131
Experience	0.004	0.010
Type of actor		
Small-scale primary middleman	0.539	0.331
Small -scale secondary middleman	−0.169	0.341
Large-scale secondary middleman	−0.653	0.456
Site		
Mayungu	−0.153	0.227
Mombasa	−0.328	0.287
Shimoni	−0.061	0.316
Vanga	−0.051	0.268
Accesses credit	−0.119	0.237
Education level		
Secondary	0.108	0.204
Tertiary	−0.285	0.658
Selling to multiple buyers	−0.618	0.400
Trained	−0.583*	0.264
Adjusted R-squared: 0.80		

Table 8
Results of factors influencing processors' profitability from IV regression.

Variable	Coefficient	Std. Error
(Intercept)	2.221***	0.531
Value of equipment	−0.002	0.006
Accesses buying price information	−0.031	0.090
Accesses selling price information	0.158	0.201
Colludes in buying	−0.051	0.151
Colludes in selling	0.262	0.173
Fish grade targeted		
Mixed	−0.112	0.362
Low	0.131	0.369
Power to determine buying price		
Negotiated	0.211	0.165
Self	−0.313	0.502
Variable costs	−0.130**	0.046
Sales	2.166***	0.351
Fixed costs	−0.022	0.024
Experience	−0.016*	0.006
Site		
Mayungu	−0.059	0.118
Shimoni	−0.158	0.151
Vanga	0.070	0.159
Accesses credit	−0.058	0.116
Education level -Secondary	−0.107	0.312
Trained	0.064	0.238
	Adjusted R-squared: 0.64	
	IV diagnostics	
	Weak instruments; $p < 0.05$ **	
	Wu-Hausman; $p = 0.021$ *	
	Sargan; NA	

lack of business management skills. Notably, structure and conduct factors showed no significant influence on profitability. The model with IV explained 64% of the variation.

4. Discussion

Findings from analysis of structure, revealed pyramidal capital asymmetries, with most low-capitalized actors at the bottom, and few high-capitalized ones at the apex. This is typical of most producer-based value chains [8]. Such differentiation creates significant entry barriers for low-capitalized actors, and often breeds monopolistic and oligopolistic un-competitiveness [12,13,59]. However, in the present study, despite dominance by high-capitalized middlemen, the value chain was competitive with relatively low HHI indices.

As expected in capital-skewed value chains [34,36], higher capital-endowed actors had higher fish volumes and sales. For middlemen, this translated to higher financial profitability compared to fishers and processors. This is consistent with other studies in East Africa [6,10,40]. However, higher catches and sales by offshore fishers, for example reef seine net fishers, did not translate to significantly higher profitability compared to inshore fishers. This contrasts a study at Kuruwitu in Kenya, where offshore fishers had higher returns compared to inshore ones [37]. This can be attributed to profit sharing amongst large crews and unfavourable cost and catch share arrangements with middlemen, as is common in middlemen-controlled fisheries [24,60]. Overall, fishers in the present study earned at least twice the incomes reported at Kuruwitu [37]. Variable costs amongst fishers were generally higher than fixed costs. This has significant implications, since fishers disproportionately shouldered the risk compared to middlemen, where variable costs were subtracted first before sharing catch proceeds. This is common in middlemen-supported fisheries [6,61,62], and lowers fishers take-home income. Consequently it leads to detrimental

intensification of fishing to cover for the skewed cost share [25,26,63].

Lack of influence of structure on actors choice of fish grade was inconsistent with literature that shows buyers' choice is determined by capital outlay [17,64]. This can be attributed to simultaneous targeting of similar grades by both high and low-endowed actors within groups. However, there was a general tendency by middlemen to target high-grade and mixed grades, while processors targeted low-grade fish, consistent with other findings in East Africa [10,18,65]. Therefore, fish supply shocks leading to higher prices would negatively impact processors' livelihoods, whom majority (97%) were women, heading 41% of households. While, targeting of high-grade fish is associated with higher profitability [59,66], this was not evidenced in the present study. Therefore, middlemen's facilitation of migrant fishers to catch high-valued fish (Wanyonyi et al., 2016a; Wanyonyi et al., 2016b), may not be necessarily profitable.

Power to determine fish buying and selling prices was not significantly influenced by structure within actor groups. Literature suggests that high-capitalized actors usually determine prices, and render less-capitalized actors such as fishers as price-takers [66,67]. Other findings have also shown that small-scale processors in Kenya and Zanzibar, are usually price takers from both fishers and middlemen [10,18]. These inconsistent findings from the present study are possibly due its focus on within group differences, and not across groups. Consequently, power to determine fish selling prices, only influenced profitability marginally amongst fishers and middlemen.

Collusion in pricing which is fuelled by uncompetitive markets [13], was not a problem in the study sites as shown by the low HHI scores. Consequently, it did not significantly influence profitability for all groups. Although price collusion is widely addressed in other industries [12–14], it is scantily addressed in SSFs [7], and the present study helps to bridge this gap.

Access to market information was also not significantly influenced by structure and neither did it significantly influence actors' profitability. While enabling access to information is often recommended to aid in price negotiation to improve profitability [20–22], this was not supported in the present study. However, other findings also show that availability of information does not necessarily translate to higher prices and income, but may depend on its usage and other factors [68]. Nevertheless, improvement of access to information improves market access [11].

While S–C–P factors had lesser significant influence on profitability, variable costs and sales showed more significant influence across all actor groups. Increasing sales influenced profitability positively, while variable costs decreased profitability. Fixed costs also significantly decreased profitability, but only for fishers. Therefore, strategies that reduce costs and increase sales are most likely to improve profitability [69]. These measures can include formation and revival of collapsed cooperatives for aggregation of produce to improve prices and marketing. Improvement in infrastructure such as roads to reach new frontier markets can also stimulate sales [46,70]. Road improvements have been undertaken recently at Shimoni and Vanga and hence likely to improve fisheries trade [46].

Improvements in the cold chain and fish landing markets can also stimulate fish trade and boost sales [71]. This can also reduce fishers' desperate dependence on middlemen for quick sales at low prices [62]. A functioning cold chain can also reduce post-harvest losses and improve fish quality for higher returns. Consequently, infrastructure improvements have potential ripple effects on other sectors, for example spurring tourism and hence increase fish demand [70,72]. Stimulating market demand through fish eating campaigns in areas with low consumption and promotion of less consumed fish can also boost sales. Training of actors in fish handling, hygiene and value addition can enable production of superior fish products with higher returns [73].

Cost reduction measures such as reduction of license fees and permits through review of the fish trade policy environment can help reduce costs and improve sales amongst middlemen and processors. Modernizing the fishery for example use of Global Positioning Systems (GPS), fish finders and nearshore Fish Aggregating Devices (FADs) can help fishers locate fish efficiently and reduce fuel costs to improve profitability [74,75]. Fishers can also be assisted by government to acquire equipment, for example through favourable loaning schemes to improve their operations and profitability position as suggested and promoted elsewhere [46,76,77]. However, in the present study, percent ownership of equipment only improved fishers' profitability marginally. In any case, modernizing the fishery should incorporate sustainability measures, to avoid eventual collapse from higher fishing effort [78,79].

The above measures need targeted strategies led by government and promoted by the private sector. They are also best anchored in law and supported by institutional and policy frameworks. Kenya now has a new fisheries law—Fisheries Management and Development Act of 2016 with varied and far reaching measures to improve the value chain [80]. The new Act established Kenya Fisheries Service to oversee fisheries management, Kenya Fisheries Marketing Authority to oversee marketing and the Fish Levey Trust Fund to provide supplementary funding to improve fisheries. The broad mandates placed on these institutions will hopefully improve the value chain for improved livelihoods and economic growth.

5. Conclusion

The present study provides new information concerning how structure based on capitalization influences actors conduct, and how these ultimately influences profitability. Influence of structure on conduct was not significant as postulated by the S–C–P paradigm. Only few structure and conduct factors significantly influenced profitability amongst some actor groups. However, other non-S-C-P factors; sales and costs, showed significant influence on profitability across all actor groups. Nevertheless, the S–C–P factors are no less important in influencing the fishery. Their impact on other aspects of the fishery such as volume of sales, access to markets and prices were not studied, and this remains a future area of study. Tracking of factors influencing profitability would also be of interest as value chain improvement interventions in the fishery progresses. Insight from the present study is useful in tropical marine small-scale fisheries management, particularly in East Africa, given shared similarities.

Author statement

We confirm authors roles as follows: Patrick Kimani: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Resources; Roles/Writing - original draft; Writing - review & editing. Dr.Andrew Wamukota: Conceptualization; Methodology; Supervision; Validation; Writing - review & editing. Prof. Julius O. Manyala: Conceptualization; Methodology; Supervision; Validation; Writing - review & editing. Prof. Chrisestom Mwatete Mlewa: Conceptualization; Methodology; Supervision; Validation; Writing - review & editing.

Funding

This study was funded by Western Indian Ocean Marine Science Association(*MARGI Contract No.*006/2014) and the National Commission for Science, Technology and Innovation (Grant no: NACOSTI/ ACC/ 003/005(33)

Role of the funding source

The funding agencies had no role in design, data collection, analysis or write-up of this publication study.

Declaration of competing interest

None.

Acknowledgements

Gratitude goes to Salim Ali for assisting with data collection. We are also grateful to respondents who provided interview information. This work forms part of the requirements for the Doctor of Philosophy degree of Pwani University by the first author.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpol.2020.104218.

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