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Small-scale Fishermen and Risk Preferences

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Abstract *Using an experimental approach, we investigate the risk preferences of artisanal fishermen in Tanzania waters of Lake Victoria. The experiment concerns pairwise comparisons of hypothetical fishing trips that vary in expected mean and spread of the net revenue. The results show that about 34% of the fishermen can be considered as risk neutral, 32% as risk averse, and 34% as risk seekers. Econometric analysis indicates that the likelihood of belonging to the risk-seeking group increases if motorboats are used, if fishing is the main source of household income, and if the fisherman is targeting Nile perch. Asset ownership and perhaps socioeconomic variables influence risk preferences.*

Key words Risk aversion, artisanal fishermen, Tanzania, Lake Victoria, Nile perch, dagaa.

JEL Classification Code Q22.

Introduction

Fishing for a livelihood, be it in commercial or artisanal fisheries, implies an economic environment characterized by financial risk. This follows from uncertainty about product prices, imperfect information about resource abundance and location, dynamic changes in both prices and abundance, and the evolution of fishing regulations (Smith and Wilen 2005). Beliefs about profitability of different locations and the decision of how long to fish in a particular location are likely to affect the variability of fishermen's incomes. Thus, fishermen targeting the same species may have dramatically different net returns depending on their location choice (Mistiaen and Strand 2000; Smith 2000). The fishermen's problem is to select the location that will yield the highest expected utility. For the fishermen, the choice depends on their risk preferences, the distribution of the catch, and the costs associated with each fishing location. A key aspect of modeling and analyzing fishermen's behavioral motivations is uncertainty, which stresses the need to understand their risk preferences (Mistiaen and Strand 2000). Each time the skipper puts out to sea, a choice of fishing ground is made, and the choice may convey information about the skippers'/

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owners' risk preferences. Sandmo (1971) showed that a risk-averse firm facing output risk would produce less than a risk-neutral firm. Following Sutinen (1979), it has almost been taken for granted that fishermen are risk averse. The scant empirical evidence on fishermen's risk preferences tends to confirm the hypothesis of Sutinen that fishermen are risk averse (*e.g.*, Bockstael and Opaluch 1983; Dupont 1993; Mistiaen and Strand 2000).

The work of Bockstael and Opaluch (1983) on fishery supply response was the first to incorporate uncertainty and risk preferences into the behavioral motivation of the fishermen. These authors (1983) examined species and location choice in a random utility model with substantial income level at stake, and found that fishermen tend to respond to economic incentives and confirmed the hypothesis that fishermen are homogenous in risk preferences, with a constant relative risk aversion equal to one. Hence, fishermen respond to alternatives with a higher expected average gain, but would sacrifice some of the expected mean in order to lower the variability of gain. Applying the same framework as Bockstael and Opaluch and adding price uncertainty into the model, Dupont (1993) confirmed the restrictive assumption of homogenously risk-averse fishermen in three of the four vessel types.[1] Mistiaen and Strand (2000) studied fishermen's location choice at the trip level, where a majority of the fishermen were using fishing grounds that were easily accessed. Despite allowing for heterogeneity, Mistiaen and Strand (2000) found that at least 95% of the trips could be characterized as risk averse. Studying commercial fishermen's behavior when facing both financial and physical risks, Smith and Wilen (2005) confirmed risk-averse behavior among sea urchin fishermen when making a daily decision trip.

Recent research, however, casts doubt on risk aversion in small-stake experiments; *i.e.*, when the difference in income among alternatives in the experiment is relatively small. Rabin (2000) has shown that the implication of risk aversion for small differences in income will imply quite extreme risk aversion for large changes in income. Similarly, Eggert and Martinsson (2004) have survey evidence that risk aversion is not an important influence for choice among locations. Fishermen often make decisions on a more short-term basis like target species, gear choice, and location. These are recurrent decisions made on a per-trip basis, indicating a time span of 1 to 30 days, in which we find the stake involved in each trip to be relatively small. Repeated risk-aversion behavior for modest stakes will lead to substantial income reduction in the long run; *i.e.*, the more risk averse the fisherman is, the lower the aggregate income he will earn. Holland and Sutinen (2000) found risk-loving behavior, but held that fishermen in their sample tried to reduce risk in ways that were not captured by their model.[2] Some recent empirical studies indicate that a substantial share of fishermen are risk neutral. Strand (2004) used a random utility model and confirmed risk-averse behavior, but finds that fishermen's risk preferences vary spatially. In his sample, fishermen from New York tend to have the greatest relative risk aversion, while fishermen from the Florida Keys exhibit behavior more consistent with risk-neutral preferences. Eggert and Tveterås (2004) find that 30% of the

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[1] Dupont (1993) used a logarithmic utility function specification, which postulates that utility is a function of *inter alia* initial wealth. Hence, we refer to the results when pre-season wealth is included. Further, Mistiaen and Strand (2000) noted that a logistic utility function imposes risk aversion and that the only legitimate test is whether the data are consistent with this function or not.

[2] They include the coefficient of variation to reflect risk preferences and conclude that the significant positive sign indicates risk-loving behaviour. However, Smith (2000) stresses that skewness-loving behaviour is an equally plausible explanation. Using a more general functional form, Golec and Tamarkin (1998) find that racetrack bettors love skewness but not variance.

trips in a sample of Swedish trawlers reflect behavior consistent with risk-neutral preferences. Similarly, using a choice experiment, Eggert and Martinsson (2004) find that about half of a sample of Swedish commercial fishermen responds in a manner inconsistent with risk aversion. The empirical evidence of risk-neutral fishermen is also supported by McConnell and Price (2006), who argue that risk neutrality is common in fisheries and that the lay system is not based on pure risk sharing, assuming that both parties are risk averse, but used as a device to handle moral hazard in teams.

If we move the perspective to poor artisanal fishermen, even less is known regarding their risk preferences, although there is rich literature in agricultural economics on farmers' risk preferences in low-income environments. A majority of these works have found that most subsistence farmers in developing countries exhibit risk aversion, which increases as payoffs are increased (Dillon and Scandizzo 1978; Rosenzweig and Binswanger 1993; Binswanger and Sillers 1983). Using an experimental approach, Binswanger (1980) found that among farmers in rural India, more than 50% could be characterized as risk averse and only 15% as risk neutral.[3] Artisanal fishermen are poor and often tend to use less sophisticated fishing technology. Many began fishing in accordance with the dictates of family tradition, and therefore fishing may be considered a way of life. Hence, fishermen may be reluctant to relocate despite the worsened conditions for the particular fishery. Fishermen in Lake Victoria typically carry out daylong trips, therefore making repeated short-run decisions. The gamble connected to each trip for these fisheries is relatively small; according to economic theory, a rational agent would choose a risk-neutral strategy, which in the long run would maximize profit. Despite the inherent riskiness of their chosen profession, it is important to know if fishermen try to reduce risk by choosing alternative locations with less variability in revenue. This is especially important to the artisanal fisheries where fishermen do not have the electronic fish-finding gear, common to commercial fisheries, that can help find an aggregation of fish en route. Artisanal fisheries are also characterized by substantial price uncertainty that involves timing a boat's return to port to sell the harvest and prevent deterioration of the fish, due to the lack of preservation facilities onboard. Thus, the decisions of where and how long to fish are intricately related and lead to variation in exposure to financial risk.

The objective of the experiment is to measure risk preferences of individual fishermen. In particular, we measure risk preferences of artisanal fishermen by means of two alternative fishing trips, which only differ in terms of expected mean and variation of net revenues. Thus, fishermen's risk preferences are appraised via their choices between hypothetical fishing trips involving risky alternatives. We are also interested in identifying factors that possibly determine the degree of absolute risk aversion in Lake Victoria fisheries. Our results could also be of importance to examine whether risk preferences in artisanal fisheries in Lake Victoria are in line with the general findings of farmers' risk preferences in low-income environments. A better understanding of fishermen's risk preferences is important in understanding the welfare consequences of regulatory policies, such as closed areas or seasons and other biological modifications. If, for example, a particular target species yields high expected profits with high variability, the welfare consequences from a temporary closed season of this fishery will vary depending on whether fishermen are risk averse, risk neutral, or risk seeking.

[3] Risk preferences of the remaining farmers are unclear.

Description of the Lake Victoria Fishery

Small-scale fishing units generate almost all of the fishing effort in Lake Victoria. These fishermen use open, wooden-hulled vessels with a total crew of 2–6 persons. About 50% of the vessels in the sample are fitted with outboard motors, while the others use sails and/or paddles. Fishermen have a limited range of options with respect to the target species and basically concentrate on two major species—Nile perch or dagaa. A few fishermen alternate between the two major targets species, while some of the Nile perch fishermen also catch a third species, tilapia, but this is of minor economic importance. Thus, the fishery to enter is already known in prior; the daily decision is mostly concerned with the choice of fishing ground. Nile perch and tilapia fishing is generally done with gillnets, while sometimes long lines or hooks are used. Dagaa is mainly caught with dagaa nets, but some fishermen use even smaller mesh sizes, so called mosquito nets. The fishing frequency for Nile perch and tilapia is usually 5–6 days a week throughout the month and is on a daily basis due to lack of preservation facilities; fishermen leave in the afternoon and come back for landing in the morning. Dagaa is fished at moonless night (which limits the number of fishing days to about 15 a month) using pressure lamps to attract the fish. Dagaa fishermen also dry catches on land, which requires work onshore.

Fishing in Lake Victoria is carried out both inshore and offshore. A majority of sail/paddle fishermen fish inshore, while those equipped with motors can move around the fishing grounds with relative ease and exploit both inshore and offshore fishing grounds. Most of the fishermen go repeatedly to the same fishing ground, and about 65% report that they usually fish the same ground up to seven days in a row.

Methodology

The seminal work by Arrow (1971) and Pratt (1964) established that under the expected-utility hypothesis, one-to-one relationships exist between preferences over random income or wealth and the measures of risk aversion. Since then, the various measures of risk aversion have played a central role in determining comparative static results of behavior under uncertainty. It is common in applied welfare economics to assume a special class of utility functions characterized by constant relative risk aversion (CRRA), as proposed by Atkinson (1970).[4] The assumption of constant relative risk aversion also implies decreasing absolute risk aversion; *i.e.*, the higher the level of initial wealth an individual has, the higher the level of risk he or she is willing to accept. The function is modeled under the assumption of concavity of utility function over wealth, suggesting that the expected utility maximizer would always want to take a sufficiently small stake in any positive expected value bet (Arrow 1971). This means that expected utility maximizers are (almost everywhere) arbitrarily close to risk neutral when stakes are small. Rabin (2000) showed that risk aversion, even to quite sizeable stakes, implies a "huge risk aversion" to a large stake. Hence, if subjects in experimental studies are found to be risk averse for small stakes, they are not expected utility maximizers (Rabin 2000). The CRRA specification states that individuals' risk preferences depend on initial wealth. However, a reasonable proxy for initial wealth is typically difficult to obtain; hence,

[4] Atkinson's utility function, $U(x) = (x^{1-r})/(1 - r)$, where r is the constant relative risk aversion (CRRA) coefficient, $r = 0$ denotes risk neutral, $r < 0$ and $r > 0$ implies risk aversion and risk seeking, respectively. When $r = 1$, $U(x) = \ln(x)$.

specifications which are wealth independent are used in the literature (*e.g.*, Ali 1977; Eales and Wilen 1986; Golec and Tamarkin 1998; Mistiaen and Strand 2000; Eggert and Martinsson 2004). Prospect theory is a critique of expected utility theory as a descriptive model of decision making under risk, and claims that risk preferences are independent of initial wealth (Kahneman and Tversky 1979). According to prospect theory, subjects are found to be risk averse in choices involving sure gains and risk seeking in choices involving sure losses.

In the experiment, the subjects were presented with pairwise choices of hypothetical payoffs. The subjects are skippers, of whom about 30% own their vessels. They are offered choices with an expected mean corresponding to the average individual net revenues from five days of fishing trips. The alternative choices presented to the subjects follow the approach used by Eggert and Martinsson (2004). The experiment requires individuals to choose among alternatives in which an increase in expected returns can be purchased only by increasing risk or the dispersion of outcomes. Because we lack good measures of wealth data, we do not use the CRRA specification, rather the relative risk premium (RRP) to assess whether the subject is risk averse, risk neutral, or risk seeking. Thus, our model is not based on a particular utility function and can be viewed as an approximation to mean-standard deviation representation within the expected utility theory suggested by Meyer (1987). The RRP of an individual is the difference between the mean revenues of two alternatives, given that the individual is indifferent between the alternatives. This measure can be seen as the amount of money the respondent is willing to tradeoff for reduced risk when comparing two alternatives. The notion of relative risk premium[5] is used since the comparison is not between a risk-free and a risky alternative, but between two risky alternatives (Johansson-Stenman, Carlsson, and Daruvala 2002). An individual who is risk neutral towards financial risk, *ceteris paribus*, has an RRP = 0; *i.e.*, he/she is indifferent between the two alternatives if they have equal mean, irrespective of differences in variance. If an individual is indifferent between two alternatives where the first implies lower mean and lower variance compared to the second, the individual has a positive RRP and is risk averse. The RRP in this case can be seen as the amount of money in terms of a reduced expected mean that the respondent is willing to tradeoff for a reduced risk. Finally, if an individual is indifferent between two risky alternatives, where the first has lower mean and higher variance, he/she has a negative RRP and is risk seeking.

Description of the Experiment

The choice experiment concerns risk preferences of Tanzanian artisanal fishermen in Lake Victoria. Data was collected in a field survey conducted during August-October 2003 in the three regions: Kagera, Mwanza, and Mara, all bordering the Lake. A total of 499 fishermen were interviewed face-to-face (approximately 160 fishermen from each region), in collaboration with the staff of the Tanzania Fisheries Research Institute (TAFIRI) in Mwanza. Tanzanian fishermen use suitable landing sites that we refer to as beaches.[6] In collaboration with the TAFIRI staff, 22 beaches equally spread in the three regions were selected. Twenty to twenty-five volunteer fishermen in each of the selected beaches were recruited for the experiment. These fishermen

[5] Risk premium refers to the minimum difference between the expected value of an uncertain bet that a person is willing to take and the certain value that he is indifferent to (Hey 2003).

[6] In bigger villages there may be a constructed landing stage, while in smaller villages fishermen use the part of the shoreline where they most conveniently can pull up their vessels.

were all skippers and decision makers[7] of a fishing vessel and did not receive any payment for their participation.[8] Results from the pre-test of the experiment indicated that almost all subjects had a basic education level and could read and write. Thus, during the interview subjects were given a copy of experiment instructions and the payoff table of the alternatives as presented in Appendix B.[9] Pre-testing of the experiment on three beaches in the Mwanza region led us to the choice of the levels of mean income and the five-days of fishing trip values used in the five pairwise comparisons in the experiment. We also used production data collected from the same respondents on this and two other occasions for another study (Lokina 2004).

In the introduction of the experiment, the respondents were asked to imagine that they were actually faced with the choice between two fishing alternatives, described as Alternative A and Alternative B. The responses were anonymous and the instructions specified that there was no 'correct' answer to the problem. The aim of the study was to find out how fishermen choose between risky alternatives. The respondents were informed that the described alternatives could differ from their actual experience, but that they should base their judgments on the alternatives as presented in the experiment. It was stressed that despite their great skills as fishermen, they could not influence the probability of the outcome.

The respondents were given five pairwise choices as described in Appendix B. Further, the respondents were told to evaluate each pair independently and that they could go back and change a previous choice. Hence, each pairwise comparison should be treated separately and not be influenced by previous choices.[10] Alternative A_i, had the same mean and spread over the five choices, while alternative B_i started with a significantly lower mean and spread, then gradually increased over the five choices both in terms of mean and spread.

The respondents were asked to consider a choice between two hypothetical fishing alternatives, where the probabilities for expected outcomes follow a uniform distribution that cannot be influenced by the fisher.[11] In the first pairwise comparison, the first alternative has an expected outcome in the range of Tanzanian shillings[12] (Tshs) 500–9,500; *i.e.*, the expected mean is Tshs 5,000. The second alternative has an expected outcome in the range of Tshs 650–5,850, *i.e.*, the expected mean is Tshs 3,250. A fisherman who prefers the second alternative has a positive RRP larger than Tshs 1,750, which means that he is willing to accept such a reduction in expected mean in order to receive the given reduction in variation of outcome; such a fisherman is labeled risk averse.[13] Those fishermen who prefer the first alternative have a RRP smaller than Tshs 1,750 and are either risk averse, risk

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[7] Some of the skippers are also owners, some are hired with an absentee owner, and some are hired with the owner on board. As pointed out by an anonymous reviewer, this may imply a difference in incentives. In reality, the skipper is the final decision maker on board, and his net revenue is always a proportion of the catch. In order to facilitate comparison between skippers irrespective of crew size, ownership, *etc*., we relate to personal net revenue for the skippers in the experiment.

[8] Fishermen around the Lake have had regular contact with the staff at TAFIRI in Mwanza over a long period, and their relationship is characterized by mutual confidence. Hence, respondents were indeed voluntary and helpful in fulfilling the interviews.

[9] One of the authors is fluent in Swahili and checked the translation to Swahili. The instructions in appendix B are a translation from Swahili back to English by a bilingual non-economist to hopefully get closer to the respondents' perception of the questionnaire.

[10] The final decision of the fisherman for each pairwise comparison can be seen as a choice made before leaving port; therefore, no extra cost was incurred due to changes.

[11] The assumption of uniform distribution might be a problem to some, especially if they deem themselves more skilled than others and that their high skill may enable them to influence the variance of the outcome.

[12] USD 1 = Tshs 1,217, March, 2006.

[13] For a uniform distribution with highest value b and lowest value a, the mean is given by $(b + a)/2$ and the variance is given by $(b - a)^2/12$.

neutral, or risk seeking. By letting respondents carry out several pairwise choices, where the mean and the spread is gradually changed for the second alternative while the first alternative is kept constant, we obtain an upper and a lower bound of the RRP for each individual, enabling us to classify each respondent's risk preferences.

For fishing Alternative A, weekly revenue always varied uniformly between Tshs 500 and Tshs 9,500. The net revenue varied less for fishing Alternative B**,** while the expected mean increased from Tshs 3,500 to Tshs 5,850. In order to reduce the cognitive burden of handling potential negative outcomes, all alternatives entailed a positive outcome. The assumption of positive outcomes has some empirical support, as a total of 1,554 trip observations for these fishermen led to positive net revenues in 95% of them. During focus group discussions, some of the respondents stated that the revenue intervals presented were too compressed, as they sometimes earn substantially more than the upper figures in the experiment, but concluded that the figures were fairly realistic, as it is possible to get nothing out of a trip and that the averages in the experiment correspond quite well to their actual net revenues.

In the dynamic version of standard consumption theory, it is assumed that people behave in a time consistent way and integrate income from all sources perfectly. The expected utility from the net revenues of a week's fishing is small compared to the expected utility of final wealth; hence, we expect *Homo economicus* to be risk neutral in this experiment (Johansson-Stenman 2007; Rabin and Thaler 2001). Given the modest stake, it is rational to prefer A_1 and A_2 to B_1 and B_2. B_3 yields equal expected mean with less variance and, hence, can be expected to be preferred to A_3. The mean and interval levels used are given in table 1, which is also the order in which the alternatives were presented in the experiment.[14]

After explaining the experiment, the respondents were given time to read the details of the experiment and ask questions. At the end of the experiment the respondents were asked if they wished to change any of their choices, and were allowed to do so. Respondents were also asked a few follow-up questions on their stated choices and about their socio-economic conditions, including age, education level, income, assets, ownership status of the vessel, *etc*. The length of the interview was approximately 45–60 minutes.

Table 1
Fishing Alternatives in the Relative Risk-aversion Experiment

Alternatives A and B	Min. Income	Mean Income	Max. Income	Relative Risk Premium if Indifferent between A and B
Trip $A_{1\text{-}5}$	500	5,000	9,500	
Trip B_1	650	3,250	5,850	1,750
Trip B_2	1,600	4,400	7,200	600
Trip B_3	2,000	5,000	8,000	0
Trip B_4	2,300	5,500	8,700	–500
Trip B_5	2,600	5,850	9,100	–850

All values are in Tanzanian shilling (Tshs). USD 1 = Tshs 1,217, March, 2006.

[14] There is a potential ordering effect here; *i.e*., the answers may depend on the order in which the choices are made. Johansson-Stenman, Carlsson, and Daruvala (2002) explicitly tested for ordering effects in a similar experiment, but did not find evidence of the problem. This strengthens our belief that the ordering effect is not a serious problem in our study.

Results

The final analysis consisted of 473 respondents.[15] Table 2 presents the summary statistics of the variables used in the analysis. The variable "asset owned" was constructed by accounting for all assets owned by the skipper as mentioned in the survey, which include livestock, bicycles, fishing boats, *etc*. We valued livestock at the prevailing market price, while other assets were valued by asking the fisherman to state the maximum price he was willing to pay if he was offered to buy it.

The results of the risk experiment are presented in table 3. Of the 473 respondents, 22% consistently preferred Alternative B to Alternative A, which indicates an RRP larger than Tshs 1,750. We group these with the next group of respondents who have an RRP in the range of Tshs 600–1,750 and label them risk averse. Respondents belonging to this group constitute 32% of the sample and are willing to accept a reduction in expected mean by more than Tshs 600 to achieve a reduction in the spread. About 32% of the respondents always preferred Alternative A to Alternative B, indicating an RRP less than Tshs –800. For further analysis, we grouped those with the next group of respondents preferring a lower mean and a higher variation; *i.e.*, those who preferred trips A_1-$_4$ to B_1-$_4$ but chose trip B_5 instead of trip A_5. These

Table 2
Descriptive Statistics for Responding Skipper

Variable	Description	Mean	Std. Dev.
Age	Age in years of the skipper	31.5	8.74
Education	Number of years the skipper spent in school	6.55	2.31
Household	Total household size	6.35	3.82
Fishing	A dummy variable =1 if fishing is the main economic activity of the household; 0, otherwise.	0.62	0.49
Asset owned	A dummy variable =1 if skipper owns assets worth at least Tshs 250,000; 0, otherwise	0.57	0.50
Dagaa species	A dummy variable = 1 if dagaa is target species; 0, otherwise	0.20	0.40
Mwanza	A dummy variable = 1 if fisherman from Mwanza region; 0, otherwise	0.36	0.48
Mara	A dummy variable = 1 for Mara region; 0, otherwise	0.34	0.47
Motor	Boat fitted with outboard motor, A dummy variable = 1; 0, otherwise	0.53	0.50
Crew size	The size of crew on board	3.14	0.73
Net length	Total net length (meters)	3,682	2,023
Hours fished	Total active net hours spent fishing per trip	8.78	3.15
Skill	A dummy variable for self–rated fishing skill (1=equal or better than average; 0, otherwise)	0.79	0.40
Habit	A dummy variable = 1 if he has been fishing the same ground for 7 days or more; 0, otherwise	0.35	0.48

Note: An anonymous reviewer suggested an enhanced table of descriptive statistics with respect to the three risk groups identified, which we provide in Appendix C.

[15] 26 out of 499 respondents (about 5%) made at least one inconsistent choice; *i.e.*, they violated the transitivity assumption and were omitted from the final analysis. In a simple risk experiment with American university students, 13% (28 of 212), violated the transivity assumption (Holt and Laury 2002). Still, this omission indicates that our sample should not be seen as fully representative of the entire population.

Table 3
Results of the Relative Risk Aversion Experiment

Relative Risk Premium (Tshs)	Frequency	Percentage	Category
1,750 < RRP	103	22.49	Risk averse
600 < RRP ≤ 1750	44	9.61	
0 < RRP ≤ 600	67	14.63	Risk neutral
–500 < RRP ≤ 0	88	19.21	
–850 < RRP ≤ –500	9	1.97	Risk seeking
RRP ≤ –850	147	32.10	

respondents constitute 34% of the responding fishermen in our sample and are classified as risk seekers. Those who preferred alternative A until trip A_2 but preferred B_3 to A_3 or preferred B_4 compared to A_4 have a RRP bounded between 600 and –500. Respondents belonging to this group comprise 34% of the fishermen, and as they can have an RRP very close to zero, we classify them as risk neutral.[16]

The use of hypothetical questions raises the issue of whether the respondent actually reveals his true preferences. We found that about 55% of the respondents consequently chose either Alternative A or Alternative B, while 45% preferred the riskier trip A_1 to B_1, but switched to trip B as the mean of B approaches the mean of Alternative A. A potential problem is that some of the respondents may have chosen the extreme alternatives as a means of reducing the cognitive burden in answering the questions, which implies an under representation of risk neutrals in this study. Some of the respondents may have spent most effort on the first pairwise choice and then repeatedly marked the same type of alternative. This potential problem of a majority of the respondents choosing one of the two extreme alternatives was also experienced in Eggert and Martinsson (2004). Camerer and Hogarth (1999) review a number of experimental papers and hold that hypothetical experiments may induce a majority of respondents to prefer the extreme alternatives. It may be that the survey design leads to overestimates of the two categories risk averse and risk seeking, while the number of risk neutrals is underestimated.[17]

The low figure of only 32% risk-averse skippers as indicated in table 3 is clearly at odds with the common findings in commercial fisheries (Bockstael and Opaluch 1983; Dupont 1993; Mistiaen and Strand 2000) and for poor farmers in developing countries (Binswanger and Sillers 1983; Rosenzweig and Binswanger 1993). According to the results, 34% of the fishermen are risk seeking. The question then arises of whether these artisanal fishermen are true risk seekers or are their stated choices induced by study design. A potential problem is the assumption of a uniform probability distribution equal to all respondents. Even though it was stressed in the experiment that fishermen could not influence the outcome, self esteem could have led to an increased number of risk seekers in the experiment. A

[16] In order to not complicate the experiment, respondents were asked to choose the preferred alternative and not given the option to state indifference, while a strict definition of risk neutrality requires indifference between A_3 and B_3; *i.e.*, RRP = 0.
[17] A design which potentially reduces such bias is outlined in Dillon and Scandizzo (1978). They introduce indifference to respondents asked to compare a safe bet A with a binary lottery B. If respondents prefer A, a second comparison is made with a lower A and so on until indifference is achieved. Similarly, preference for B led to a second comparison with A increased and so on, until indifference is achieved. On the other hand, a purely risk-free alternative may not be seen as realistic.

third issue is whether the whole experiment is too hypothetical; *i.e.*, can respondents relate to the described choices?

Some of these issues were dealt with in the follow-up questions. About 66% of the respondents thought that the hypothetical Alternatives A and B corresponded to real fishing grounds in Lake Victoria where A, with higher mean and spread, resembled areas offshore, while B could be seen as inshore fishing grounds. Fishermen were asked to state the reason for their selections concerning the first and the fifth pairwise choices. The 71% who preferred B_1 to A_1 said that they were guided by the minimum revenue in the alternatives. This could be caused by the fishermen following a maximin strategy; *i.e.*, they maximize the minimum gain (Mas-Colell, Whinston, and Green 1995). In our study, this corresponds to constantly preferring B trips to A trips; B-alternatives always result in the highest revenue for bad luck at all levels, which is consistent with risk-averse behavior. For those who preferred trip A_5 to B, 85% said that maximum revenue was the main force behind the choice. The choice of trip A_5 is a typical risk-seeking strategy; *i.e.*, the fisherman is willing to sacrifice almost a 20% reduction in a week's income for the small chance of achieving the slightly larger maximum income in trip A_5 compared to trip B_5. Respondents were asked to rate their own fishing skills in comparison to their fellow fishermen at their common landing beach; 75% rated themselves as good, the remaining 25% rated themselves as not good. From a strict profit-maximizing perspective, risk-neutral fishermen appear more skilled than the other two groups, as they earn more in the long run.

As a test of the implications of the findings in the stated preference survey, the risk preference variables were included in a production function using production data from the fishermen. Table 4 presents the results from a Cobb-Douglas specification for the 473 respondents.[18] Along with the inputs crew size, net length, and hours of fishing, we used dummies for motor, dagaa as target species, risk averse, and risk neutral, with risk seekers as the reference alternative. Hence, the coefficients on, for instance, the risk-averse and risk-neutral dummies should be interpreted as the differences with regards to the base group, which includes vessels that do not have an outboard motor, target Nile perch, and are risk seeking. All the parameters are significant at the 10% or less level of significance, and the traditional inputs have the expected signs. Having a motor leads to substantially higher landing values, while the opposite applies for those targeting dagaa species. For a log-log

Table 4
Cobb–Douglas Production Function of Landing Values

Variable	Coefficient	P–Value
LogCrew size	0.439	0.000
LogNetlength	0.076	0.102
LogHours	0.197	0.009
Motor	0.726	0.000
Risk averse	–0.174	0.096
Risk neutral	–0.140	0.043
Dagaa	–0.109	0.047
Constant	7.841	0.000
Adj. R–squared	0.329	
Number of observations	473	

[18] We controlled for potential problems with heteroskedasticity using the Huber/White sandwich estimator.

specification, the proportionate change is calculated as exp [$c - V(\delta)/2$] – 1, where c is the estimated coefficient and V is the estimated variance of the coefficient (Halvorsen and Palmquist 1980; Kennedy 1981). This indicates that risk-averse fishermen earn 16% less than risk seeking, while risk-neutral fishermen earn 13% less than risk seeking. Hence, risk seekers seem to be the best fishermen when we adjust for the inputs in this simple specification.[19]

Of additional interest is to identify factors that possibly determine risk preferences. Using the three risk categories as dependent variables, we analyze them with a multinomial logit (MNL) model (McFadden 1974). The maximum likelihood estimates of the MNL model can be found in table A1 in Appendix A. In order to estimate the model, the coefficients of one risk category must be normalized to zero. The coefficients of the other risk categories are interpreted with reference to the normalized category. In our case, risk-seeking behavior is the omitted category. The sign of a coefficient shows how the ratio of probability of a fisherman in a particular category changes relative to the risk-seeking category when a covariate changes. Furthermore, the MNL puts restrictions on agents' choices; *i.e.*, the independence of irrelevant alternatives (IIA) assumption. The Hausman specification test for the IIA assumption is implemented, and the results suggest that the null hypothesis of independent risk alternatives cannot be rejected (see table A2 in Appendix A). Table 5 reports the changes in probability evaluated at the mean of the variable. We find that the probability of belonging to the risk-averse category declines with household size, while household size increases the probability of belonging to the risk-neutral group. For example, an increase in household size reduces the probability of belong-

Table 5
Changes in Predicted Probabilities Evaluated at the
Mean of the Variable based on MNL Estimates

	Risk Averse		Risk Neutral		Risk Seeking	
Explanatory Variable	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Age	–0.001	0.003	0.000	0.003	0.001	0.003
Education	0.009	0.011	–0.005	0.011	–0.004	0.012
Household size	–0.095***	0.033	0.096***	0.030	0.002	0.033
Dagaa species	0.194***	0.063	–0.031	0.077	–0.163**	0.082
Mwanza region	–0.007	0.062	–0.087	0.057	0.093	0.067
Mara region	–0.024	0.064	–0.079	0.063	0.103	0.070
Motorboat	–0.109**	0.045	0. 444***	0.040	0.336***	0.044
Crew size	0.009	0.033	0.069**	0.032	–0.077**	0.035
Total net length	–0.119	0.113	–0.051	0.102	0. 170**	0.086
Self-rated skills	–0.066	0.050	0.039	0.049	0.027	0.053
Hours spent fishing	–0.006	0.008	–0.018**	0.008	0.023***	0.008
Fishing habits	0.110*	0.061	–0.029	0.064	–0.081	0.071
Fishing the main income	–0.236***	0.050	0.277***	0.044	–0.041	0.052
Asset owned	–0.153	0.097	0.022	0.088	0.131	0.077

***, **, * indicate significance at 1%, 5%, and 10% levels, respectively, pertaining to the original Multinominal Logit (MNL) coefficient estimates.

[19] The difference between risk-averse and risk-neutral fishermen is not statistically significant at the 10% significance level.

ing to the group of risk-averse fishermen by 0.09 units, while it increases the probability of being risk neutral by 0.10 units.

The effect of boat size on risk preference is captured by a motor dummy variable and a crew size variable. The results show that skippers operating a motorboat are more likely to be risk seekers. The likelihood of fishermen belonging to the risk-seeking category increases by 0.34 units if motorboats are used, while the probability of being risk averse is reduced by 0.11 units. This may reflect the fact that motorboats in Lake Victoria fisheries imply more expensive gear, as the majority of fishermen with outboard motors have direct or indirect connections with the processing factories which provide them with credits for buying fishing crafts and gear.[20] This result can be compared with the results in Eggert and Martinsson (2004) where trawl fishermen were found to be less risk averse compared with others. This finding is also comparable to results in Binswanger (1980), where mechanized farmers in low-income environments tended to be less risk averse than less-mechanized farmers.

The results also show that larger crew size increases the probability of being risk neutral and decreases the probability of being risk seeking. Similarly, we find that the longer the fisherman spends fishing, the more likely he is to belong to the risk-seeking category and the less likely that he is risk neutral. A fisherman with high self esteem is more likely to belong to the risk-seeking category. According to table 4, risk-seeking fishermen are more skilled than others, which also is how they perceive themselves, according to table 5. These fishermen believe that, thanks to their skills, they can influence the uniform probability distribution in the experiment and land the maximum figure.

From an analysis of the observations of revenues, without accounting for input use, we find that a risk-averse fisherman (in this sample) earns an average of Tshs 3,500 (4,100) in a five-day trip, a risk-neutral fisherman receives an average net revenue of Tshs 6,100 (6,000), and risk seekers earn an average of Tshs 6,300 (7,900) with the standard deviation in parentheses over the same period (Lokina 2004). This indicates that risk-seeking fishermen earn almost the same as risk neutral, but with relatively more variation in their income than risk-neutral fishermen. We find a highly significant relationship between asset ownership and the degree of risk aversion, indicating that more wealthy fishermen are less likely to be risk averse. The result is consistent with the view that risk aversion is a decreasing function of wealth.

The results further show that regional dummies have a significant influence on fishermen's risk preferences; fishermen operating from the Mwanza and Mara regions are found to have a higher likelihood of being risk seekers compared to those in the Kagera region. The market potential in Mwanza may explain this phenomenon. Of the 13 fish-processing factories in the Tanzanian region, 11 are located in the Mwanza region, 2 are in the Mara region, while none are in the Kagera region. Also, the market in Mwanza is more easily accessible for fishermen from Mara than Kagera.

Discussion and Conclusion

A key aspect of modeling and analyzing fishermen's behavioral motivations is uncertainty, which stresses the need to understand their risk preferences (Mistiaen and Strand 2000). Although there is growing interest in fishermen's risk preferences, most—if not all—studies focus on commercial fisheries in developed countries. To our knowledge, this is the first study dealing with fishermen's risk preferences in a

[20] The general attitude of a majority of fishermen in Lake Victoria is that the fisherman operating a motorboat is considered well established and more commercially oriented.

developing country and artisanal fishery context. The study measures risk preferences of artisanal fishermen in Tanzania waters of Lake Victoria fisheries from a sample of 473 fishermen. Our results suggest that artisanal fishermen are risk averse to a lesser extent than what is indicated from evidence of risk aversion in low-income environments in the agricultural economics literature (Dillon and Scandizzo 1978; Rosenzweig and Binswanger 1993). In our sample, 32% can be characterized as risk averse, which is substantially less than what has been found in earlier studies using revealed preference data (Bockstael and Opaluch 1983; Dupont 1993; Mistiaen and Strand 2000; Strand 2004). The results, however, are consistent with recent findings in Eggert and Tveterås (2004) and Eggert and Martinsson (2004) for Swedish commercial fishermen.[21]

Stemming from this analysis, we find that risk-averse fishermen have small households, use boats without motors, target dagaa, and can fish the same location for seven days or more, earn only part of their income from fishing, and possess limited assets. Risk-neutral fishermen have large households, use motorboats, have large crews, fish shorter hours, and earn their main income from fishing. Risk-seeking fishermen are not from the Kagera province, use motorboats, have small crews, have high self esteem regarding their skills, fish long hours, and possess substantial assets. From a profit-maximizing perspective, we would expect risk-neutral fishermen to earn more compared to the other two groups in the long run. This study finds that risk-averse fishermen have a substantially lower average income, while this does not apply to the risk-seeking group. The risk-seeking fishermen have an average income comparable with the risk neutral, though with higher variance.

Either risk seekers are true gamblers that sacrifice the expected mean because they enjoy variation in daily income and the potential chance of striking 'gold,' or they are more skilled than others; their skill leads to high average income despite the fact that they take 'too' high risks with regard to maximizing income. A second element supporting their risk-seeking behavior is that they enjoy the positional welfare that comes from being "top scorers" among their colleagues at the landing beach.[22] Our result of less than one third being risk averse is not supportive of previous assumptions of both owners and crew being risk averse; therefore, preferring revenue-share contracts (Sutinen 1979; Plourde and Smith 1989). The finding that a substantial share of fishermen are risk neutral is more in line with the argument by McConnell and Price (2006), that fishermen are risk neutral and that the sharing system is used to control the problems of moral hazard and team agency.

The production relations that prevail in Lake Victoria fisheries could possibly explain the fact that risk-averse fishermen are the minority group in our sample, especially since our results contradict the main findings in low-income environments. Many of the fishermen, especially the Nile perch fishermen, have direct or indirect links to the fish-processing factory, which quite often extends credit for buying crafts and gear in return for the fishermen supplying the catch to the factory daily. This arrangement can be seen as a risk-sharing deal from the factories; it enables fishermen to invest in outboard motors for facilitating moving around the fishing grounds in search of the most productive ground, hence, taking chances becomes part of the daily routine. These fishermen might be enjoying relative wealth com-

[21] While Eggert and Martinsson (2004) had one alternative reflecting true risk-seeking behavior, in our case we designed the experiment to have two alternatives reflecting true risk-seeking behavior and two alternatives reflecting risk averse, with a middle alternative reflecting true risk neutrality.

[22] It is well established that both absolute and relative income matters to individuals (Johansson-Stenman, Carlsson, and Daruvala 2002). If the relative standings are asymmetric; *i.e.*, landing the highest catch one day and the lowest the next yields higher welfare than two average catches, the risk seekers are better off when the relative income effect is taken into account.

pared to poor farmers; hence they are consistent with traditional neoclassical risk taking with increasing wealth.

We found from our results that risk preferences are related to a set of important structural variables that characterize the fishermen in the sample; *e.g.*, target species, vessel type, skills, or regional dummies. Though risk aversion can be positive as far as resource conservation is concerned, it can lead to significant distortions from risk-neutral levels of input use (Hardaker 2000). Risk aversion may lead fishermen to use resources less intensively than would be the case if they were indifferent to risk. The implication of this on the fishermen's welfare very much depends on the extent to which the individual fisherman manages to diversify his source of income. A poor fisherman, who depends largely on fishing for his daily household needs, may be trapped in the risk-averse strategy for daily survival, despite knowing that a more risk-neutral strategy would be beneficial. The risk-averse fishermen in our sample, on average, earn significantly lower incomes than the others. While it may be a legitimate role of public policy to consider reduction in the cost of risk aversion for farmers in developing countries in order to reduce the social welfare loss from farm-level risk aversion (Rosenzweig and Binswanger 1993; Hardaker 2000), this arrangement may be weakly justified for fisheries. For instance, improving credit facilities for poor fishermen could enable them to invest in motors and gear which would increase their choice set of fishing grounds and target species and potentially increase their earnings. However, increased landings, *ceteris paribus,* would reinforce the trend of declining fish stocks in Lake Victoria and lead to overall reductions of landings over time. It may be the case that in order to improve the situation in the long run, some individuals will have to be worse off in the short run; *i.e.*, motorboats for all fishermen is a desirable prospect only if the number of vessels and fishermen decrease over time. The signs of overfishing in Lake Victoria are likely to generate traditional measures for improving stocks, which often include closing fishing grounds. If the chosen grounds are those with low mean and low variance in yield, which according to the fishermen in this study correspond to inshore grounds that also are easy to monitor and enforce, the risk-averse fishermen will be worse off. The fact that they fish without motors also implies a limitation of accessible substitutes, further intensifying their poverty problem.

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Appendix A

Table A1
Parameter Estimate of Multinomial Logit Model of Fishermen's Risk Preferences

	Risk Averse			Risk Neutral		
Explanatory Variable	Coeff.	Std. Err.	P-value	Coeff.	Std. Err.	P-value
Age of the skipper in years	–0.007	0.014	0.629	–0.001	0.016	0.940
Education of skipper in years	0.036	0.057	0.532	–0.010	0.061	0.875
Household size	–0.266	0.165	0.107	0.360	0.170	0.034
Dagaa species	1.061***	0.392	0.007	0.274	0.411	0.504
Mwanza region	–0.260	0.312	0.405	–0.579*	0.350	0.098
Mara region	–0.333	0.321	0.299	–0.570*	0.366	0.119
Motorboat	–0.616**	0.250	0.014	–2. 705***	0.298	0.000
Crew size onboard	0.223	0.165	0.165	0.458**	0.185	0.013
Total net length	–0.862	0.537	0.108	–0.736	0.552	0.183
Self–rated skill of the skipper	–0.260	0.249	0.297	–0.074	0.280	0.791
Hours spent fishing	–0.077*	0.040	0.051	–0.127***	0.046	0.005
Habit of fishing in the same ground	0.454	0.353	0.198	0.096	0.348	0.783
Fishing is the main income	–0.536**	0.249	0.032	1.291***	0.314	0.000
Asset owned by the skipper	–0.785*	0.472	0.097	–0.328	0.563	0.560
Constant	1.081	1.040	0.298	0.854	1.133	0.451
Sample size		473				
Pseudo R2		0.186				
Log–Likelihood		–422.711				

***, **, * indicate significance at 1%, 5%, and 10% levels, respectively.

Table A2
Hausman Test Statistics of IIA Assumption for Multinomial Logit Model

Omitted	Ch-sq.	Df.	p-value	Decision
Risk averse	1.086	15	1	Accept Ho
Risk neutral	2.341	15	1	Accept Ho

Risk seeking is the reference category.

Appendix B

Experiment Design in Risk Preferences

The National Environment Management Council (NEMC) in collaboration with the Tanzania Fisheries Research Institute (TAFIRI) is undertaking a study on how fishermen respond to variation in catch and revenue in different time periods. The study is being conducted in Mwanza, Mara, and Kagera regions. You have been randomly chosen as one of the respondents for this study. We believe that your experience in fishing will greatly help us learn more. We would like you to participate in this study by answering the following questions. Your response will be used for research purposes only. Your individual responses will not be revealed in any way. Only average or aggregated responses will be reported. The responses will be anonymous.

Think about the following situation

As a fisher, you face potentially large numbers of choices in different circumstances. However, here we ask you to assume that you can only choose between two alternatives for the next week's fishing trip. The two alternatives are characterized by high and low variation in net revenue. For the first Alternative, net revenue will vary a lot, while not so much for the other. Assume that catch net revenue is guaranteed between the given intervals (*i.e.*, the stated highest and lowest net revenue). The chance is equal for all outcomes. Variation in net revenue can be due to the choice of the fishing location. It is possible that the described alternatives can differ from what you use to get from your trips, but we still want you to judge the alternative alternatives as presented.

The two fishing alternatives are named A and B**.** They vary in spread and average revenue; you are not sure about the distribution of the stock in the two alternatives but we assume that you can choose between two fishing alternatives with different catch profiles. For fishing alternative A, the net revenue will always vary from Tshs 500 to Tshs 9,500 and the average is Tshs 5,000 per week. For fishing alternative B**,** the net revenue does not vary as much and in the first B alternative the average is Tshs 3,250 and then increases. This variation in net revenue is outside your control and even if you are a skilled fisherman you cannot influence the outcome.

We ask you to imagine five different situations where you make a choice between two different alternatives. There is no correct answer; thus you can go back and change them. We are only interested in your choices. We acknowledge that these choices are not perfectly equal to real-life fishery choices, but we are very interested in your judgment. We assume that you are a skilled fisherman, but you cannot influence the outcome. Your personal net revenue from the alternative is somewhere in the stated interval and each amount from the lowest to the highest given has the same chance of occurring.

In this scenario we ask you to make five pairwise comparisons. Each comparison is independent of the previous. In this example, the distribution of revenue from the two fishing grounds is given in the table you have. How would you choose?

	Fishing Trip A	**Fishing Trip B**
Lowest/highest net revenue (Mean value):	Tshs 500–9,500 (Tshs 5,000)	Tshs 650–5,850 (Tshs 3,250)
Your choice:		

	Fishing Trip A	**Fishing Trip B**
Lowest/highest net revenue (Mean value):	Tshs 500–9,500 (Tshs 5,000)	Tshs 1,600–7,200 (Tshs 4,400)
Your choice:		

	Fishing Trip A	**Fishing Trip B**
Lowest/highest net revenue (Mean value):	Tshs 500–9,500 (Tshs 5,000)	Tshs 2,000–8,000 (Tshs 5,000)
Your choice:		

	Fishing Trip A	**Fishing Trip B**
Lowest/highest net revenue (Mean value):	Tshs 500–9,500 (Tshs 5,000)	Tshs 2,300–8,700 (Tshs 5,500)
Your choice:		

	Fishing Trip A	**Fishing Trip B**
Lowest/highest net revenue (Mean value):	Tshs 500–9,500 (Tshs 5,000)	Tshs 2,600–9,100 (Tshs 5,850)
Your choice:		

Appendix C

Table C1
Descriptive Statistics for Responding Skipper with respect to
Risk Category and Test of Significant Difference in Mean Values

	Mean Values (full sample mean in bold)			
	Risk Averse	Risk Neutral	Risk Seeking	F-test*/Chi-2
Age	31.53	31.21	31.74	NOT SIGN*
		31.5		
Education	6.56	6.57	6.53	NOT SIGN*
		6.55		
Household	6.25	6.13	6.63	NOT SIGN*
		6.35		
Fishing	0.46	0.78	0.60	1% LOS
		0.62		
Asset	0.59	0.59	0.54	NOT SIGN
		0.57		
Dagaa	0.16	0.22	0.22	NOT SIGN
		0.20		
Mwanza	0.35	0.33	0.39	NOT SIGN
		0.36		
Mara	0.33	0.31	0.37	NOT SIGN
		0.34		
Motor	0.51	0.53	0.54	NOT SIGN
		0.53		
Crewsize	3.16	3.18	3.07	NOT SIGN*
		3.14		
Tot net	3,623	3,708	3,709	NOT SIGN*
		3,682		
Hours fished	8.79	8.33	9.21	5% LOS*
		8.78		
Skill	0.78	0.78	0.80	NOT SIGN
		0.79		
Habit	0.31	0.43	0.32	10% LOS
		0.35		