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Keywords: common pool resource, fishing, risk aversion

JEL Classification: C91, D81, H23, J24

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Die Hard:

Exploring the Characteristics of Resource Users who Persist in the Tragedy of the Commons

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Abstract

This field study investigates the characteristics and preferences of artisanal fishers who continue their profession in a lake afflicted by overfishing. We relate their economic preferences, fishing data, social networks, and socio-demographic information to their decision to either persist or discontinue fishing 4 and 15 years later. Our findings reveal that an increasing portion of fishers have chosen to cease fishing over time. We observe that the fisher's risk preference is an important and robust factor for persistence: More risk-averse fishers are more likely to endure in their fishing endeavors. We also find evidence that better socially integrated, older and less educated individuals are more persistent. In contrast, we do not observe any notable relationships between persistence and the individual extent of overfishing or social preferences. These insights offer valuable novel knowledge regarding the evolving dynamics of resource user groups. By understanding these factors, policymakers and managers can optimize their approach to designing effective management practices and policies.

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1. Introduction

The sustainable use of natural resources is one of the biggest challenge humankind is facing. Open access common pool resources (CPR) such as forests and fishing grounds are particularly difficult to sustain because privatization and monitoring of usage are typically not feasible or exceedingly expensive. Thus, there are abundant examples of the Tragedy of the Commons (Hardin, 1968) where these resources are overexploited, sometimes to the extent that they have irreversibly collapsed, endangering the lives of those who directly depend on these resources and potentially causing devastating ripple effects such as the disruption of entire ecosystems and climate.

However, there are also many instances where such CPR are sustained and the existing evidence suggests that characteristics and preferences of the involved resource users are important predictors for success and failure (Ostrom, 1990; Baland and Platteau, 1996; Agrawal and Gibson, 1999; Ostrom, 2010). For instance, successful self-governance of CPR crucially depends on the resource users' ability and willingness to refrain from and monitor resource exploitation, which in turn depends on their social preferences (Ostrom et al., 1992; Rustagi et al., 2010) and their social network (Cavalcanti et al., 2013). There is also evidence that social and time preferences are directly linked to the extent of overfishing (Fehr and Leibbrandt, 2011).

To understand how to account for the characteristics and preferences of the involved resource users, it is important to consider the dynamic nature of the CPR environment. There are many reasons to believe that there is no simple causal relationship between resource users and CPR but a complex interplay in which both average user characteristics and the state of the CPR change over time. In particular, it is possible that the characteristics of the typical CPR user systematically changes when resource stocks decline. For example, prosocial CPR users who are more inclined to refrain from overexploitation than self-interested CPR users may have to cease if their lower resource use does not anymore sustain their livelihoods. Similarly, CPR users who are less integrated into their community may have to change professions as they have less access to assistance through their social networks when CPR returns are low. The choice to cease may also depend on risk preferences: CPR

users who are more willing to take risks, may be more willing to leave the CPR environment and change professions.

In this field study, we explore the characteristics and preferences of CPR users who cease and compare them to those that persist and continue fishing at a lake that suffers from overexploitation. We captured the characteristics and preferences of fishers in a set of economic experiments and surveys on their social networks, fishing behavior, and socio-demographics. Four and 15 years later, we returned to the same group of fishers and identified who persisted and who ceased fishing. This unique and comprehensive data collection over substantial time periods renders it possible to explore one important piece of the interplay between resource users and the resource itself – the evolving nature of CPR users in an environment where CPR stocks decline.

Several significant patterns emerge through linking the different data sets. The findings may provide useful guidelines for the management of CPR. In particular, they suggest the importance of focusing attention and resources on resource users who are more integrated in the social network of their community because they are more likely to persist and continue harvesting the CPR.[1] They also suggest that successful management of CPR crucially depends on taking into account the increasing level of risk aversion among the prevailing group of CPR users.

This study contributes to different research streams. *First*, it fills a gap in the field of CPR research by exploring the importance of the temporal aspects of CPR users.[2] It also contributes to the rich literature on studies investigating the behavior and preferences of resource users in laboratory environments capturing CPR (Walker et al.,1990; Cardenas, 2000; Casari and Plott, 2003; Velez et al., 2009; Prediger et al., 2011; Hayo and Vollan, 2012; Leibbrandt et al., 2021). *Second*, our study is related to research on the role of risk preferences for migration (Jaeger et al., 2010; Falk et al., 2018) and occupational choice (Fouarge et al., 2014; Koudstaal et al., 2016). The novel angle of our study is the focus on resource users and its impact on the sustainability of these resources. *Third*, our research provides a fresh look at the

[1] In addition, better socially integrated CPR users are also more willing to contribute to the success of CPR change management (Cavalcanti et al., 2013).
[2] There is a literature on the temporal aspects of CPR itself, but this literature does not focus on the individual resource users and their changes (Feeny et al., 1990; Ostrom and Nagendra, 2006).

factors underlying persistence and job mobility (O'Reilly et al., 1989; van Huizen and Alessie, 2019).

2. Field Setting

We study professional fishers who specialize in catching shrimp at a lake in north-eastern Brazil in the state of Bahia. There are several rural fishing villages at this lake where inhabitants directly depend on shrimp and fishing (i.e., shrimping) is the main profession. Fishers in this setting catch shrimp on their own and sell their catch at fish markets to provide their family with nutrition and income. The fishing activity typically takes place the whole year and typically fishers go fishing for six days each week during the whole year.

Shrimp is an open access common pool resource (CPR) in this setting. There is free access to the fishing (shrimp) grounds and capital entry requirements are low. Fishers only need a small boat and mostly use shrimp traps which they manufacture from used PET bottles. There are no legal constraints on catching shrimp, no recovery periods, and no restrictions on the use of shrimp traps (both quantity and kind).

Fishers are aware that their CPR is overfished and in danger of collapse (Cavalcanti et al., 2010). While there is no data available on the actual shrimp stocks, a large majority of fishers complain about decreasing catch rates, which they mostly blame on overexploitation; i.e., catching large amounts of infertile shrimp with many shrimp traps with small holes. Governmental and local university institutions have taken note of the severity of the situation and have initiated first steps to help sustain the fishing grounds. A management council was implemented to examine the current fishing situation and an environmental program on the use of shrimp traps was introduced. However, still to date fishers report a declining shrimp stock.

3. Field Data

This study uses data collected from three sources. In 2008, we invited 216 fishermen from nine Brazilian fishing villages at Lake Pedra do Cavalo to take part in a set of laboratory experiments on social, risk, time and competition preferences, surveys on their socio-demographics, fishing related outcomes and behaviors as well

as on their social network. In addition, to capture the individual extent of CPR exploitation, we went to their houses to collect a sample of their shrimp traps and measured the holes in these traps with smaller holes being associated with larger CPR exploitation (see also Fehr and Leibbrandt, 2011). Four years later in 2012, we returned to eight of the nine fishing villages and collected information whether our participants are still fishing. We were able to collect information from 190 out of the 216 participants. 15 years later in 2023, we returned to all nine fishing villages and again collected information whether our participants are still fishing. We have information from 205 out of the 216 initial participants. We have panel data from both 2012 and 2023 for 180 participants.

Table 1 provides a summary of our data collection in 2008. Our sample was on average 37.8 years old (i.e., the average age is approximately 53 years during the latest data collection in 2023), mostly male (78%), went to school for 3.2 years and had 3.1 children. Fishing provided them with an average income of 252.6 Brazilian Reais[3] and they worked for 5.85 days per week. To catch shrimp, they used on average 371 shrimp traps which had an average hole size of 45 millimeters.

To capture fishers' social preferences, they took part in an anonymous laboratory public goods experiment (Fehr and Leibbrandt, 2011). We find that participants contributed on average 3.67 out of the 10 monetary units (MUs). To capture their risk preferences, fishers participated in a simple investment game (Gneezy and Potters, 1997). In this game, fishers chose how many out of ten MUs they invest in a lottery with a payoff of 2.5 times the invested amount and a winning probability of 50%. We find an average investment of 3.02 out of 10 MUs. To capture their time preferences, fishers participated in a simple impatience game (Gneezy et al., 2016). In this game, all fishers had to decide whether they preferred two pralines immediately or three pralines at the end of the experimental session approximately two hours later. We find that 39% were impatient and preferred two pralines immediately. To capture their competitiveness, they took part in a simple competition game (Leibbrandt et al., 2013). We observe that 44% decided to compete. More detailed information on procedures can be found in the Appendix.

[3] The Brazilian currency is called Real (singular) or Reais (plural). 1 Real = US$ 0.47 during the data collection in 2008.

To capture the fishers' social integration, we use a standardized indegree measure (Cavalcanti et al., 2013). We standardize the centrality measure to account for different network sizes across the different villages. The average standardized indegree of our fishers is 8.98. Finally, we ask participants to find out whether they have stopped fishing. If we could not talk directly with a participant from 2008, we obtained information from their family, friends, or the village leader. We observe that about 25% (46 out of 190) of the participants stopped fishing four years later. Three of the 190 participants have reached 70 years in 2012. In 2023, we observe that 73 (out of 205) participants have stopped fishing[4], 95 participants are still fishing, 21 participants have reached 70 years and 20 participants have died.[5]

4. Findings

In this section, we relate our laboratory, field, and survey measures to the participants' choice to persist or cease fishing. We present four main findings.

Finding 1: *Risk preferences are closely linked to persistence: more risk-averse individuals are more likely to persist fishing. In contrast, social, time, and competition preferences are not significantly related to persistence.*

Table 2 provides first evidence for Finding 1. In this table, we compare the individual characteristics of fishers who continued fishing after four years (column 1) versus those who ceased after four years (column 2) and also compare fishers who continued after 15 years (column 3) to those who ceased after 15 years (column 4). We observe pronounced differences in risk taking between these groups. Participants who persist fishing after four years (n=141) risk only 2.79 whereas participants who cease fishing risk 34% more (3.74, n=46, p<.001). This difference is robust and holds after 15 years. Participants who persist fishing after 15 years risk only 2.83 (n=95) whereas participants who cease fishing risk 26% more (3.56, n=73, p=.031). The

[4] We have further information on the reasons to cease fishing from 47 out of these 73 participants. The large majority (n=37) changed professions.
[5] We exclude participants who have died. We also exclude participants who have reached the age of 70 in 2012 and 2023 as there is a high likelihood that they had to cease fishing due to age.

relationship between risk aversion and persistence is particularly pronounced for the most risk averse fishers: 89.7% (71.9%) of the participants who do not risk at all; i.e., invest zero in the risk game, persist for 4 (15) years in their profession compared to only 68.7% (52.9%) of the participants who risk any positive amount. In contrast, we do not observe any significant differences between fishers who persist and cease for social, time, and competition preferences regardless whether we look at the 4- or 15-year time period.

Table 3 provides a closer look at persistence over time by focusing on the sample for we which we have data from both time periods. Thus, we can distinguish three main groups: (1) 71 participants who persisted fishing throughout the whole time period of 15 years, (2) 50 participants who persisted for one of the two time periods, and (3) 28 participants who ceased fishing altogether.[6] We observe that fishers who persist throughout are most risk-averse (2.62) and invest less than fishers who fished only for one time period (3.62) and fishers who ceased altogether (3.64). We observe no differences between the three groups with regards to time and competition preferences and a non-linear pattern with regards to social preferences as participants who fish for only one period contribute more than the other two groups.

A final piece of evidence comes from Table 4, where we regress the choice to fish on our set of potential covariates in linear probability models (LPM).[7] The outcomes from the regressions collaborate with the previous findings and indicate substantial effect sizes. The coefficients vary between -.034 to -.049 showing that one MU more invested in the risk game is associated with a 3.4-4.9% higher probability to cease fishing.

Finding 2: *Fishing outcomes and behaviors do not predict persistence. Fishers who cease fishing do not extract more of the CPR than fishers who persist.*

[6] 37 participants fished after 4 but not after 15 years and 13 participants ceased fishing after 4 but returned fishing after 15 years. 31 out of the 180 participants for which we have data from both time periods either died or were 70 years or older in a given time period.

[7] We do not control for *children* because it is highly correlated with age (r=.72). Replacing age with children in our regression models would lead to very similar findings, with children generally being less predictive than age. We also do not control for hole size in shrimp traps and *impatience* because it would significantly reduce our sample size as we did not collect information on these two variables for our whole sample and because both variables are not significantly related to the choice of fishing.

In Table 2, we observe that none of the four fishing variables is related to the decision to persist fishing after 4 and 15 years. In particular, we find that fishing incomes and working hours are very similar between the two different groups. There is some difference in terms of hole size in shrimp traps and the number of shrimp traps used, with fishers who persist using smaller hole sizes in their traps and more of the traps, but this difference between the two groups never reaches statistical significance (for all comparisons $p>.151$). Table 3 presents a similar pattern but again with insignificant differences between the different groups of participants. Further, in Table 4 we can see that the number of shrimp traps, fishing income, and working hours are never significantly related to any of our dependent variables.[8]

Finding 3: *Better socially integrated individuals are more likely to persist fishing.*

Table 2 shows much larger levels of social integration for participants who persisted fishing for 4 years (10.17, n=141) as compared to those who ceased (5.7, n=46, $p<.01$). Interestingly, we do not find such pronounced differences 15 years later. Participants who still fish 15 years later (n=95) are similarly well integrated as compared to participants who fish for 4 years but participants who ceased fishing after 15 years are much better integrated as compared to participants who ceased fishing after 4 years. Thus, participants that persist fishing after 15 years have only an insignificantly higher social integration level as compared to participants who ceased fishing (n=73, 9.81 vs 8.17, $p=.258$).

Table 3 further illustrates that participants who already ceased fishing after 4 years have lower levels of social integration (5.51) than participants who fished for both (10.65) or at least one time period (9.13). Regression Table 4 corroborates that social integration is a significant predictor with $p<.01$ for the decision to cease fishing after 4 years (model 1) and when comparing participants who always fished as compared to those who ceased altogether (model 3).

[8] If we were to include hole size in Table 4, it would be a marginal factor in model (1) for the choice to fish after 4 years ($p=.066$) and insignificant for all other models.

Finding 4: *Older and less educated individuals tend to be more likely to continue fishing. Sex and the number of children are not closely linked to persistence.*

We also observe some differences when looking at the socio-demographic characteristics of our participants and their choice to persist. Participants who persist after 4 and 15 years are older than participants who cease after 15 years (38.4 vs. 31.2, $p<.01$ and 35.48 vs 32.51, $p=.055$). Table 3 shows that participants who ceased fishing already after 4 years are on average 29.68 years old whereas participants who persisted in both time periods are on average 35.78 years old ($p<.01$). These differences are less pronounced in our regression models and only significant in the first time period. The patterns for education are similar, there are large differences in the years of schooling in Tables 2 and 3. However, we also observe in our regression analysis that education is only significant in model (5) and only marginally in model (3).[9] Finally, we observe only minor evidence that sex and children are related to persistence. Sex is predictive when comparing participants who fished for both as compared to one period. Children is only predictive in Table 2 for the choice to persist after 4 years.[10]

5. Discussion

This field study offers a glimpse into the changing nature of individuals who continue to be directly dependent on CPR. While studying the evolving nature of CPR users is interesting on its own, it is important to take into account that successful CPR management does not only depend on the characteristics and preferences of the current resource users but also on anticipating the likely characteristics and preferences of resource users who persist over time and especially when resource stocks decline.

To illustrate the importance of taking into account the evolving nature of resource users consider the plausible scenario that selfish and impatient resource users were most likely to persist with increasing pressure on the CPR. If this was true, the

[9] The lower significance of age and education in our regression models may be partly due to multicollinearity issues. Age and education are moderately correlated (r=-.47) and when only using age or education in Table 4, we do observe that both variables but in particular education is a more significant predictor.

[10] If we were to replace age with children in Table 4, we would find that children is not a significant factor in any of the five models.

self-governance of CPR would become more difficult over time as these resource users have a low inclination to monitor and refrain from overexploitation. We indeed find that resource users who persist are systematically different from resource users who sort out of their profession. However, the observed systematic differences and in particular that more risk-averse and better socially integrated users persist may give hope that CPR can be sustained. High levels of social integration and risk-aversion may provide a base for CPR monitoring as these characteristics facilitate monitoring and are associated with a lower willingness to overexploit CPR because of the risk being caught.

However, high levels of risk-aversion can also be a barrier for the successful management of CPR. In environments where change management is necessary to prevent CPR from collapse, the inherent risks of change may cause risk-averse users to be more hesitant to support changes, for example in the way they have exploited CPR. Thus, in such environments it is crucial to minimize the perceived risks for resource users in order to maximize their support.

Tables

Table 1: Summary Data from 2008

	Mean	*S.D.*	*N*
Age	37.8	12.9	216
Gender (male = 1, female = 0)	0.78	0.42	216
Education (years of schooling)	3.24	2.5	214
Children	3.13	3.02	215
Income from fishing (Reais per month)	252.67	184.61	215
Fishing days per week	5.85	1.22	216
Hole size in shrimp trap	0.45	0.11	118
Number of shrimp traps	371.08	311.88	216
Contribution in Public Goods Game (0-10)	3.67	2.79	216
Risk-taking in Risk Game (0-10)	3.02	2.21	216
Impatience in Praline Game (1 = impatient, 0 = patient)	0.61	0.49	174
Competitiveness in Competition Game (1 = competes, 0 = does not compete)	0.44	0.5	216
Social network integration (standardized friend indegree)	8.98	8.82	216

Table 2: Distinguishing factors between fishers who ceased and those who persisted fishing after 4 and 15 years.

	still fishing 4 years later	*not fishing anymore 4 years later*	*p-value*	*still fishing 15 years later*	*not fishing anymore 15 years later*	*p-value*
	(1)	(2)	(1)-(2)	(3)	(4)	(3)-(4)
Age	38.4	31.2	<0.001***	35.48	32.51	0.055*
Gender (male = 1, female = 0)	0.74	0.8	0.433	0.73	0.79	0.366
Education (years of schooling)	3	4.33	0.002***	3.16	3.98	0.039**
Children	3.3	2.2	0.023**	2.73	2.19	0.141
Income from fishing (Reais per month)	247.02	250.49	0.913	266.02	252.67	0.664
Fishing days per week	5.84	5.91	0.744	5.81	5.97	0.401
Hole size in shrimp trap	0.44	0.475	0.223	0.429	0.455	0.274
Number of shrimp traps	376.93	332.3	0.399	406.54	334.55	0.151
Contribution in Public Goods Game (0-10)	3.56	3.57	0.991	3.73	3.6	0.771
Risk-taking in Risk Game (0-10)	2.79	3.74	0.009***	2.83	3.56	0.031**
Impatience in Praline Game (1 = impatient, 0 = patient)	0.71	0.65	0.526	0.59	0.61	0.862
Competitiveness in Competition Game (1 = competes, 0 = does not compete)	0.45	0.35	0.233	0.45	0.41	0.639
Social network integration (standardized friend indegree)	10.17	5.7	0.004***	9.81	8.17	0.258

Table 3: Panel data on Fishers

	(1) *fishing after 4 and 15 years*	*(1) vs (2)*	(2) *fishing for one period*	*(2) vs (3)*	(3) *not fishing after 4 and 15 years*	*(1) vs (3)*
Age	35.74		33.02		29.68	>***
Gender (male = 1, female = 0)	0.65	<**	0.82		0.75	
Education (years of schooling)	3.11		3.65	<*	4.84	<***
Children	2.89		2.43		2	
Income from fishing (Reais per month)	261.3		256.3		232.8	
Fishing days per week	5.85		5.8		6.11	
Hole size in shrimp trap	0.421		0.46		0.471	
Number of shrimp traps	415.5		329.9		306.6	
Contribution in Public Goods Game (0-10)	3.39	<*	4.28	>**	2.79	
Risk-taking in Risk Game (0-10)	2.62	<***	3.62		3.64	<**
Impatience in Praline Game (1 = impatient, 0 = patient)	0.68		0.72		0.63	
Competitiveness in Competition Game (1 = competes, 0 = does not compete)	0.44		0.48		0.29	
Social network integration (standardized friend indegree)	10.65		9.13	>*	5.51	>**

Table 4: Determinants of persisting fishing (LPM)

model	(1)	(2)	(3)	(4)	(5)
Dependent variable	still fishing 4 years later	still fishing 15 years later	still fishing after 4 and 15 years	fishing for two vs one period	fishing for one period
Age	0.006**	0.003	0.002	0.005	-0.002
	(0.003)	(0.005)	(0.005)	(0.005)	(0.007)
Male	-0.126	-0.131	-0.182*	-0.204*	-0.003
	(0.077)	(0.094)	(0.101)	(0.106)	(0.157)
Education	-0.022	-0.020	-0.036*	0.001	-0.052**
	(0.014)	(0.018)	(0.019)	(0.020)	(0.026)
Fishing Income	-0.000	-0.000	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Days fishing	-0.024	-0.038	-0.007	-0.012	-0.078
	(0.023)	(0.031)	(0.035)	(0.037)	(0.050)
Number of shrimp traps	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Risk-taking in risk game	-0.034**	-0.036**	-0.046**	-0.049**	-0.013
	(0.015)	(0.018)	(0.023)	(0.020)	(0.032)
Contribution in public goods game	0.009	0.005	0.031*	-0.014	0.041*
	(0.012)	(0.016)	(0.017)	(0.020)	(0.024)
Competitiveness in competition game	0.048	0.033	0.093	-0.045	0.147
	(0.065)	(0.082)	(0.088)	(0.096)	(0.114)
Social network integration	0.009***	0.004	0.013***	0.003	0.006
	(0.003)	(0.005)	(0.004)	(0.005)	(0.005)
Constant	0.952***	0.997***	0.973**	0.961**	1.170**
	(0.259)	(0.333)	(0.379)	(0.386)	(0.537)
N	184	166	98	119	77

Notes: ***p<.01, **p<.05, *p<.1.

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Appendix

To capture fishers' social preferences, they took part in an anonymous laboratory public goods experiment (Fehr and Leibbrandt, 2011). They were divided into groups of three and played this experiment for one period. Each participant had to decide how many out of ten monetary units (MUs) he wants to contribute to a public good. For each unit he contributed, he increased each of his group members' monetary payoff by 0.5 MUs, while simultaneously reducing his own balance by 0.5 MUs. For each unit one of his group members decided to contribute, his own balance was increased by 0.5 MUs. Since the participants net return from contributing was negative, selfish participants should never contribute. However, if none of the three individuals in the group decided to contribute, each of them only earned 10 MUs, compared to 15 MUs if all of them contributed all ten MUs. The experiment was framed in abstract and neutral terms. We find that participants contributed on average 3.67 out of the 10 MUs.

To capture their competitiveness, they took part in a simple competition game (Leibbrandt et al., 2013). In this game, fishers had to throw a tennis ball 10 times into a bucket that was set 3 m away. Competitiveness was identified by a single choice: subjects decided, before performing the task, whether they wanted to compete. They were informed that if they decided not to compete, they would earn 1 MU per successful attempt. If they decided to compete, they would earn 3 MUs per successful attempt, but only if they outperformed one unknown other subject; if they scored less than this other subject they would not earn anything. In case of a tie they would earn one monetary unit per successful attempt. They did not know against whom they were to compete. We observe that 44% decided to compete.

To capture the fishers' social integration, we use a standardized indegree measure (Cavalcanti et al., 2013). According to the degree concept an individual is more central, the more direct ties this individual possesses. In our setting this means that a participant is more central, the more others mentioned him in the survey as a friend. We treat our social network data as undirected, meaning that if A names B as a friend, we assume that B is also friend with A. For example, if A named three fishers

and two others named him as a friend, A has a degree of five. We standardize the centrality measure to account for different network sizes across the different villages. The average standardized indegree of our fishers is 8.98.