Prudence and Precautionary Saving by Natural Resource Users.

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Submission BioEcon, updated May 6, 2019

Abstract

An experimental literature is emerging investigating the theoretically predicted relation between higher-order risk preference and financial behaviour. This paper utilizes the institutional framework and diversity of the artisinal Chilean fisheries to link precautionary savings behaviour with prudence. In this environment we test if prudence is a predictor of precautionary savings and whether prudence relates to occupational choice. We find substantially lower levels of prudence in our sample compared to previous research with non-fishers. We detect differences in prudence and precautionary savings based on target species and demographic correlates. However, we do not find a direct relation between prudence and precautionary savings.

Keywords: Bioeconomics, Social-Ecological Systems, Higher order Risk preference, Fisheries.
(JEL: D14 D81, Q22)

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1 Introduction

Individuals save for expected expenses but also to create a buffer for contingencies such as declines in future income or medical expenses. The savings allocated for unanticipated events are called precautionary savings. Under expected utility, the convexity of the marginal utility function (prudence) should increase the desire for precautionary savings as background risk increases [Leland, 1968, Sandmo, 1970]. The direct assessment of prudence using experimental methods has become accessible due to the work of Eeckhoudt and Schlesinger [2006], in developing a behavioural definition for prudence. Since then a rapidly growing experimental literature has developed on the prevalence of prudence [Trautmann and van de Kuilen, 2018], however experimental evidence for its predicted effect on precautionary savings remains scarce [Noussair et al., 2014].

Measuring the importance of prudence as a predictor for precautionary saving behaviour is complicated by the unobserved financial uncertainty that individuals face. The perceived uncertainty on which precautionary savings decisions are made, is shaped by institutional and environmental characteristics, such as the welfare system, and individual characteristics, including age, wealth and health [Lugilde et al., 2018]. Due to data availability constraints, the empirical precautionary savings literature is often dependent on macro level data to measure income uncertainty, however it is not certain that these aggregate measures reflect the income uncertainty faced by individual households.

In this paper we utilize the institutional framework of the Chilean artisinal fisheries to analyse how individual characteristics, and in particular prudence, influence preferences for precautionary savings. Chilean artisinal fishers form fisheries organisations in order to attain quotas or territorial use rights for fishing[Castilla, 2010]. Within these fisheries organisations, environmental and institutional influences on financial uncertainty are similar between individuals, allowing us to investigate the effects of individual characteristics on precautionary savings. Furthermore, the diversity of Chilean fisheries allows us to test whether fishers preferences for prudence and savings differ based on their target resource.

We aim to contribute to the literature by linking prudence and preferences for precautionary savings in a setting where income risk is controlled for, we also provide evidence for the demographic correlators of prudence. Furthermore we argue for the importance of precautionary savings behaviour by natural resource users, a group which could be become more vulnerable to large income fluctuations in future. We test the following hypotheses: (i) Do prudent resource users have a higher preference for precautionary savings than non-prudent resource users, when income risk is controlled for? (ii) Are resource users preferences for precautionary savings and prudence correlated to their target resource?

In the next section we review some of the literature on precautionary savings and higher order risk preference. In section 3 we describe our subject pool and the data collection process, we also show our methods for determining precautionary savings and prudence. In section 4 we report the demographic correlates for prudence. In section 5 we present our results and lastly we conclude and discuss our results in section 6.

2 Background literature

Savings are generally defined as the residual between disposable income and the current consumption. The standard desire for savings comes from an expected future decline in consumption, and a preference for smoothing consumption between time periods. The extra savings generated by uncertainty about future income are referred to as precautionary savings [Carroll and Kimball, 2006].

Difficulties present themselves when estimating the effect of uncertainty on savings behaviour, as it is difficult to identify which part of savings is allocated to protect against uncertainty. In a recent review on the empirical literature by Lugilde et al. [2018] it was concluded that no consensus has been established on the appropriate measure for uncertainty nor the strength of the precautionary savings motives. Furthermore wealth can be out of equilibrium due to negative financial shocks, which can potentially cause misleading observations. To measure precautionary saving, we follow the methods of Tullio et al. [2008] and Deidda [2013]. They take a direct approach by asking Italian households for the desired amount of precautionary savings, using a survey question.

The heterogeneity of risk preferences can lead to biases when regressing precautionary savings onto income risk [Fuchs-Schündeln and Schündeln, 2005]. Since Leland [1968] and Sandmo [1970] it has been established that under expected utility, the convexity of the marginal utility function is equivalent to the precautionary savings motive. They show that a person with a positive third derivative of the utility function would have a preference for precautionary savings in response to income risk. This concept was coined as prudence by Kimball [1990], as it suggests *"..the propensity to prepare and forearm oneself in the face of uncertainty,.."*.

For measuring the participants' prudence we utilize the seminal work by Eeckhoudt and Schlesinger [2006]. They proposed a behavioural definition of prudence and devised a class of lottery pairs, where participants are given the choice of allocating an unavoidable mean-zero risk to the good outcome or a bad outcome of a lottery. They show that a preference for allocating the risk to the good outcome is equivalent to putting a positive sign on the third derivative of the utility function, which implies prudence. Furthermore they argue that prudence can be considered a preference for disaggregating harms, such that a prudent individual would rather take a risk when wealth is high than when wealth is low.

The evidence for a direct link between experimentally elicited prudence and financial behaviour is still scarce. The lotteries by Eeckhoudt and Schlesinger [2006] were used in Noussair et al. [2014] to show that prudence positively correlates with the presence of savings and negatively with credit card debt, in a representative panel of the Dutch population. To my knowledge there exists no experimental paper which shows a link between revealed prudent preferences and self-selection into low income risk jobs as proposed by Fuchs-Schündeln and Schündeln [2005].

3 Subject pool, survey and experimental design

3.1 Experimental sessions

Between the 29th of October and the 24th of November 2018 we held 26 session, with a total of 440 participants in the IV, V and VIII regions of Chile. Fisheries organisations were approached by researchers of the Pontificia Universidad Católica de Valparaíso during a round preparatory visits in September 2018. When there was interest from the fisheries organisation to participate, the contact person of this fisheries organisation was asked to invite participants for the session. If a minimum number of fishers (12) agreed to participate, a meeting was scheduled. Organisations were approached based on their main target species (or group of species). Table 1 shows the composition of our experimental sample.

Sessions had between 8 and 22 participants, and all participants in a session were member of the same fisheries organisation. Each session consisted of a series of incentivized preference questions and a demographics survey. We measured risk aversion, public goods preferences and prudence using incentivized choices. At the end of the sessions one of the three questions was randomly chosen to be paid out. The preference questions and demographic survey were answered on tablets running OpenDataKit survey software[Hartung et al., 2010]. The sessions lasted between 1.5 and 2 hours. Participants were paid 10,000 Chilean pesos (CLP) for finishing the survey and could earn an additional 0 to 24,000 CLP with the incentivized preference questions. The average payout was 18,100 CLP, which is equivalent to 23,76 Euro.

Table 1: Session composition. Small pelagic fish refers to a combination of *Strangomera bentincki, Trachurus trachurus*,*Engraulis ringens*. The Squid fishery targets the humbolt squid or *Dosidicus gigas*. Macro Algae refers to a large collection of different types of a algae species. The macro algae fishery in the IV region is more specific and focusses only one type of algae called Huiro Palo or *Lessonia trabeculata*. Molluscs refers to *Tagelus dombeii*, *Ensis macha*, *Venus antiqua*. Crabs consists of a large collection of crab species.

Region	Resource (group)	# sessions	# participants
VIII	Small pelagic fish	5	95
V	Small pelagic fish	2	38
VIII	Squid	3	61
V	Squid	3	57
IV	Macro Algae(Huiro Palo)	2	31
VIII	Macro algae	3	52
VIII	Molluscs	3	60
IV/V	Crabs	4	51

3.2 Survey

3.2.1 Prudence

Prudence is measured using the lotteries as designed by Eeckhoudt and Schlesinger [2006], the experimental design is similar to Noussair et al. [2014]. Participants are given a scenario where a coin flip determines their payout. If they flip heads they will receive high payout H and if they flip tails they will receive low payout L. Before they flip the coin, there are asked to put a mean-zero lottery on one of the two outcomes. We will call putting the lottery on the high outcome, option A, and on the low outcome, option B. This mean-zero lottery will be a second coin flip with payout h and l, where $l = -h$.

The average outcome and standard deviation of outcomes is identical for both options, but option A has a positive skew, whilst option B has a negative skew. An example for the distribution of outcomes for option A and B can be seen in figure 1. We classify a participant to be prudent if they choose option A. In total participants are given 5 lotteries. The first lottery is a true prudent lottery, and will be referred to as the baseline lottery. The four subsequent lotteries have differences in expected payout for choosing option A and option B. The payout for the first coin toss is increased by 1 or 2 point(s) if option A (B) is chosen. This adds an extra incentive for choosing the (in)prudent options. The lotteries are presented in table 2

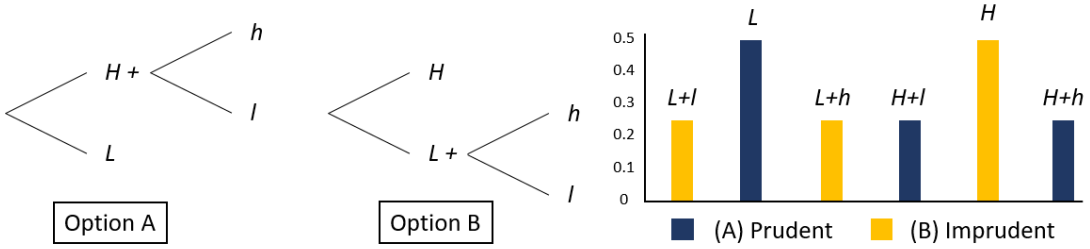

Figure 1: The Left panel of the figure shows the two options participants can choose between, where option A is prudent and option B imprudent. The right panel shows the outcome distribution associated with option A and B. The blue bars represent option A and the yellow bars option B. The y-axis shows the probability of an outcome, and the x-axis represents the payout.

Table 2: List of lotteries. The table can be read as follows, 9|6 would indicate that the flip of a coin would result in a payout of either 9 or 6. $9 + (4| - 4)|6$ indicates that the first flip of a coin would result in a payout of $9 + (4| - 4)$ or 6. The second coin flip would determine if the payout would be $9 + (4)$ or $9 + (-4)$

	Option A	Option B
Baseline	$9 + (4 \mid -4) \mid 6$	$9 \mid 6 + (4 \mid -4)$
Prud + 1	$10 + (4 \mid -4) \mid 7$	$9 \mid 6 + (4 \mid -4)$
Prud + 2	$11 + (4 \mid -4) \mid 8$	$9 \mid 6 + (4 \mid -4)$
Inprud + 1	$9 + (4 \mid -4) \mid 6$	$10 \mid 7 + (4 \| -4)$
Inprud + 2	$9 + (4 \mid -4) \mid 6$	$11 \mid 8 + (4 \mid -4)$

3.2.2 Precautionary savings

To measure precautionary savings we follow the same approach as Tullio et al. [2008], Deidda [2013]. We use a survey question to ask participants for the amount savings they need to protect themselves against contingencies. The question is a variation on one asked in the Bank of Italy Surveys on Household Income and Wealth (SHIW) in 2002 and 2004. The question reads as follows:

> People save in various ways, (depositing money in a bank account, hiding it under their bed, buying property, or other assets) and for different reasons. A first reason is to prepare for a planned event, such as the purchase of a house, children's education, etc. Another reason is to protect against uncertainty about future earnings or unexpected expenses (owing to health problems or other emergencies). About how many weeks of expenses do you and your family need to have in savings, to meet such unexpected events?

We diverge from the SHIW question by asking the participants to express their answer in weeks of expenses, as opposed to a quantity of money[1]. We did so because fishers could be weary of sharing data regarding income and wealth. Furthermore this allows us to interpret their answer as a target wealth over income ratio.

3.3 Self-assessment of risk exposure

We elicit the expected income variability of participants when they consider their own fishery. Our method for eliciting perceived income variability is based on a series of questions originally used in the 1995 'Bank of Italy Survey of Households Income and Wealth' [Guiso et al., 2002, Attanasio and Kaufmann, 2017] and more recently in a labour market field experiment in Uganda [Alfonsi et al., 2017]. We ask the participants to give their maximum (Y_{max}) and minimum expected income (Y_{min}) from fishing for next year. We also ask the chance that they will earn less than a typical year (Z). With this data we construct a double triangular distribution, as in figure 2. Using the constructed distribution we calculate the coefficient of variation of expected income.

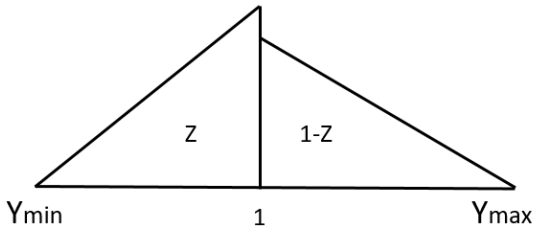

Figure 2: Depiction of the double triangular income distribution, where Y_{min} is the minimum expected income, Y_{max} the maxmimum expected income and Z the expected probability for earning less than a typical year. The data is gathered in fractions of a typical yearly income. We assume that the density of the distribution is highest at a typical yearly income, which is depicted by 1 in this figure.

The questions are phrased as follows:

> (i) What are the chances that you will earn less than you would in a typical year?
> (ii) Suppose that in the next year you will continue fishing. What is the minimum income that you expect to earn from fishing, compared to a typical year?

[1] We verbally told participants that a month contains 4 weeks and a year 48 weeks.

(iii) Suppose that in the next year you will continue fishing. What is the maximum income that you expect to earn from fishing, compared to a typical year?

Most fishers have a comprehension of percentages in relation to fractions, however it is unclear if they are able to relate this to probabilities of events. To increase comprehension we relate numeric percentages in relation to verbal expressions of likelihood according to Manski [2004].

4 Demographic Correlates

We briefly touch on the demographic correlates of prudence and precautionary savings as these have not yet been explored for common-pool resource users. We define prudence as the number of prudent choices in the series of lotteries presented in table 2. In table 3 we report regression results, specifications 1 and 2 report OLS coefficients. Specification 2 includes economic variables specific to fishers. Specification 3 reports ordered probit estimates to show the robustness of the OLS results. We find that prudence reduces with age ($p < 0.01\%$) and that women are more prudent than men when economic variables are controlled for ($p < 0.05\%$). Concerning family situation we see that participants living close to their parents are less prudent ($p < 0.05\%$). We find no relation between education and prudence, which contradicts previous findings [Trautmann and van de Kuilen, 2018][2].

For variables more specific to fishers, we find that prudence positivity correlates with the percentage of household income coming from fishing, utilization of territorial use right and selection into fishing[3] ($p < 0.05$). Lastly we asked participants where they would turn to if they had no money. They were allowed to pick multiple answers from the following list, family, friends, fish buyer, bank and government. Those that preferred going to the bank are more prudent ($p < 0.05$), whilst there is no effect for the other choices[4].

In specification 4 we report OLS estimates for desired precautionary savings, expressed in weeks of expenses. We find a positive correlation with gender ($p < 0.10$) and with parents living in the same area ($p < 0.01$)[5]. Furthermore, selection into fishing ($P < 0.05$) and an increasing share of household income from fishing is positively correlated with precautionary savings ($p < 0.1$). Fishers registered as boat owners have a lower preference for savings ($p < 0.1$).[6]

[2]Less than 10% of our sample has attained a tertiary education, of which most have a technical degree.

[3]A participant did not select into fishing if he answers that fishing was his only option, and that he lived in the same area his entire live.

[4]Fish buyer is not reported due to low sample size ($N = 3$).

[5]In 2009 just 30% of fishers in Chile were part of any type of social security system and only 1.71% specifically to a pension system Benítez and Nava [2016]. Therefore it is likely that children are responsible for their parents expenses.

[6]Boat owners are generally wealthier, Tullio et al. [2008] finds that the target wealth to income ratio drops, as permanent income increases.

Table 3: Table shows regression result for demographic and economic correlates for number of prudent choices (1,2,3) and desired weeks of expenses as precautionary savings. Specifications 1,2 and 4 are OLS and 3 reports ordered logit.

	Dependent variable:			
	Number of prudent choices			Savings
	(1)	(2)	(3)	(4)
Age	−0.039***	−0.033***	−0.042***	0.178
	(0.006)	(0.010)	(0.013)	(0.164)
Female	0.183	0.500**	0.600**	7.285*
	(0.181)	(0.225)	(0.304)	(3.817)
Education	0.117	0.081	0.169	−1.598
	(0.099)	(0.107)	(0.143)	(1.802)
Spouse	0.353*	0.294	0.393	2.877
	(0.196)	(0.202)	(0.271)	(3.444)
Children	−0.381*	−0.303	−0.446	−3.449
	(0.206)	(0.213)	(0.284)	(3.635)
Parents live here	−0.433**	−0.413**	−0.534**	11.382***
	(0.178)	(0.195)	(0.261)	(3.279)
Tenure as fisher		−0.005	−0.006	−0.223
		(0.008)	(0.011)	(0.142)
% Income from fishing		0.008**	0.009**	0.096*
		(0.003)	(0.004)	(0.056)
Active on Turf		0.247**	0.298**	−0.268
		(0.114)	(0.151)	(1.937)
Boat owner		−0.307	−0.384	−5.786*
		(0.199)	(0.262)	(3.356)
Selected into fishing		0.347**	0.435**	6.504**
		(0.162)	(0.215)	(2.759)
Money from Bank		0.446**	0.585**	−0.468
		(0.191)	(0.254)	(3.222)
Money from Family		0.140	0.171	0.165
		(0.183)	(0.244)	(3.100)
Money from Friends		−0.343	−0.391	5.144
		(0.301)	(0.407)	(5.004)
Money from Government		−0.402	−0.609*	21.611***
		(0.282)	(0.358)	(4.753)
VIII Region		0.364**	0.479*	3.147
		(0.185)	(0.246)	(3.187)
City		0.003	−0.038	−4.301
		(0.199)	(0.264)	(3.395)
Constant	4.347***	2.413***		−7.289
	(0.551)	(0.741)		(12.648)
Observations	378	335	335	317
R^2	0.144	0.231		0.143
Adjusted R^2	0.130	0.189		0.094

*p<0.1; **p<0.05; ***p<0.01

5 Results

Figure 3 shows histograms for the measures of precautionary savings and prudence. For precautionary savings, we find that participants on average desire 25.63 weeks of savings, however the figure shows a bimodal distribution with peaks at 0 to 12 weeks of savings and 48 to 56 weeks of savings. We find that participants choose the prudent option 2.74 out of 5 times on average. With this the sample as a whole show significant prudence, as the mean is not equal to 2.5 (Wilcoxon signed rank test, $p < 0.01$). In the baseline lottery the prudent option was chosen by 53.26% of the participant, which does not differ significantly from 50% (binomial test, $p = 0.1843$).

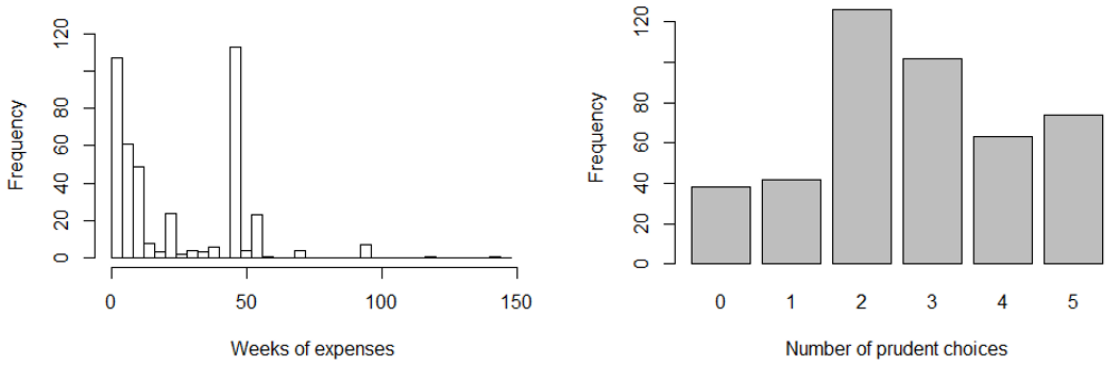

Figure 3: The figure shows the distribution for precautionary savings and prudent choices. Precautionary savings is measured in weeks of expenses.

Table 4 shows that we find no correlation between experimentally elicited prudence and precautionary savings. In specifications 1 and 2, we regress the choice in the baseline prudence lottery on the participants preference for precautionary savings. In specifications 3 and 4 we do the same for the number of prudent choices in all lotteries. The entire sample was used for specifications 1 and 3, whilst 2 and 4 use a sub sample of participants that made only consistent choices in the series of prudent lotteries[7]. We control for income risk by using a fixed effect for the fisheries organisation.

To test whether fishers occupational choice and prudent preferences are correlated, we utilize a sub sample of fishers in the VIII region in Chile. The high density and diversity of fishers in this area allows for fishers to select into their fishery of preference[8], furthermore our sample has the highest coverage of different fisheries in this area. Within the VIII region we have data for four types of fishers, with the target species: algae, molluscs, squid and small pelagic fish.

In figure 4, we show the average number of prudent choices by participants for each fishery and the accompanying 95% confidence interval. We find that algae gatherers are the most prudent type of fisher, followed by squid, small pelagic fish and molluscs respectively. In table 5 we present an ordered logit regression of the number prudent choices. Algae gatherers are the base category. We find that algae gatherers are significantly more prudent than all other types, when we control for demographic variables ($p < 0.05$). However there is no significant difference between the other groups. This result does not hold when we subsample for participants with consistent choices. Table 6 shows that we find no correlation between subjective income risk and precautionary savings. We do find that

[7]We consider a participant their choices to be inconsistent, if between lotteries they change from prudent to imprudent when the expected payout of the prudent option increases, or vice versa.

[8]Fisheries choices are limited in more remote areas.

Algae gatherers want significantly less savings than those that harvest small pelagic fish or crabs.

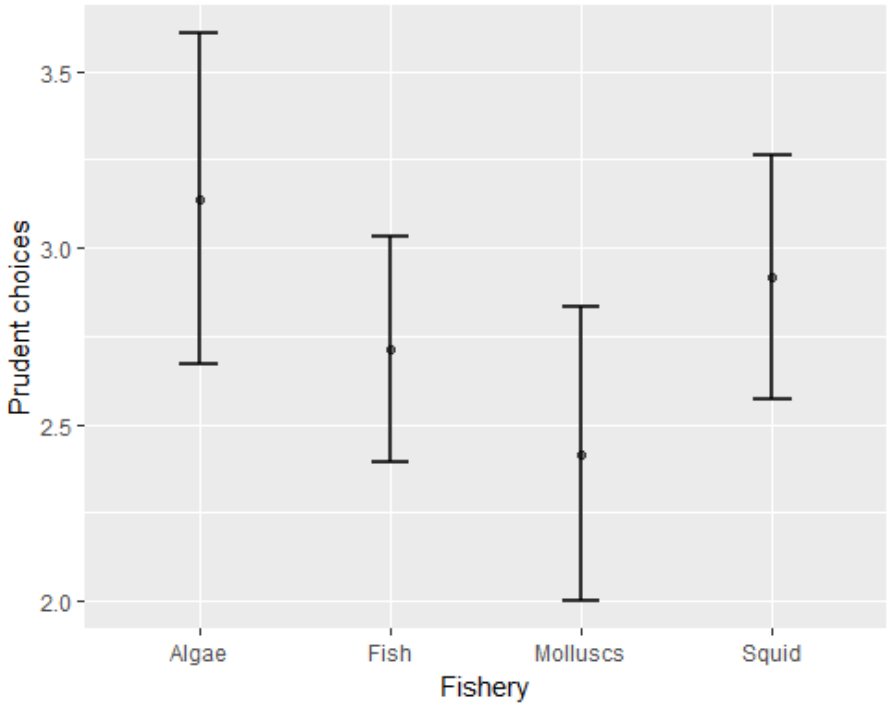

Figure 4: The figure illustrates the number of prudent choices made on average per fishery. The bars indicate the 95% confidence intervals.

Table 4

	Dependent variable:			
	Weeks of expenses as savings			
	(1)	(2)	(3)	(4)
Baseline lottery	0.318	−1.334		
	(2.274)	(3.259)		
Number of prudent choices			−0.160	−0.256
			(0.658)	(0.719)
Organisation fixed effect	Yes	Yes	Yes	Yes
Demographic controls	Yes	Yes	Yes	Yes
Sample	Complete	Consistent	Complete	Consistent
Observations	398	186	398	186
R^2	0.281	0.366	0.281	0.366
Adjusted R^2	0.228	0.258	0.228	0.257
Note:				*p<0.1; **p<0.05; ***p<0.01

Table 5: Table shows the results of a ordered logistic regression of target species on prudence. Demographic controls are: age, gender, education and family composition. Sample is limited to participants from the VIII region.

	Dependent variable:	
	Number of prudent choices	
	(1)	(2)
Small pelagic fish	−1.084**	−1.074
	(0.502)	(0.838)
Molluscs	−1.069**	−1.202*
	(0.417)	(0.618)
Squid	−0.930*	−0.763
	(0.495)	(0.832)
Observations	249	114
Sample	Complete	Consistent
	*p<0.1; **p<0.05; ***p<0.01	

Table 6: Table shows the results from an OLS regression regarding precautionary savings. Subject income risk is the coefficient of variation in income calculated using the distribution from section 3.3. Regression includes all demographic and economic controls used in explored in section 4.

	Dependent variable:	
	Weeks of expenses as savings	
	(1)	(2)
Subjective income risk	−0.669	
	(8.433)	
Small pelagic fish		11.195**
		(5.598)
Molluscs		3.344
		(4.453)
Crabs		12.578*
		(6.536)
Squid		5.835
		(5.132)
Demographic controls	Yes	Yes
Economic controls	Yes	Yes
Observations	295	337
R^2	0.158	0.155
Adjusted R^2	0.103	0.095
Note:	*p<0.1; **p<0.05; ***p<0.01	

6 Conclusion

Within social ecological systems interactions between the resource users, the resource system and governance system create challenges and opportunities for sustainable resource management [Ostrom, 2009]. Natural resource users are exposed to levels of income risk inherent to the resource they harvest [Anderson et al., 2017] and the institutions that govern that resource [Essington, 2010]. Downward fluctuations in prices, resource abundance and quotas can severely limit the income of resource user. Understanding if and how resource users mitigate income risk can help in designing institutions that reduce the negative consequences of periods with low income.

Several methods have been proposed for reducing the inter-annual variation in income of fishers, such as diversification of fishing targets and promoting income from non-fishing sources [Anderson et al., 2017]. However in overexploited fisheries these options can be limit due to restrictions on fishing licences and limited employment opportunities. Small-scale fishermen can be especially vulnerable to negative financial shocks, as corporate fishing companies may be better at mitigating risk. As a consequence fishing effort could shift away from small-boat owners after low-income periods [Kasperski and Holland, 2013]. Within Chile this process could increase already existing tension between artisinal and industrial fishers Tam et al. [2018]

There exists little research on the savings behaviour of fishers and how this depends on income risk. There exists some evidence that people with high income risk jobs generally have higher savings. In a paper using data on Japanese households, Zhou [2003] states that fishers combined with forestry and agricultural workers have much higher precautionary savings than salaried workers, 64.3% and 5.6% respectively, however this is not a universal finding Lugilde et al. [2018]. This paper is the first to investigate how the risk of specific fisheries within a sector corresponds to savings behaviour.

The data we collected shows a dichotomy in the preferred target wealth of precautionary savings by Chilean fishers. Close to 50% of our sample has a target wealth of 12 weeks of expenses or less. Whilst 32% of our sample has a target wealth of more than 48 weeks. The bimodal shape of our distribution could be inherent to the phrasing of the question, as the peaks of the distribution are centred around 1,2,3 and 12 months of savings. The average target wealth is 25.63 weeks of expenses or 53.4% of yearly income[9]. This is substantially lower than the findings for Italian households [Tullio et al., 2008].

Using a lab-in-field approach we find that 53% of our sample chooses the prudent option in a lottery task. This is in contrast to the basic finding that people are on average prudent Trautmann and van de Kuilen [2018]. Using a lottery with identical parameters[10], Noussair et al. [2014] found that 68.6% of a sample representative for the Dutch population chooses the prudent option. Whilst this could suggest that fishers as a demographic group are less prudent, such a conclusion should be met with caution due to the large contextual differences. Research using a comparable control group would be necessary.

We find no direct evidence that prudence is a predictor for precautionary savings. However we do find that both preferences for prudence and precautionary savings are influenced by the target species and by several demographic and economic characteristics. We do not find that subjective income risk correlates with precautionary savings.

[9] Under the assumption that expenses are equal to income and that a year contains 48 weeks

[10] Lottery: Prud 3

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