LICOS Discussion Paper Series

Discussion Paper 364/2015

Voodoo versus fishing committees: The role of traditional and contemporary institutions in fisheries management

Elena Briones Alonso *Romain Houssa* *Marijke Verpoorten*

KU LEUVEN

Faculty of Economics And Business

LICOS Centre for Institutions and Economic Performance
Waaistraat 6 – mailbox 3511
3000 Leuven
BELGIUM

TEL:+32-(0)16 32 65 98
FAX:+32-(0)16 32 65 99
http://www.econ.kuleuven.be/licos

Voodoo versus fishing committees: The role of traditional and contemporary institutions in fisheries management*

Elena Briones Alonso[a] Romain Houssa[b] Marijke Verpoorten[a,c]

[a] LICOS - Centre for Institutions and Economic Performance
KU Leuven, Belgium

[b] CRED - Centre of Research in the Economics of Development, and CeReFiM
University of Namur, Belgium

[c] IOB - Institute for Development Policy and Management
University of Antwerp, Belgium

March 3, 2015

Abstract

We study the co-existence of two community-based institutions for fisheries management in Benin: a traditional institution embedded in the Voodoo religion and a recent secular institution in the form of fishing committees. Using household survey data on fishing activities, we find that rules of both institutions have a statistically significant but small impact on the use of unsustainable fishing gear. We further find that Voodoo fishers who break the traditional Voodoo-based rule follow the fishing committee rule to the same extent as other fishers. This finding is consistent with a possible transition from the traditional Voodoo-based institution to the secular fishing committee institution. More research is needed to fully assess the effectiveness of, and interactions between, the two institutions.

* Corresponding author: Elena Briones Alonso (elena.brionesalonso@kuleuven.be). We are grateful for valuable comments from Gani Aldashev, Jean-Marie Baland, Erwin Bulte, Jean-Philippe Platteau, Nik Stoop, Jo Swinnen, Maarten Voors and David Zetland. We also thank seminar and conference participants at the University of Namur, Wageningen University, Utrecht University, 2013 EAAE PhD workshop and Paris Dauphine University. This research was financially supported by the Centre for Institutions and Economic Performance (LICOS) under the KU Leuven Methusalem Grant and by the Research Foundation – Flanders (FWO).

1. Introduction

Around the globe, marine and inland fishery stocks are being overexploited (Allan et al., 2005; FAO, 2012). The importance of small-scale fisheries for food security and poverty alleviation stresses the need for sustainable fisheries management (FAO, 2014). Community-based natural resource management has been advocated as an effective and sustainable resource management strategy under certain conditions (Agrawal, 2001; Baland and Platteau, 1996; Berkes, 1989; Cox et al., 2010; Ostrom, 1990), in particular for small-scale fisheries (Berkes, 2001; Pinkerton, 2011).

Community-based natural resource management is often integrated in traditional culture or religion, relying on institutions such as sacred sites and taboos (Berkes, 2008; Berkes et al., 2000; Bhagwat and Rutte, 2006; Colding and Folke, 2001; Dudley et al., 2009; Jones et al., 2008). Although traditional resource management is often undermined by socio-economic modernization and the introduction of new institutions and religions, case studies find that traditional religions continue to regulate resource exploitation and conservation today (Deb and Malhotra, 2001; Eneji et al., 2012; Kajembe et al., 2003; Kokou et al., 2008; Ntiamoa-Baidu, 2008; Ormsby and Bhagwat, 2010; Sharma et al., 1999; Veitayaki et al., 2011).

In this paper we examine community-based fisheries management at Lake Nokoué in Benin. The lake fisheries provide a livelihood to artisanal fishing communities, but are severely affected by overfishing and resource degradation (FAO, 2008; Gnohossou, 2006). Fishing was historically regulated by an institution embedded in Voodoo, the traditional animistic religion of Benin (Bourgoignie, 1972; Clédjo, 2006; Dangbégnon, 2000; Pliya, 1980). After colonization, socio-economic changes undermined the influence of the Voodoo religion and Voodoo-based institutions. The erosion of traditional fisheries management in combination with failing government institutions, strong population pressure and the rising value of fishery products resulted in increasingly severe overfishing (Dangbégnon, 2000). In the 1990s the

fishing communities attempted to curb this negative trend by creating committees to regulate fishing activities (Atti-Mama, 1998).

These fishing committees issued rules that differ and sometimes conflict with traditional Voodoo-based rules. For instance, both the committees and the traditional institution formulate a rule concerning the *konou* – a highly productive fishing technique that makes use of fine mesh nets. The traditional rule bans the use of the fine meshed konou at all times (Clédjo, 2006; Pliya, 1980), while the fishing committees impose a periodical prohibition: open weeks – in which the use of the konou is allowed – alternate with closed weeks – in which the konou is banned.

In this dual institutional setting we examine three empirical questions. First, does the traditional Voodoo-based rule still keep Voodoo fishers from using the fine meshed konou? Second, does the fishing committee rule keep fishers from using the konou in closed weeks? Third, do Voodoo fishers who break the traditional Voodoo rule comply in any way to the fishing committee rule?

To answer these questions, we perform an empirical analysis using two different datasets. The first is taken from a 2006 fishery census implemented by the Beninese government, and contains information for 5,852 fishermen across 34 villages near lake Nokoué. The second is a 2009 household survey implemented by the authors, and contains weekly information on fishing activities across 14 weeks for 103 fishermen living near lake Nokoué. While the large census allows us to better control for village level heterogeneity, the household survey has the advantage of a weekly time dimension. To contextualize our analysis we went back to the field in 2013 and surveyed 137 fishers at lake Nokoué, collecting additional information about fishermen's perceptions of fishery institutions.

To examine compliance to the traditional Voodoo-based rule we explore the conditional correlation between Voodoo adherence and the use of the konou, both in the large census data and in the household survey data. To examine compliance to the fishing committee rule we

study the relation between the use of the konou and the closing of the lake across weeks. As this approach requires a time dimension, we use the household survey data. We also use the survey data to study how Voodoo fishers who break the traditional rule behave towards the fishing committee rule. More specifically, we explore the relation between the use of the konou and the interaction term between Voodoo adherence and the closing of the lake.

To our knowledge this is the first study that quantitatively examines the compliance of resource users to rules formulated by a traditional institution as well as a competing secular institution. In addition, we did not find studies discussing the interaction between traditional and recent management institutions, i.e. how resource users who break with traditional rules behave towards recent alternative rules. Benin provides an ideal testing ground to answer these questions because of its particular setting of dual community-based fishery institutions and because of its remarkable religious tolerance and pluralism, which manifests itself amongst others in considerable variation in religious adherence within villages (Barbier and Dorier-Apprill, 2002). We can therefore compare the behaviour of fishers who explicitly identify themselves with Voodoo to fishers who follow other religions while controlling for village-level characteristics.

The next section discusses fishery management institutions and the social-ecological system of lake fisheries in southern Benin. Section 3 presents our data and Section 4 explains the methodology used to analyse the data. Section 5 presents our results, and in Section 6 we investigate a number of competing explanations for our findings. Section 7 concludes.

2. The lake fisheries of southern Benin

2.1. The social-ecological system

We study fishing communities living in the commune So-Ava near lake Nokoué in the south of Benin (see Figure 1). Lake Nokoué is the largest water body in Benin and part of the most productive water basin, accounting for 65 to 70 percent of inland fisheries production (Gnohossou, 2006). In the course of history different ethnic groups settled around the lake and specialized in fishing activities (Bourgoignie, 1972; Pliya, 1989, 1980). Today the communities have a long-established tradition of artisanal fishing that dates back several generation, and industrial fishing remains absent (Atti-Mama, 1998).

In recent years, the coastal lakes in Benin suffered from severe environmental degradation and overfishing (FAO, 2008; Gnohossou, 2006).[1] As the fishing communities have few income activities outside the fishery sector, they are particularly vulnerable to resource degradation (Stoop et al., 2013).[2] Instead of diversifying their income, the communities cope with the rising pressure on their livelihoods by developing more productive fishing technologies. One of the most important innovations in fishing techniques was the introduction of the konou in the 1980s.

The konou (or *medokpokonou*) is a fixed fishing installation used in circulating water that consists of a long (100 to 400 m) central rectangular net with several pouches (République du Bénin, 2008). This structure and the length of the net make the konou one of the most productive fishing instruments used at lake Nokoué. However, because of these features installing and harvesting the konou requires considerable physical effort.

[1] In the 2006 fishery census about 99 % of more than 14,000 fishers at lake Nokoué report that the size of catches and average catches have declined in the last 3 years.

[2] In the 2009 household survey over 85 % of annual household income derives from the fishery sector (see Table A.1 in the online appendix).

The konou is considered an unsustainable fishing technique mainly because of the use of fine mesh fishing nets (20 to 5 mm). While these fine mesh nets make the konou very productive, especially for shrimp fishing, they undermine the sustainability of the fishery stock by catching juveniles and even eggs (République du Bénin, 2008).

2.2. Fisheries management

The traditional Voodoo-based institution

Voodoo (*Vodun*) is an animistic religion found along the coast of West Africa (Ghana, Togo, Benin, Nigeria). From the end of the 16th century until the colonization and subsequent introduction of Christian religions, Voodoo was the dominant religion in South Benin and played a fundamental part in all aspects of society (Bourgoignie, 1972; Tall, 1995b).

In the world view of Voodoo, the natural world is connected to a supreme divine force through Voodoo deities (Bourgoignie, 1972; Tall, 1995a). These deities are immaterial beings, neither human nor divine, that belong to the spirit world. Each spirit is connected to and controls specific natural elements such as trees or water bodies. Voodoo spirits are both respected and feared, as they will help mankind when appeased, but will inflict punishments such as flooding, sickness or even death when offended.

The Voodoo religion gave birth to institutions that regulated the exploitation of natural resources. One example is the sacred forest, found throughout Benin and Togo (Juhé-Beaulaton and Roussel, 2002; Kokou et al., 2008). The southern lakes of Benin provide another example. Voodoo spirits are believed to control the movements of the water and its fauna (Bourgoignie, 1972; Clédjo, 2006; Pliya, 1980), and fishing activities were regulated by a wide array of concrete rules and taboos embedded in Voodoo beliefs (Clédjo, 2006; Pliya, 1980). Fishing was for instance prohibited on days of worship (one day out of four) and in the vicinity of sacred sites (*fétiches*). The use of fine mesh nets was also prohibited. According to Clédjo (2006) these

rules served to limit fishing intensity and protect fishery reproduction, for instance by converting spawning grounds into fétiches.

Voodoo priests were powerful religious and political leaders and played a crucial role in the organization, monitoring and enforcement of the traditional Voodoo-based fishery institution (Dangbégnon, 2000; Pliya, 1980). Sanctions were applied by priests and were severe, ranging from the confiscation of fishing gear to public flagellation. The worst offenses were sanctioned by death.

According to Pliya (1980) the traditional institution managed to keep resource exploitation in check, even in the face of population growth. The system started to fail, however, when (post-)colonial Benin underwent profound changes, such as the disappearance of traditional politico-religious power structures, an increasing market demand for fishery products and the rising popularity of Christian religions (Dangbégnon, 2000; Pliya, 1980).[3]

Even though the religious landscape in post-colonial Benin became dominated by Christianity, the traditional Voodoo religion remains influential today (Tall, 1995a). In 2011 13 % of Beninese reported to follow traditional religion (Afrobarometer 2014). Voodoo has also been recorded as an official religion in the constitution and is celebrated each year in a national Voodoo festival.

Similarly, the traditional fishery institution did not disappear. Several rules, taboos and sanctions still exist today (Clédjo, 2006; Dangbégnon, 2000; République du Bénin, 2008). One such rule is the taboo of fishing near fétiches. In our 2013 survey, 85 % of fishers were aware of such fétiches and, among these fishers, 91 % said not to fish near them. Another rule that remains today is the prohibition to use fine mesh nets. Although the death sentence is no longer applied, present-day sanctions can range from the destruction of fishing gear to heavy fines and even the demolition of the perpetrator's house (Clédjo, 2006).

[3] See online appendix C for more details.

The fishing committees

In 1993 fishers created a new institution to regulate fishing activities in the form of fishing committees (Atti-Mama, 1998). This institution was a local response to overfishing, failing fisheries management and increasingly frequent conflicts. In 1997 the government legalized the fishing committees to increase their effectiveness (République du Bénin, 1997). As such the committees became a co-management institution, organized at the level of the fishing village but legitimized and supported by the central government (Atti-Mama, 1998). The main tasks of the committees – as reported by fishers in 1996 – are the settling of conflicts, implementing and monitoring regulations such as the meshing of nets, protecting the resource and sensitizing fishers (Atti-Mama, 1998). Each village or group of villages has a committee representing all fishers. The committee members are fishers from the village, elected in a village assembly for a (renewable) mandate of three years (République du Bénin, 1997).

The fishing committees created a new rule for the konou that allows its use during four consecutive weeks (open weeks) and bans it for the following two weeks (closed weeks). These periods of open and closed weeks alternate throughout the shrimp fishing season (January – August) when larvae migrate from the ocean to the lake, mature and return to the ocean (Hoestlandt, 1939). By periodically banning the use of the konou across the entire lake, the rule intends to reduce the damaging impact of the konou. Fishers are well informed about the rule: in the 2013 survey, only one fisher said not to know it.

The fishing committees impose a number of sanctions when the rule is violated, such as the confiscation of fishing gear or catches. However, the effectiveness of the sanctioning mechanism is said to be undermined by corruption (Dangbégnon, 2000).

3. Data

3.1. Data sources

For our empirical analysis, we rely on two different datasets. The first is a 2006 fishery census, administered by the Beninese government in southern Benin. The census includes individual-level information on 27,568 actors in the fishery sector. Our analysis relies on a sample of 5,852 fishers (full-time, part-time and seasonal fishers) living in 34 villages across 10 *arrondissements* around lake Nokoué.[4]

The second dataset is a household survey administered in April-July 2009 by the authors among 180 households at lake Nokoué. The households were selected by taking a stratified random sample from the 2006 fishery census in six villages, located in two different arrondissements in the commune So-Ava near lake Nokoué (see Figure 1). These households were visited bi-weekly during a period of 14 weeks.[5] Hence, in contrast to the census data the household survey has a time dimension. In particular, the survey provides detailed weekly information on the fishing activities of 200 fishermen.

In our empirical analysis we focus on those fishermen whose main occupation is fishing and who were visited in all 14 weeks.[6] This baseline sample counts 103 fishermen. For one aspect of our empirical analysis we look at a subsample of these fishers, namely the konou users. We define a konou user as a fisher who reports to have used the konou *at least once* during the survey period. This subsample includes 47 fishers living in five villages across two arrondissements.[7]

[4] The arrondissement is the administrative unit in-between the village and the commune level.

[5] See online appendix B for more information on survey implementation.

[6] We explain this choice in section A.3.1.of the online appendix.

[7] One village (Sokomey) drops out compared to the baseline sample because there was no konou user among the sample fishers in this village. All but one of the sample fishers in Sokomey are Voodoo adherents.

Finally, during an additional field visit we collected supplementary information on fishermen's perceptions of fishery institutions. This visit took place in April 2013, when we surveyed 137 fishermen across three villages at lake Nokoué. These fishers are a subsample of the fishers interviewed in the 2009 household survey. Table 1 summarizes the key characteristics of each data sample used in the paper.

3.2. Descriptive statistics

Summary statistics of individual and household characteristics in the 2009 household survey and 2006 fishery census samples are reported in the online appendix (Table A.1). Below we report descriptive statistics for our key variables: religious adherence and the use of konou.

Table 2 presents the variation in religious affiliation in our two main datasets. The distribution is similar across the two samples, with Voodoo and Catholicism being the main religions. In the census 24 % of fishers are Voodoo adherents, compared to 27 % in the household survey.

Table 3 presents the share of konou users among Voodoo adherents and among all other fishers. In both samples the share of konou users is lower among Voodoo adherents. In the household survey the difference is most pronounced: only 29 % of Voodoo fishers are konou users compared to 52 % of other fishers.[8]

The bars in Figure 2 give the share of fishers that report using the konou in each week in the household survey. The konou is generally used less in closed weeks compared to open weeks, in particular in the first week of closing. The difference, although small, is statistically significant at the 1 % level.

[8] The difference in konou use across Voodoo adherents and other fishers is statistically significant at the 1 % level in the census sample and at the 2 % level in the survey sample.

4. Data analysis

4.1. The traditional rule

To examine compliance to the traditional Voodoo rule, which prohibits the use of the fine meshed konou at all times, we exploit variation in Voodoo adherence across and within villages in both the household survey and the fishery census sample. For the household survey sample we estimate the following equation:

$$Konou_{it} = \alpha_0 + \alpha_1 Voodoo_i + \tau_t + \lambda_a + X_i'\Omega + \varepsilon_{ita} \quad (1)$$

$Konou_{it}$ is an indicator variable taking value 1 if individual *i* reports to have used the konou in week *t* (and 0 otherwise)[9]; $Voodoo_i$ is an indicator variable that equals 1 if individual *i* reports his religion to be Voodoo (and 0 otherwise); τ_t is a count variable that indicates the week of the survey period; λ_a are dummy variables at the arrondissement level that capture time-invariant community characteristics; X_i' is a vector of control variables; ε_{ita} denotes the random error term. To deal with serial correlation of the error terms we cluster error terms at the individual level, thereby allowing error terms to be correlated within individuals (across weeks) while still imposing independence of the error terms between individuals (Wooldridge, 2010).

The time variable τ_t is included to capture unobserved time-varying environmental factors affecting the use of the konou, such as the growth cycle of shrimp. The 2009 household survey was implemented during the shrimp season (January-August). In this period, the quantity and size of shrimp in lake Nokoué gradually increase, which may affect a fisherman's incentive to use the konou. Other environmental factors that typically change as the fishing season progresses are water characteristics such as salinity and transparency.

[9] The time dimension is not essential for our hypothesis test in this case, as Voodoo is time-invariant. In section A.3.3. of the online appendix we explain why we use it for our baseline estimations.

The list of control variables X_i' contains the logarithms of age, years of education and annual income of the fisher, and the size and dependency ratio of his household. We control for age because installing and handling the konou requires considerable physical strength. Years of education are included to control for access to other income sources. Annual income captures wealth, and controls for the fact that the konou is an expensive instrument to purchase and maintain.[10] Household size and the dependency ratio capture the need of fishers to use high-yielding fishing instruments, to earn enough income or to bring home enough food.

The variable of interest in Eq.(1) is Voodoo adherence. A significantly negative estimate for α_1 would indicate that Voodoo fishermen use the konou less than other fishermen, on average. Assuming that we are adequately controlling for confounding factors, this result would suggest that Voodoo fishermen respect the traditional Voodoo rule more than other fishermen.

An important confounding factor that is however not addressed in Eq.(1) is unobserved village-level heterogeneity. The estimate of α_1 may be biased if, for instance, villages with a large share of Voodoo adherents are located in areas that are less suitable for the use of the konou. The household survey sample does not allow us to meaningfully control for village-level heterogeneity because of the small sample size and proximity of the villages. We therefore make use of the larger 2006 fishery census sample (34 villages) to estimate the following equation:

$$Konou_i = \alpha_0' + \alpha_1' Voodoo_i + \varphi_v + \Phi_i' \Upsilon + \varepsilon_{iv} \quad (2)$$

$Konou_i$ is an indicator variable taking value 1 if individual *i* reports to use the konou for fishing (and 0 otherwise); $Voodoo_i$ is as specified in Eq.(1); φ_v are village dummy variables; Φ_i' is a vector of control variables; ε_{iv} denotes the random error term, in this case clustered at the

[10] Controlling instead for the logarithm of the value of assets yields highly similar results. In any case, in our sample Voodoo fishers are on average richer than other fishers in terms of annual income and asset holdings.

village level to allow for within-village correlation of the error terms across individuals. The set of control variables Φ_i' consists of the logarithm of age, a categorical variable indicating the level of education, the number of children in the household[11] and ethnicity dummy variables.[12] A significantly negative estimate of $\alpha_1{}'$ would indicate that any negative relation between Voodoo adherence and the use of the konou holds when accounting for unobserved village-level heterogeneity.

4.2. The fishing committee rule

To identify compliance to the fishing committee rule, which prohibits the use of the konou in closed weeks and allows it in open weeks, we exploit the time dimension in the 2009 survey. We study the variation in the use of the konou across open and closed weeks in the subsample of konou users (i.e. fishers that used the konou at least once) by estimating the following equation:

$$Konou_{it} = \beta_0 + \beta_1 Closed_t + \tau_t + \lambda_a + X_i'\Omega + \varepsilon_{ita} \quad (3)$$

$Closed_t$ is an indicator variable taking value 1 if the lake is closed in week *t* (and 0 otherwise); all other variables are as specified in Eq.(1). A significantly negative estimate for β_1 would indicate that the use of the konou is on average lower in closed weeks compared to open weeks, suggesting compliance to the fishing committee rule.

[11] Dependent children.

[12] The 2006 fishery census does not contain information on household size or income. We control for ethnicity because it is correlated with the use of fishing gear and religion. In the household survey sample ethnicity was omitted because all fishers belonged to the same ethnic group (Tofin). The ethnicities in the fishery census sample are reported in Table A.1 of the online appendix.

4.3. Compliance of traditional rule breakers to the fishing committee rule

To examine how Voodoo fishers who break the traditional rule behave towards the fishing committee rule, we again look at the subsample of konou users. This subsample includes Voodoo adherents, who are thus breaking the traditional Voodoo-based rule, and fishers of other religions. We estimate an extended version of Eq.(3) that includes the indicator variable for Voodoo adherence and an interaction term between Voodoo adherence and the closing of the lake:

$$Konou_{it} = \gamma_0 + \gamma_1 Voodoo_i + \gamma_2 Closed_t + \gamma_3 Voodoo_i * Closed_t + \tau_t + \lambda_a + X_i'\Omega + \varepsilon_{ita} \quad (4)$$

If Voodoo fishers who break the traditional rule also comply less to the fishing committee rule (compared to non-Voodoo fishers) the estimate of γ_3 should be significantly positive. That is, among konou users we should find that Voodoo adherents use the konou more in closed weeks than other fishers.

4.4. Estimation technique

Given that our dependent variable is binary, we could opt for a nonlinear limited dependent variable model such as a logit or probit model. Alternatively, we can estimate our equations by a linear model such as (linear) OLS, treating the categorical answer as if it were part of a continuous scale and assuming that the dependent variable is a linear function of the regressors. Linear models offer the advantage of straightforward interpretation, as the marginal effects are equal to the coefficient estimates (whereas in nonlinear models additional calculations are required to obtain marginal effects). Moreover, Angrist and Pischke (2009) argue that OLS coefficient estimates for the regressor of interest will usually be close to the marginal effects obtained in a probit or logit model when the regressor is binary. For these reasons, we opt for linear models to estimate our baseline results and report probit estimates in the online appendix (section A.3.2).

To address concerns of unobserved individual heterogeneity confounding our results, we use an individual fixed effects model to estimate Eq.(3) and Eq.(4). However, this model does not allow us to estimate the impact of Voodoo adherence in Eq.(1) and Eq.(2). We therefore estimate these equations using an OLS model.[13]

5. Results

Table 4 presents the results on compliance with the traditional Voodoo-based rule. Columns (1) and (2) show coefficient estimates for Eq.(1), without and with controls. The estimate for Voodoo adherence is negative and statistically significant, indicating that on average Voodoo fishers use the konou less than other fishers. The probability of using the konou in any given week is on average 25 percent lower for Voodoo fishers compared to other fishers (all else equal).

Columns (3) and (4) show coefficient estimates for Eq.(2), again without and with controls. The estimate for Voodoo adherence remains negative and statistically significant when village dummy variables are included. We therefore rule out the competing explanation that unobserved village-level heterogeneity is driving the negative relation between the use of the konou and Voodoo adherence. The absolute size of the coefficient is, however, substantially smaller in this specification: on average the probability of using the konou is 7 percent lower for Voodoo fishers compared to other fishers (all else equal).

Table 5 presents the results for compliance with the fishing committee rule. Columns (1) and (2) show the results for Eq.(3), with and without controls, and column (3) shows the

[13] The individual effects in a fixed effects model absorb all time-invariant variables such as Voodoo adherence. The Hausman-Taylor model (Hausman and Taylor, 1981) offers the possibility of estimating the impact of time-invariant regressors in a fixed effects model, but requires instruments that were not available in our data. In section 6.1. we use alternative methods to address the concern of unobserved individual heterogeneity for Eq.(1) and (2).

results for Eq.(4). The coefficient estimates for closed weeks are negative and statistically significant in all columns, indicating that konou users are on average 9 to 10 percent less likely to use the konou in closed weeks compared to open weeks (all else equal). This finding suggests that there is some, although limited, compliance to the fishing committee rule.

The coefficient estimate for the interaction term is close to zero and not statistically significant. This result indicates that, among konou users, Voodoo adherents and other fishers are on average equally likely to use the konou in closed weeks. In other words, Voodoo fishers who decide to break the traditional rule (by using the konou) adopt the behaviour of non-Voodoo fishers towards the fishing committee rule.

To get an idea of the size of the estimated effects discussed above, we compare the impact of our regressor of interest to the impact of another important determinant of the konou: a fisherman's age. To generate the same average negative effect on the probability of konou use as Voodoo adherence does in Eq. (1) (-25 percent), the age of the fisherman would have to increase by 150 percent, for instance from 30 to 90. Turning to Eq.(2), in which Voodoo adherence is estimated to reduce the probability of konou use by 7 percent, one would need a 35 percent increase of the fisherman's age, to have the same impact, for instance from the sample average of 37 to 50. In Eq.(3), the age of the fisherman would have to increase by 55 percent – say from the survey sample average of 44 to 68 – to reduce the probability of konou use by the same extent as the closing of the lake does (about -14 percent).[14]

The difference in effect size of $Voodoo_i$ between the survey (Eq.1) and census (Eq.2) could be due to the fact that Eq.(2) takes village-level confounding factors into account, but other explanations are possible. The census sample includes 28 additional villages, the dependent variables are measured differently and the identity of the interviewer may have

[14] The marginal effect for the logarithm of age is -0.16 in Table 4, column (2) , -0.20 in Table 4, column (4), and -0.24 in column (8) of Table A.10 (using probit estimates for Eq.(3)) (see online appendix).

mattered: fishers may have been less inclined to report konou use to census interviewers working for the government, with whom they have had many conflicts in the past about fishing activities (Dangbégnon, 2000)).

We conduct a number of robustness checks. The results for Eq.(1), (3) and (4) are robust to the use of a larger unbalanced household survey sample of 121 fishers (not relevant for Eq.(2)), which includes fishers who were not interviewed in all weeks. The results for Eq.(1)-(4) are robust to the use of a binary probit model. The results for Eq.(3) and (4) hold when estimated using an individual fixed effects probit model (not relevant for Eq.(1) and (2)). Finally, the results for Eq.(1) hold when we replace the time-varying dependent variable *use of the konou in week t* by a time-invariant measure of overall compliance: *total use of the konou across 14 weeks*. Details for these robustness checks and full results for all tables in this paper are provided in online appendix A.

6. Competing explanations

6.1. Unobserved individual heterogeneity

In our analysis of compliance with the traditional rule we controlled for village-level unobservables, but not for individual-level unobservables. Our estimated relation between Voodoo adherence and the use of the konou may therefore result from unobserved individual heterogeneity. One specific concern relates to unobserved preferences for the traditional. Fishers with such a preference may reject both non-traditional religions (i.e. all religions other than Voodoo) and non-traditional fishing gear such as the konou.

As explained in section 4.4 (footnote 13), the individual fixed effects model or Hausman-Taylor model, which control for unobserved individual-level heterogeneity, cannot be implemented in our case. We therefore turn to two alternative methods.

We start by addressing the specific concern that Voodoo adherents have a preference for the traditional. If this were the case, we would expect to find a negative relation between Voodoo adherence and other (relatively) recently introduced technologies as well. We test this by re-estimating Eq.(1) while replacing the dependent variable *use of the konou* by dummy variables indicating ownership of a mobile phone, electricity generator, radio and TV.[15] The results, presented in Table 6., indicate that Voodoo fishers (or their households) are equally likely to own a mobile phone, electricity generator, radio or TV compared to other fishers. [16] This finding suggests that Voodoo adherents do not to reject recently introduced technologies more than others. It therefore seems unlikely that Voodoo fishers would reject productive fishing innovations such as the konou solely because of a preference for the traditional.

Aside from the specific concern of such unobserved preferences, there may be other unobserved characteristics related to Voodoo adherence and the use of the konou that confound our findings. We follow Oster (2013) and attempt to gauge the extent of the remaining omitted variable bias by looking at coefficient movements along with movements in R-squared values when control variables are included.

Table 7 presents OLS estimation results for Eq.(1) when we consecutively control for the week variable, arrondissement dummies, the list of basic controls discussed in section 4.1 and the following additional control variables: the fisherman's relationship with the household head, his marital status, his number of wives, a dummy variable indicating whether he owns a mobile phone and three dummy variables indicating whether his household owns an electricity generator, radio or TV.

[15] Except for the mobile phone, ownership of assets was recorded at the household level. However, 85 percent of sample fishers are head of the household and presumably have considerable decision making power regarding the purchasing of these items.

[16] Since we do not exploit the time dimension here, we can also use the larger unbalanced sample of fishers. The results are qualitatively the same, except that Voodoo adherents are significantly less likely to own a TV (see Table A.14 of the online appendix).

The results in Table 7 show that the size of the coefficient estimate for Voodoo adherence changes when arrondissement dummies are included – from -0.16 in column (2) to -0.25 in column (3) – but remains quite stable afterwards. The R-squared value is 0.06 when arrondissement dummies are included and increases to 0.17 when all controls have been added, suggesting that the included controls are not uninformative. We can conclude from Table 7 that controlling for a variety of informative individual characteristics has a limited effect on the coefficient estimate for Voodoo adherence, making us quite confident that there are no major unobservables that would entirely knock out the effect.

6.2. Reporting bias regarding the use of the konou

A potential caveat is that fishers may lie about using the konou when the lake is closed. In this case we would overestimate compliance to the fishing committee rule. To verify whether there is reason for such concern, we examine the fluctuations of shrimp fishing revenue across open and closed weeks. As the konou is one of the most productive instruments used for shrimp fishing, any periodical variation in its use should be reflected in shrimp fishing revenue (when controlling for the use of other fishing gear).[17] If fishers respect the fishing committee rule and abandon the konou in closed weeks, we should find that shrimp fishing revenue is lower in closed weeks compared to open weeks. Moreover, the abandonment of the konou in closed weeks may increase fishing yield when the lake is re-opened, thus giving an additional boost to fishing revenue.

[17] We do not normalize fishing revenue by prices as prices are reported by local measures, which vary between villages, and greatly depend on the quality and size of shrimp. We therefore expect measurement error to be larger for recall data on prices than for recall data on nominal fishing revenue. Moreover, as most catches are sold within the same day, weekly fishing revenue should be strongly correlated with weekly catches. Finally, any price rise that follows from the closing of the lake will attenuate our estimates, reducing the risk of obtaining false positive results.

One possible objection is that self-reported data on fishing revenue might also suffer from reporting bias. We cannot completely rule out this possibility, but we do expect reporting bias in fishing revenue data to be much less severe. Weekly fishing revenue is reported by species, not by fishing instrument. As there are other high-yielding shrimp fishing instruments apart from the konou, such as shrimp pots, fishers can explain high shrimp fishing revenue in closed weeks by intensive use of these alternative, non-prohibited fishing instruments. We therefore believe that fishermen had little incentive to lie about shrimp fishing revenue in closed weeks.

Figure 3 depicts the fluctuation of average weekly shrimp fishing revenue across open and closed weeks. The graph supports our hypothesis, showing that average fishing revenue generally drops in closed weeks compared to open weeks. The graph further shows a rise of fishing revenue in week 10 – a closed week – which indicates that fishers were not hesitant to report increases in fishing revenue when the lake was closed. We also note a boost in revenues once the lake is opened again, which can certainly not be attributed to conscious misreporting by fishermen.

To examine the weekly fluctuations of shrimp fishing revenue more formally, we use an individual fixed effects model to estimate two equations. In the first equation we include indicator variables for each closed week, taking the open period as the baseline category. In the second equation we include indicator variables for each of the open weeks, taking the closed period as the baseline category. The two equations can be written as follows:

$$F_{it} = \omega_0 + \omega_1 Closed_t^1 + \omega_2 Closed_t^2 + \tau_t + \varphi_i + \text{К}'_{it}\Theta + \varepsilon_{it} \quad (5)$$

$$F_{it} = \omega'_0 + \omega_3 Open_t^1 + \omega_4 Open_t^2 + \omega_5 Open_t^3 + \omega_6 Open_t^4 + \tau_t + \varphi_i + \text{К}'_{it}\Theta + \varepsilon_{it} \quad (6)$$

F_{it} denotes average weekly shrimp fishing revenue for fisherman *i* in week *t*; $Closed_t^w$ ($Open_t^w$) are indicator variables that take value 1 if the lake is closed (open) in week *t* for the w-th consecutive week (and 0 otherwise); τ_t is a count variable as specified in Eq.(1); φ_i are

individual fixed effects (i.e. individual-level dummy variables); K'_{it} is a vector of control variables; ε_{it} denotes the random error term clustered at the individual level. The control variables in K'_{it} reflect the fishery production function and capture the input of time, labour and capital. We include the logarithms of the number of fishing days and the number of persons fishing, and dummy variables indicating the use of the three main shrimp fishing instruments other than the konou.

Table 8 presents estimation results for Eq.(5) in columns (1) and (2). The coefficient estimate for the first week of closing is negative, large and statistically significant. The findings indicate that, all else equal, shrimp fishing revenue is on average 78 percent lower in the first week of closing compared to the average of open weeks. In contrast, the coefficient estimate for the second week of closing is small and not statistically significant. This finding may be explained by two mechanisms. First, in the second closed week fishermen may already start to benefit from less intensive konou use in the previous week through a higher yield for other fishing gear. Second, fishermen may resume their konou use already in the second closed week to reap the benefits of the restraint exercised by other konou users.

Columns (3) and (4) in Table 8 show estimation results for Eq.(6). The coefficient estimates for the first and second week of opening are positive, large and statistically significant. The results indicate that shrimp fishing revenue is on average 117 percent higher in the first open week and 67 percent higher in the second open week, compared to the average of closed weeks. The coefficient estimates for the third and fourth open weeks are positive but not statistically significant. These findings suggest that there is a strong increase in fishing revenue in the first two open weeks, which dies out in the third and fourth weeks of opening. One

possible explanation is that intensive use of the konou in the first two open weeks reduces fishing yield again, driving down fishing revenue in the two weeks after.[18]

These findings are a strong indication of reductions in konou use when the lake is closed However, one may still object that the fluctuations in fishing revenue are caused by a natural cycle rather the fishing committee rule. We therefore perform a falsification test, comparing the fluctuations in shrimp revenue at Nokoué with those at another southern lake in Benin (Ahémé, see Figure 1), where similar natural conditions prevail but the fishing committee rule does not apply. Finding no significant differences between the two lakes would suggest that the fluctuations observed at Nokoué are caused by a natural cycle rather than the fishing committee rule. However, we find significantly larger fluctuations of shrimp revenue at Nokoué, suggesting that the observed fluctuations do not merely result from natural cyclicality (see the online appendix for more details).

[18] The average estimated jump in fishing revenue in the first open week is larger than the average estimated drop in fishing revenue in the first closed week. A possible explanation is that the rise in fishing revenue in open weeks is also driven by an increase in overall fishing yield, and not merely the result of fishers resuming the use of the konou.

7. Conclusion

The lake fisheries of southern Benin provide a textbook example of the *tragedy of the commons*. Overfishing has compromised the sustainability of the fishery stock, which has dramatically declined in the last decades (Clédjo, 2006; FAO, 2008).

Fishing activities at lake Nokoué – the largest lake in Benin – are regulated by two fishery management institutions, one embedded in the traditional Voodoo religion and one recent secular institution in the form of fishing committees. We have attempted to shed light on the effectiveness of each of these institutions. In addition, we have examined how Voodoo fishers who break with traditional Voodoo-based rules behave towards the recent fishing committee institution.

Regarding the traditional Voodoo-based institution, we have found a statistically significant negative relation between the use of the konou and Voodoo adherence, suggesting that Voodoo adherents respect the traditional fine mesh nets taboo more than others. This result remains, although it becomes weaker, when we take unobserved village-level heterogeneity into account. The relation is also robust to the use of different samples and model specifications.

In addition, we have addressed the competing explanation of an unobserved preference for the traditional, by showing that Voodoo adherents adopt other recently introduced technologies (e.g. the mobile phone and radio) to the same extent as other fishers. We have also shown that the inclusion of a variety of informative individual characteristics has little effect on the coefficient estimate for Voodoo adherence, thereby mitigating the concern that our results are driven by unobserved individual heterogeneity. Although we cannot completely rule out omitted variable bias, the results suggest that it is unlikely that such bias can entirely knock out the effect of Voodoo adherence.

Regarding the fishing committee institution, we have found evidence for a statistically significant impact of the opening-closing rule on the use of the konou. However, quantitatively the impact is small. One possible explanation for the observed compliance is that collectively halting konou use for some weeks raises fishing yield in the following weeks, incentivizing konou users to respect the rule. The limited quantitative effect is likely explained by insufficient monitoring and corruption, which create incentives to free ride on the compliance of others.

One concern regarding these findings is that fishermen may lie about konou use in closed weeks. We have therefore studied the fluctuations of fishing revenue for shrimp – strongly correlated with konou use – across open and closed weeks. This analysis corroborates our findings regarding the fishing committee rule. Although we cannot completely rule out the possibility of fishermen also lying about fishing revenue, we have argued that it is unlikely that revenue data suffer from an equally severe reporting bias, reducing the concern that such bias is driving our findings on compliance with the fishing committee rule.

We have further found that Voodoo adherents who break the traditional rule comply to the fishing committee rule in the same way as other fishers. If it were the case that Voodoo rule breakers simply display free rider behaviour, we might expect these fishers to free ride on other fishing rules as well, and more so than other fishers. Our results instead suggest that Voodoo fishers who decide to abandon the (strict) traditional rule may still see the need to exercise some collective restraint and shift towards the fishing committee rule.

Our empirical findings confirm qualitative evidence on the continued role of the traditional Voodoo institution in regulating fishing activities at the southern lakes of Benin (Amoussou, 2004; Clédjo, 2006; République du Bénin, 2008). Our findings also resonate with those of several other studies (see introduction) and with recent research advocating an integrated resource management

approach, where traditional institutions are combined with contemporary management institutions and technologies (Becker and Ghimire, 2003; Cinner and Aswani, 2007; Colding and Folke, 2001; Drew, 2005: Dudley et al., 2009).

At the same time, the above analysis is only a first step towards a quantitative assessment of the effectiveness and potential substitutability of these institutions. More research is needed to fully understand how these institutions and their interaction affect fishing behaviour, and what the policy implications are. Our first analysis suggests that both institutions affect fishing behaviour, but only in a limited way. In this case resource management needs to be strengthened. One integrated management strategy that is increasingly being implemented is the incorporation of sacred sites into official protected areas. Sacred forests in Benin are already being integrated into a national system of protected areas (GEF, 2010). Although the southern lakes of Benin are similarly characterized by sacred sites, the official protection of sacred sites also involves risks such as a loss of spiritual value (Dudley et al., 2009). Hence, careful research is needed to evaluate the potential success of this strategy. Future research could further examine whether other elements of the traditional Voodoo institution (such as the prohibition to fish on days of worship) can be valuably integrated into modern management institutions, or whether other religions can play a role in natural resource management.

References

Afrobarometer. 2014. "Round 5 (2010-2012). [Last viewed 22 February 2014]." http://www.afrobarometer.org/.

Agrawal, Arun. 2001. "Common Property Institutions and Sustainable Governance of Resources." *World Development* 29 (10): 1649–72. doi:10.1016/S0305-750X(01)00063-8.

Allan, J. David, Robin Abell, Z. E. B. Hogan, Carmen Revenga, Brad W. Taylor, Robin L. Welcomme, and Kirk Winemiller. 2005. "Overfishing of Inland Waters." *BioScience* 55 (12): 1041–51. doi:10.1641/0006-3568(2005)055[1041:OOIW]2.0.CO;2.

Amoussou, Ernest. 2004. "Systèmes Traditionnels de Gestion Durable Du Lac Ahémé Au Bénin." *Développement Durable: Leçons et Perspectives*, 263–70.

Angrist, Joshua D., and Jörn-Steffen Pischke. 2009. *Mostly Harmless Econometrics: An Empiricist's Companion*. Princeton university press.

Atti-Mama, Cyriaque. 1998. "Co-Management in Continental Fishing in Benin: The Case of Lake Nokoué." In *The International Workshop on Fisheries Co-Management*. http://www.worldfishcenter.org/Pubs/Way%20Forward/12%20Atti-Mama.pdf.

Baland, Jean-Marie, and Jean-Philippe Platteau. 1996. *Halting Degradation of Natural Resources: Is There a Role for Rural Communities?*. Food and Agriculture Organization.

Barbier, Jean-Claude, and Élisabeth Dorier-Apprill. 2002. "Cohabitations et Concurrences Religieuses Dans Le Golfe de Guinée. Le Sud-Bénin, Entre Vodun, Islam et Christianismes." Colloque *Géopolitiques africaines, Bulletin de L'association Des Géographes Français*: 223–36.

Becker, C. Dustin, and Kabita Ghimire. 2003. "Synergy between Traditional Ecological Knowledge and Conservation Science Supports Forest Preservation in Ecuador." *Ecology and Society* 8 (1): 1. [online] URL: http://www.consecol.org/vol8/iss1/art1.

Berkes, Fikret. 1989. *Common Property Resources: Ecology and Community Based Sustainable Development*. Belhaven Press.

———. 2001. *Managing Small-Scale Fisheries: Alternative Directions and Methods*. IDRC.

———. 2008. *Sacred Ecology*. 2nd ed. New York: Routledge.

Berkes, Fikret, Johan Colding, and Carl Folke. 2000. "Rediscovery of Traditional Ecological Knowledge as Adaptive Management." *Ecological Applications* 10 (5): 1251–62. http://dx.doi.org/10.1890/1051-0761(2000)010[1251:ROTEKA]2.0.CO;2.

Bhagwat, Shonil A., and Claudia Rutte. 2006. "Sacred Groves: Potential for Biodiversity Management." *Frontiers in Ecology and the Environment* 4: 519–24. http://dx.doi.org/10.1890/1540-9295(2006)4[519:SGPFBM]2.0.CO;2.

Bourgoignie, Georges Edouard. 1972. *Les Hommes de L'eau: Ethno-Écologie Du Dahomey Lacustre*. Paris: Éditions universitaires.

Cinner, Joshua E., and Shankar Aswani. 2007. "Integrating Customary Management into Marine Conservation." *Biological Conservation* 140 (3-4): 201–16. doi:10.1016/j.biocon.2007.08.008.

Clédjo, F.G.A.P. 2006. *La Gestion Locale de L'environnement Dans Les Cités Du Lac Nokoué Au Bénin Méridional*. Thèse de Doctorat (Thèse Unique), Ecole Doctoral Pluridisciplinaire FLASH DGAT UAC.

Colding, Johan, and Carl Folke. 2001. “Social Taboos: ‘Invisible’ Systems of Local Resource Management and Biological Conservation.” *Ecological Applications* 11: 584–600. http://dx.doi.org/10.1890/1051-0761(2001)011[0584:STISOL]2.0.CO;2.

Cox, Michael, Gwen Arnold, and S. Villamayor Tomás. 2010. “A Review of Design Principles for Community-Based Natural Resource Management.” *Ecology and Society* 15 (4): 38. [online] URL: http://www.ecologyandsociety.org/vol15/iss4/art38

Dangbégnon, Constant. 2000. “Governing Local Commons: What Can Be Learned from the Failures of Lake Aheme’s Institutions in Benin.” In *Eighth Biennial Conference of the International Association for the Study of Common Property, Bloomington, Indiana, USA.*

Deb, Debel, and K. C. Malhotra. 2001. “Conservation Ethos in Local Traditions: The West Bengal Heritage.” *Society & Natural Resources* 14 (8): 711–24. doi:10.1080/08941920118542.

Drew, Joshua A. 2005. “Use of Traditional Ecological Knowledge in Marine Conservation.” *Conservation Biology* 19 (4): 1286–93. doi:10.1111/j.1523-1739.2005.00158.x.

Dudley, Nigel, Liza Higgins-Zogib, and Stephanie Mansourian. 2009. “The Links between Protected Areas, Faiths, and Sacred Natural Sites.” *Conservation Biology* 23 (3): 568–77. doi:10.1111/j.1523-1739.2009.01201.x.

Eneji, C. V. O., G. U. Ntamu, C. C. Unwanade, A. B. Godwin, J. E. Bassey, J. J. Willaims, and Joseph Ignatius. 2012. “Traditional African Religion in Natural Resources Conservation and Management in Cross River State, Nigeria.” *Environment and Natural Resources Research* 2 (4): p45. doi:10.5539/enrr.v2n4p

FAO. 2008. *Fishery and Aquaculture Country Profiles: Benin*. no. 700. Rome: Food and Agriculture Organization.

———. 2012. *The State of World Fisheries and Aquaculture 2012.* Rome: Food and Agriculture Organization.

———. 2014. *State of World Fisheries and Aquaculture 2014.* Rome: Food and Agriculture Organization.

GEF. 2010. *GEF's Programmatic Approach to Biodiversity Conservation in West and Central Africa*. The Global Environment Facility.

Gnohossou, Pierre. 2006. *La Faune Benthique D'une Lagune Ouest Africaine (le Lac Nokoue Au Bénin), Diversite, Abondance, Variations Temporelles et Spatiales, Place Dans La Chaine Trophique*. http://ethesis.inp-toulouse.fr/archive/00000481/.

Hausman, Jerry A., and William E. Taylor. 1981. "Panel Data and Unobservable Individual Effects." *Econometrica: Journal of the Econometric Society*, 1377–98.

Hoestlandt, H. 1939. *Premières Recherches Sur Le Cycle Biologique de Penaeus Duoranrun Burkenroad En Afrique Occidentale*. Mémoire I.F.A.N., n°77.

Jones, Julia P. G., Mijasoa M. Andriamarovololona, and Neal Hockley. 2008. "The Importance of Taboos and Social Norms to Conservation in Madagascar." *Conservation Biology* 22 (4): 976–86. doi:10.1111/j.1523-1739.2008.00970.x.

Juhé-Beaulaton, Dominique, and Bernard Roussel. 2002. "Les Sites Religieux Vodun: Des Patrimoines En Permanente Évolution." In *Patrimonialiser La Nature Tropicale: Dynamiques Locales, Enjeux Internationaux (Colloques et Séminaires)*, edited by Marie-Christine Cormier Salem, Dominique Juhé-Beaulaton, Jean Boutrais, and Bernard Roussel, 415–38. Paris: IRD.

Kajembe, G. C., E. J. Luoga, M. S. Kijazi, and C. S. Mwaipopo. 2003. "The Role of Traditional Institutions in the Conservation of Forest Resources in East Usambara, Tanzania." *The*

International Journal of Sustainable Development & World Ecology 10 (2): 101–7. doi:10.1080/13504500309469789.

Kokou, Kouami, Kossi Adjossou, and Adzo D. Kokutse. 2008. "Considering Sacred and Riverside Forests in Criteria and Indicators of Forest Management in Low Wood Producing Countries: The Case of Togo." *Ecological Indicators* 8 (2): 158–69. doi:10.1016/j.ecolind.2006.11.008.

Ntiamoa-Baidu, Yaa. 2008. "Indigenous Beliefs and Biodiversity Conservation: The Effectiveness of Sacred Groves, Taboos and Totems in Ghana for Habitat and Species Conservation. " *Journal for the Study of Religion, Nature and Culture* 2(3). [online] URL: http://ugspace.ug.edu.gh/handle/123456789/567.

Ormsby, Alison A., and Shonil A. Bhagwat. 2010. "Sacred Forests of India: A Strong Tradition of Community-Based Natural Resource Management." *Environmental Conservation* 37 (03): 320–26. doi:10.1017/S0376892910000561.

Oster, Emily. 2013. "Unobservable Selection and Coefficient Stability: Theory and Validation." National Bureau of Economic Research. http://www.nber.org/papers/w19054.

Ostrom, Elinor. 1990. *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge university press.

Pinkerton, Evelyn, ed. 2011. *Co-Operative Management of Local Fisheries: New Directions for Improved Management and Community Development.* UBC Press.

Pliya, Jean. 1980. *La Pêche Dans Le Sud-Ouest Du Bénin. Etude de Géographie Appliquée Sur La Partie Continentale et Maritime*. Paris: AGECOOP.

———. 1989. *Migrations Historiques et Peuplement Dans Les Régions Lagunaires Du Bénin Méridional*. Florilège offert à P. Pélissier et Gilles Sautier. http://horizon.documentation.ird.fr/exl-doc/pleins_textes/doc34-08/30707.pdf.

République du Bénin. 1997. *Arrêté Interministériel N° 312/MDR/MISAT/DCAB/CC/CP Portant Institution, Organisation, Attributions et Fonctionnement Des Comités et Conseils de Pêche En République Du Bénin.*

———. 2008. *Plan de Gestion de Plans d'Eau (PGPE): Lac Nokoué*. http://www.fidafrique.net/IMG/pdf/Version_finale_-_PGPE_Lac_Nokoue-3.pdf.

Sharma, Subrat, Hem C. Rikhari, and Lok Man S. Palni. 1999. "Conservation of Natural Resources Through Religion: A Case Study from Central Himalaya." *Society & Natural Resources* 12 (6): 599–612. doi:10.1080/089419299279461.

Stoop, Nik, Romain Houssa, and Marijke Verpoorten. 2013. *To Fish or Not to Fish? Resource Degradation and Income Diversification in Benin*. LICOS Discussion Paper. http://www.econstor.eu/handle/10419/74879.

Tall, Emmanuelle. 1995a. "Dynamique Des Cultes Voduns et Du Christianisme Céleste Au Sud-Bénin." *Cahiers des sciences humaines* 31 (4): 797–823.

———. 1995b. "De la démocratie et des cultes voduns au Bénin." *Cahiers d'études africaines* 35 (137): 195–208. doi:10.3406/cea.1995.2030.

Veitayaki, J., A. Nakoro, T. Sigarua, and N. Bulai. 2011. "On Cultural Factors and Marine Managed Areas in Fiji." In *Pacific Island Heritage Archaeology, Identity and Community*, 37–49. Acton, A.C.T.: ANUE Press.

Wooldridge, Jeffrey M. 2010. *Econometric Analysis of Cross Section and Panel Data*. MIT press.

Figures and Tables

Figure 1: Location of the southern lakes and the 2009 household survey area in Benin

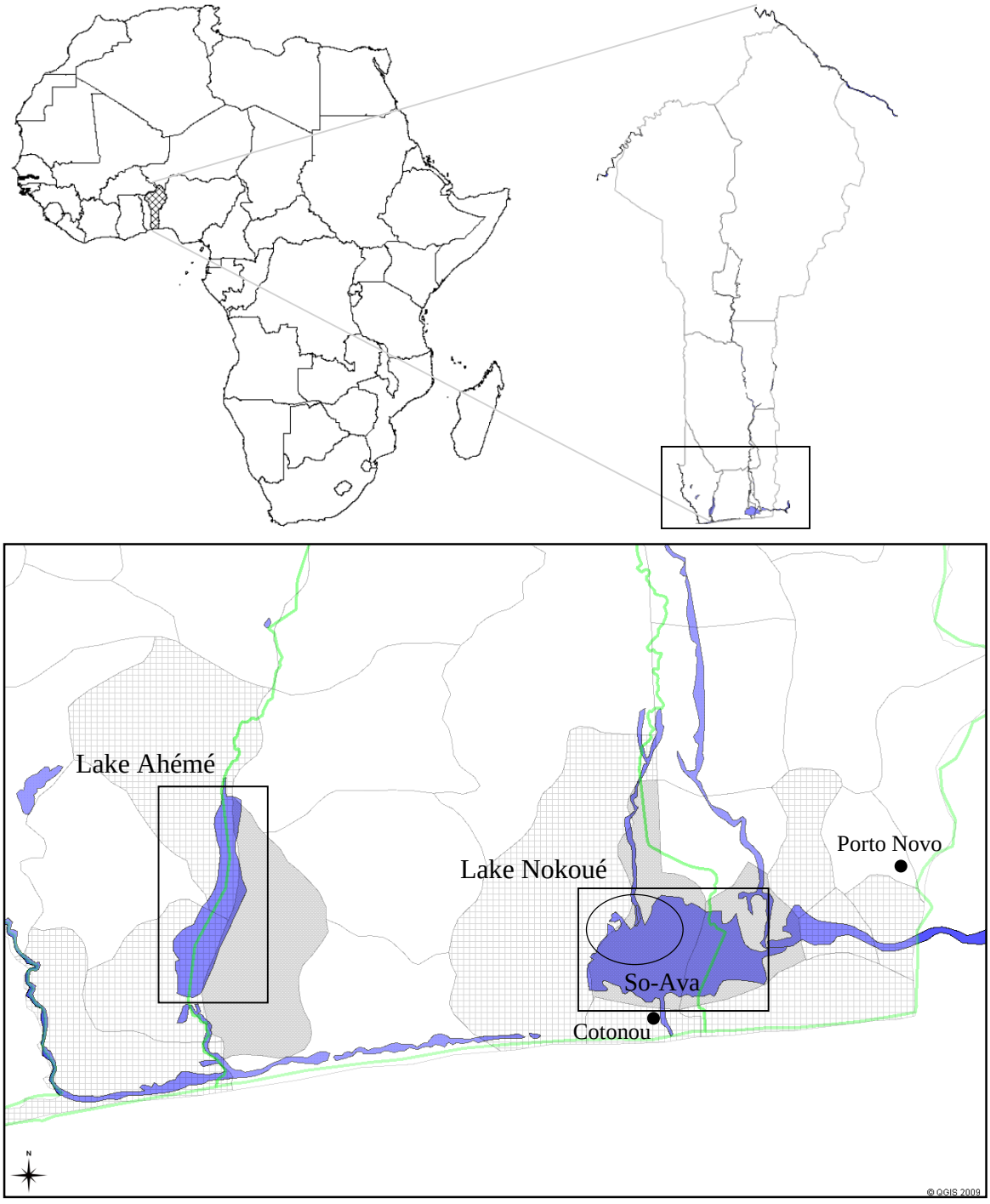
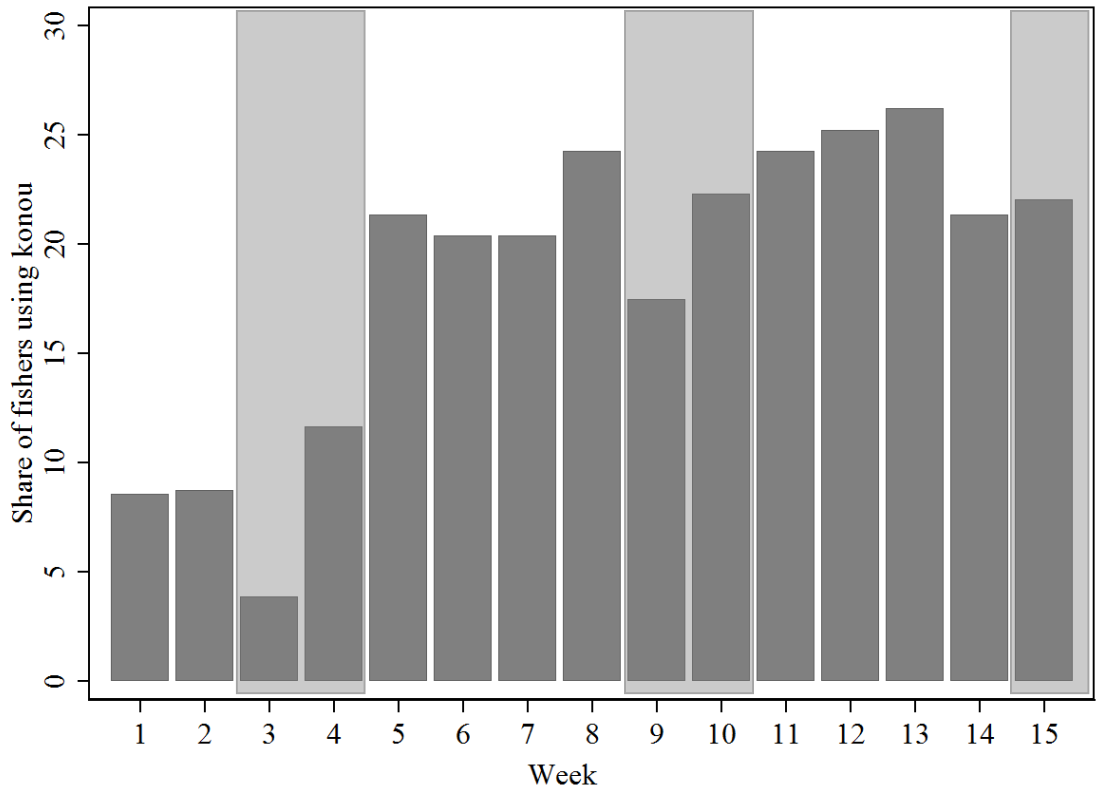
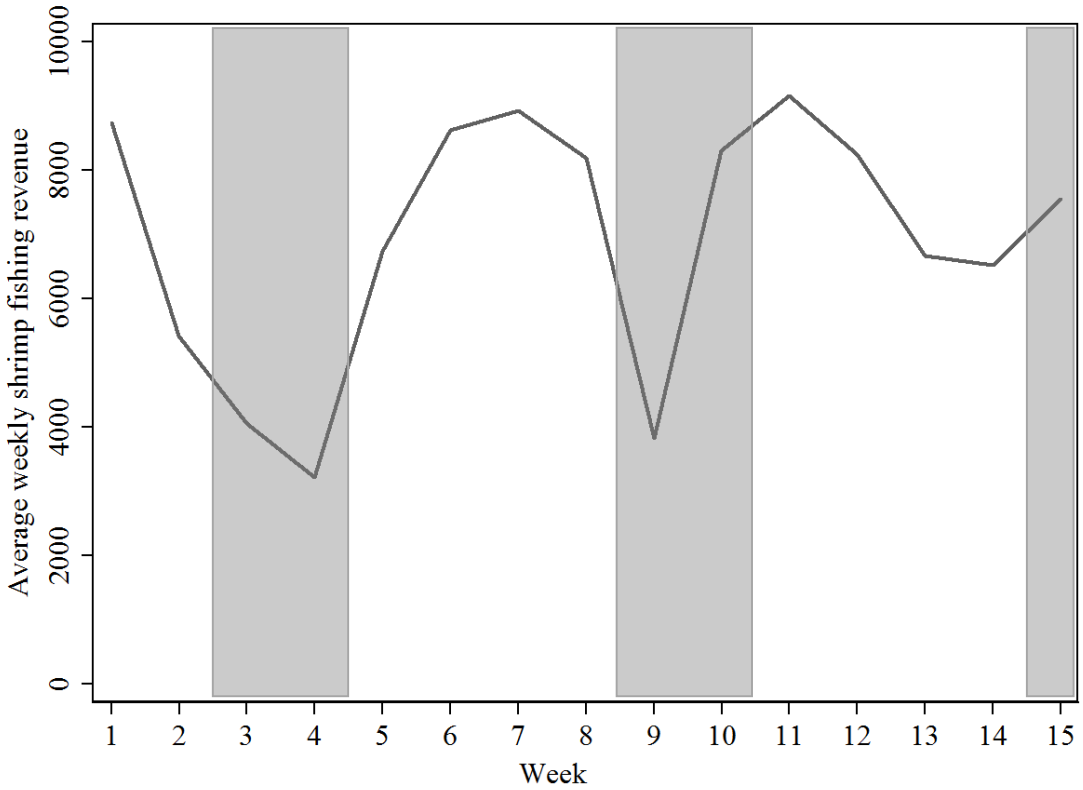


Figure 2: Share of fishers using the konou in each week, across open and closed weeks



Source: Author's calculations.
Notes: Light-grey areas indicate closed weeks. Konou users are fishers who report to have used the konou at least once during the survey period.

Figure 3: Average weekly shrimp fishing revenue across open and closed weeks



Source: Author's calculations.

Notes: Light-grey areas indicate closed weeks. Fishing revenue is expressed in CFA; one euro equalled about 656 CFA in 2009.

Table 1: Characteristics of data samples used

Characteristic	Fishery census	Household survey	Household survey - konou users	Perception survey
Year	2006	2009	2009	2013
Arrondissements	10	2	2	1
Villages	34	6	5	3
Individuals	5,852	103	47	137
Weeks	/	14	14	/
Observations	5,852	1,442	658	137

Source: Author's calculations. Notes: konou users are defined as fishers who report to have used the konou at least once during the survey period.

Table 2: Religious affiliation of fishers in two samples

	Fishery census (2006)		Household survey (2009)	
Religion	Share (%)	Obs	Share (%)	Obs
Catholicism	22.5	1,317	27.2	28
Protestantism	12.9	757	11.7	12
Islam	3.3	192	0	0
Voodoo	23.5	1,375	27.2	28
Christianisme Céleste	19.0	1,114	22.3	23
Other	8.7	510	4.9	5
None	10.0	587	6.8	7
Total	100	5,852	100	103

Source: Author’s calculations.

Table 3: Share of konou users by religious adherence in two samples

	Fishery census (2006)			Household survey (2009)		
Religion	Konou users (%)	Obs.	N	Konou users (%)	Obs.	N
Voodoo	19.6	269	1,375	28.6	8	28
Other	34.2	1,530	4,477	52.0	39	75
Overall	30.7	1,799	5,852	45.6	47	103

Source: Author's calculations. Notes: Konou users are fishers who use the konou. In the household survey, we define a konou user as a fisher who reports to have used the konou at least once.

Table 4: OLS estimation results: Use of the konou and Voodoo adherence in two samples

Sample	Household survey		Fishery census	
Dependent variable	Use of the konou in week t		Use of the konou	
Variables	(1)	(2)	(3)	(4)
Voodoo	-0.151**	-0.252***	-0.146***	-0.066*
	(0.059)	(0.090)	(0.050)	(0.034)
Week	No	Yes	No	No
Arrondissement	No	Yes	No	No
Controls	No	Yes	No	Yes
Village	No	No	No	Yes
Constant	Yes	Yes	Yes	Yes
Number of clusters	102	88	34	34
Observations	1,190	1,039	5,852	5,162
R-squared	0.025	0.125	0.018	0.267

Notes: Coefficients are reported with standard errors in parentheses. Standard errors are clustered at the individual level for columns (1) and (2) and at the village level for columns (3) and (4). ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Week refers to a count variable that indicates the week of observation. Arrondissement refers to dummy variables indicating the arrondissement in which the individual lives. Village refers to dummy variables indicating the village in which the individual lives. Controls refer to the control variables discussed in section 4.1.

Table 5: Fixed effects estimation results: Use of the konou and the fishing committee rule (2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week *t*			
Variables	(1)	(2)	(3)
Closed	-0.109***	-0.090***	-0.095***
	(0.029)	(0.027)	(0.031)
Voodoo*Closed			0.035
			(0.059)
Week	No	Yes	Yes
Arrondissement	Yes	Yes	Yes
Controls	Yes	Yes	Yes
Constant	Yes	Yes	Yes
Number of clusters	47	47	47
Observations	577	577	577
Within R-squared	0.014	0.079	0.079

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Columns (1) and (2) show estimation results for Eq.(3). Column (3) shows estimation results for Eq.(4). The regression sample is limited to the subsample of konou users, i.e. fishers who report to have used the konou at least once during the survey period. The estimates for time-invariant regressors, including Voodoo adherence, are omitted in this model. For more details on the explanatory variables we refer to the notes below Table 4.

Table 6: OLS estimation results: Ownership of recent technologies and Voodoo adherence (2009 household survey)

Dependent variable	Individual owns mobile phone	Household owns electricity generator	Household owns radio	Household owns television
Variables	(1)	(2)	(3)	(4)
Voodoo	-0.184	0.168	0.084	-0.006
	(0.164)	(0.133)	(0.195)	(0.084)
Controls	Yes	Yes	Yes	Yes
Arrondissement	Yes	Yes	Yes	Yes
Constant	Yes	Yes	Yes	Yes
Observations	79	79	79	79
R-squared	0.135	0.123	0.073	0.119

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For details on the explanatory variables we refer to the notes below Table 4. Controls are listed in section 4.1.

Table 7: OLS estimation results: Voodoo adherence and the use of the konou - inclusion of series of control variables (2009 household survey)

Dependent variable	Use of the konou in week *t*										
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Voodoo	-0.151**	-0.157***	-0.245***	-0.252***	-0.252***	-0.252***	-0.238**	-0.233**	-0.209*	-0.201*	-0.201*
	(0.059)	(0.060)	(0.086)	(0.090)	(0.091)	(0.091)	(0.098)	(0.107)	(0.116)	(0.113)	(0.114)
Week		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Arrondissement			✓	✓	✓	✓	✓	✓	✓	✓	✓
Basic controls				✓	✓	✓	✓	✓	✓	✓	✓
Relationship household head					✓	✓	✓	✓	✓	✓	✓
Marital status						✓	✓	✓	✓	✓	✓
Number of wives							✓	✓	✓	✓	✓
Mobile phone								✓	✓	✓	✓
Electricity generator									✓	✓	✓
Radio										✓	✓
TV											✓
Constant	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Number of clusters	102	102	102	88	88	88	88	79	79	79	79
Observations	1,190	1,190	1,190	1,039	1,039	1,039	1,039	927	927	927	927
R-squared	0.025	0.041	0.059	0.125	0.138	0.138	0.141	0.160	0.164	0.169	0.169

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Basic controls refer to the list of control variables discussed in section 4.1. For more details on the explanatory variables we refer to the notes below Table 4.

Table 8: Individual fixed effects estimation results: Shrimp fishing revenue across weeks (2009 household survey)

Dependent variable: (log) Average weekly fishing revenue for shrimp in week *t*				
Variable	(1)	(2)	(3)	(4)
Closed first week	-1.186***	-0.783***		
	(0.277)	(0.253)		
Closed second week	-0.505**	-0.094		
	(0.233)	(0.221)		
Open first week			1.513***	1.169***
			(0.305)	(0.280)
Open second week			1.179***	0.670**
			(0.346)	(0.311)
Open third week			0.990***	0.375
			(0.347)	(0.319)
Open fourth week			0.632**	0.228
			(0.245)	(0.243)
Week	No	Yes	No	Yes
Controls	No	Yes	No	Yes
Constant	Yes	Yes	Yes	Yes
Number of clusters	103	102	103	102
Observations	1,438	1,184	1,438	1,184
R-squared	0.016	0.255	0.022	0.260

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. For more details on the explanatory variables we refer to the notes below Table 4.

Online Appendix to the Paper 'Voodoo versus fishing committees: the role of traditional and contemporary institutions in fisheries management'

Appendix A reports summary statistics, full results and a detailed discussion of the robustness checks. Appendix B provides additional information on data collection. We explain the implementation of the 2009 household survey in detail, discuss variable measurement and present the questions asked in the household survey and fishery census. Appendix C provides a more detailed description of the history of Voodoo and fisheries management, which was summarized in the introduction of the paper.

A. Summary statistics and full results

A.1. Summary statistics

Table A.1: Summary statistics of individual and household characteristics

Panel A: Household survey sample (2009)				
Variable	Mean	St. Dev.	Max.	N
Age	44.25	13.73	90	97
Years of education	0.67	2.02	12	103
Annual income	1,810,613	1,446,688	7,850,000	102
Annual income from fishery sector	1,557,422	1,341,902	7,850,000	102
Household size	6.76	4.09	22	95
Dependency ratio	0.83	0.75	4	90
Number of fishing days	4.37	2.15	7	1,442
Number of persons fishing	1.73	0.73	8	1,201
Panel B: Fishery census sample (2006)				
Variable	Mean	St. Dev.	Max.	N
Age	37	13.06	80	5,803
Number of dependent children	4.7	2.80	15	5,187
Share with formal education	16.5			5,852
Share Goun ethnicity	2.0			5,852
Share Aizo ethnicity	4.0			5,852
Share Tofin ethnicity	83.3			5,852
Share Xwla ethnicity	9.6			5,852
Share Wémè ethnicity	0.2			5,852
Share Sèto ethnicity	0.7			5,852
Share Adja ethnicity	0.2			5,852
Share Sahouè ethnicity	0.2			5,852

Source: Author's calculations. Notes: Earnings are expressed in CFA. One euro equaled about 656 CFA in 2009. The dependency ratio is defined as the ratio of dependent members (dependent children and seniors of 60 years and older) over active members of the household.

A.2 Full tables for main results

Table A.2: OLS estimation results: Use of the konou and Voodoo adherence (2009 household survey)

Dependent variable: Use of the konou in week *t*								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Voodoo	-0.151**	-0.157***	-0.245***	-0.233**	-0.232**	-0.260***	-0.259***	-0.252***
	(0.059)	(0.060)	(0.086)	(0.096)	(0.096)	(0.085)	(0.092)	(0.090)
Week		0.013***	0.013***	0.014***	0.014***	0.015***	0.016***	0.016***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
(log) Age				-0.131	-0.132	-0.142*	-0.159	-0.161
				(0.091)	(0.091)	(0.084)	(0.098)	(0.098)
(log) Years of education					-0.006	-0.011	-0.026	-0.023
					(0.045)	(0.044)	(0.047)	(0.047)
(log) Annual income						0.153***	0.151***	0.149***
						(0.049)	(0.054)	(0.053)
Household size							0.015	0.016
							(0.011)	(0.012)
Dependency ratio								-0.028
								(0.053)
Arrondissement	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.268***	0.160***	0.272***	0.750**	0.758**	-1.445*	-1.442*	-1.406
	(0.035)	(0.039)	(0.076)	(0.352)	(0.354)	(0.799)	(0.849)	(0.849)
Number of clusters	102	102	102	97	97	97	89	88
Observations	1,190	1,190	1,190	1,124	1,124	1,124	1,053	1,039
R-squared	0.025	0.041	0.059	0.066	0.066	0.110	0.121	0.125

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Annual income is expressed in CFA; one euro equaled about 656 CFA in 2009. *Week* refers to a count variable that indicates the survey week. *Arrondissement* refers to dummy variables indicating the arrondissement in which the individual lives.

Table A.3: OLS estimation results: Use of the konou and Voodoo adherence (2006 fishery census)

Dependent variable: Use of the konou by fisher *i*					
Variables	(1)	(2)	(3)	(4)	(5)
Voodoo	-0.146***	-0.067**	-0.067**	-0.069*	-0.066*
	(0.050)	(0.032)	(0.032)	(0.035)	(0.034)
(log) Age		-0.175***	-0.176***	-0.200***	-0.197***
		(0.042)	(0.042)	(0.049)	(0.050)
Level of education			-0.004	0.000	0.004
			(0.010)	(0.011)	(0.013)
Number of children				0.004	0.004
				(0.003)	(0.003)
Ethnicity	No	No	No	No	Yes
Village	No	Yes	Yes	Yes	Yes
Constant	0.342***	0.687***	0.696***	0.787***	0.809***
	(0.046)	(0.153)	(0.153)	(0.181)	(0.183)
Number of clusters	34	34	34	34	34
Observations	5,852	5,824	5,824	5,162	5,162
R-squared	0.018	0.261	0.261	0.263	0.267

Notes: Coefficients are reported with standard errors clustered at the village level in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. *Village* refers to dummy variables indicating the village in which the individual lives. *Ethnicity* refers to ethnicity dummies indicating to which ethnicity the fisherman belongs.

Table A.4 : Individual fixed effects estimation results: Use of the konou in closed weeks
(2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week *t*			
Variables	(1)	(2)	(3)
Closed	-0.109***	-0.090***	-0.095***
	(0.029)	(0.027)	(0.031)
Week		0.028***	0.028***
		(0.009)	(0.009)
Voodoo*Closed			0.035
			(0.059)
Constant	0.509***	0.268***	0.268***
	(0.009)	(0.072)	(0.072)
Number of clusters	47	47	47
Observations	577	577	577
Within R-squared	0.014	0.079	0.079

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For more details on the explanatory variables we refer to the notes below Table A.2.

A.3. Detailed exposition of robustness checks

A.3.1. Alternative sample

Our baseline analysis of the 2009 household survey data relied on a balanced sample of fishers, i.e. fishers who were visited in all 14 weeks. This choice was motivated by the fact that the timing of missing weeks may be related to the use of the konou and the fishing committee rule. For instance, fishers who were violating the fishing committee rule by using the konou in closed weeks may have avoided to be interviewed in those weeks. It is also possible that fishers who generally comply to the fishing committee rule take up alternative economic activities in closed weeks to compensate for the inability to use the konou.

We verify whether our results hold when we re-estimate Eq.(1), (3) and (4) using an unbalanced sample of fishers, including fishers who were not interviewed in one or more weeks.[1] The unbalanced sample includes 121 fishers. We extend Eq.(1) with the regressor $Missing\ weeks_i$ which counts the number of weeks in which the fisher was not interviewed. The OLS estimation results for Eq.(1) are reported in Table A.5; the individual fixed effects estimation results for Eq.(3) and Eq.(4) are reported in Table A.6. The results are qualitatively the same and quantitatively similar to our baseline results.

A.3.2. Alternative estimation model

We check whether we obtain the same results using nonlinear estimations models. We start by re-estimating Eq.(1)-(4) using a probit model. The results are presented in Tables A.7-A.10 and are highly similar to the results obtained using linear estimation models. In contrast to the individual fixed effects model used for the baseline estimation of Eq.(4), the probit model allows us to estimate the coefficient for Voodoo adherence (a time-invariant variable). Table A.10 presents the

[1] As there is no time dimension in the census data, this test is not relevant for Eq.(2).

probit estimation results for Eq.(4). The marginal effect for Voodoo adherence has a negative sign but is not statistically significantly different from zero. This finding might at first appear to contradict our earlier results regarding the relation between Voodoo adherence and the use of the konou (Table A.2). However, these earlier results applied for the full sample of fishers, which includes konou users and fishers who do not use the konou at all. In contrast, the results presented in Table A.10 hold only for the subsample of konou users. Among these konou users are Voodoo fishers who have decided to break the traditional rule. Hence, the insignificant result for Voodoo adherence in Table A.10 indicates that Voodoo fishers, once they have decided to break the traditional rule, are on average equally likely to use the konou in any given week as other konou users (all else equal).

We further re-estimate Eq.(3) and (4) using a probit individual fixed effects model (by adding 47 individual dummy variables as regressors).[2] The results for Eq.(3) and (4), presented in Table A.11, are again quantitatively similar to the main results for Eq.(3) and (4) (cfr. Table A.4).

A.3.3. Alternative dependent variable

We verify whether our results for Eq.(1) hold when we use an alternative definition of compliance to the traditional rule. So far we have used a time-varying dependent variable, i.e. the use of the konou across weeks. This choice is motivated by the fact that the decision to use the konou depends in part on unobserved time-varying variables such as the growth cycle of shrimp or local conditions on the lake (e.g. salinity of the water). Looking at the variation in the use of the konou across weeks allows us to control for these unobserved weekly-varying variables and produce a more precise coefficient estimate for Voodoo adherence.

[2] As explained before, we do not apply this robustness check to Eq.(1) and (2) since our variable of interest is time-invariant.

Nevertheless, since our regressor of interest – Voodoo adherence – does not vary over time, we can construct a time-invariant measure of overall compliance to the traditional rule. More specifically, we take the simple sum of the number of weeks the konou was used by fisherman *i* across the observation period of 14 weeks. In Eq.(1), we replace the binary dependent variable *use of the konou in week t* by the aggregated variable *total use of the konou by individual i*. We estimate this adjusted equation using OLS. We use heteroskedasticity-robust standard errors rather than clustered standard errors, as we no longer exploit the time dimension of the data and serial correlation of the error terms is not a concern.

The results are reported in Table A.12 and indicate that a Voodoo fisherman on average uses the konou 2.9 weeks less than a fisherman who follows another religion (all else equal). Sample fishermen who are not Voodoo adherents used the konou on average in 3.2 weeks (with a standard deviation of 3.6 weeks) in total. Hence, the average estimated impact of Voodoo adherence on total konou use amounts to 90 % of the sample average of total konou use among non-Voodoo fishers.

Table A.5: OLS estimation results: Use of the konou and Voodoo adherence – unbalanced sample (2009 household survey)

Dependent variable: Use of the konou in week *t*									
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Voodoo	-0.103*	-0.109*	-0.165**	-0.154**	-0.154**	-0.166**	-0.162**	-0.160**	-0.173**
	(0.055)	(0.055)	(0.071)	(0.076)	(0.076)	(0.073)	(0.077)	(0.076)	(0.077)
Week		0.012***	0.011***	0.012***	0.012***	0.013***	0.014***	0.014***	0.015***
		(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
(log) Age				-0.109	-0.106	-0.123	-0.139	-0.140	-0.119
				(0.076)	(0.076)	(0.077)	(0.085)	(0.085)	(0.084)
(log) Years of Education					0.015	0.011	-0.001	0.000	0.002
					(0.044)	(0.043)	(0.045)	(0.045)	(0.043)
(log) Annual income						0.048**	0.045**	0.045**	0.064**
						(0.023)	(0.022)	(0.022)	(0.027)
Household size							0.012	0.013	0.011
							(0.008)	(0.009)	(0.009)
Dependency ratio								-0.010	-0.004
								(0.046)	(0.044)
Missing weeks									0.032**
									(0.014)
Arrondissement	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.282***	0.187***	0.260***	0.654**	0.639**	0.009	0.033	0.034	-0.335
	(0.030)	(0.036)	(0.063)	(0.297)	(0.297)	(0.376)	(0.371)	(0.371)	(0.433)
Number of clusters	158	158	158	152	152	148	137	136	136
Observations	1,555	1,555	1,555	1,485	1,485	1,465	1,374	1,360	1,360
R-squared	0.011	0.023	0.030	0.035	0.035	0.051	0.060	0.061	0.076

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. The regressor *Missing weeks* counts the number of weeks for which information is missing for individual *i*. For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.6: Individual fixed effects estimation results: Use of the konou in closed weeks - unbalanced sample
(2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week *t*			
Variables	(1)	(2)	(3)
Closed	-0.133***	-0.115***	-0.107***
	(0.030)	(0.029)	(0.032)
Week		0.023***	0.023***
		(0.007)	(0.007)
Voodoo*Closed			-0.041
			(0.071)
Constant	0.541***	0.341***	0.341***
	(0.009)	(0.064)	(0.064)
Number of clusters	76	76	76
Observations	789	789	789
Within R-squared	0.020	0.062	0.063

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.7: Probit estimation results: Use of the konou and Voodoo adherence (2009 household survey)

Dependent variable: Use of the konou in week *t*								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) Marginal effects
Voodoo	-0.571**	-0.847**	-0.780**	-0.778**	-0.925***	-0.878***	-0.851***	-0.216***
	(0.262)	(0.331)	(0.345)	(0.346)	(0.327)	(0.332)	(0.326)	(0.064)
Week		0.045***	0.047***	0.047***	0.054***	0.056***	0.056***	0.017***
		(0.014)	(0.015)	(0.015)	(0.016)	(0.016)	(0.016)	(0.005)
(log) Age			-0.463	-0.470	-0.525*	-0.558*	-0.558*	-0.171*
			(0.303)	(0.305)	(0.290)	(0.326)	(0.325)	(0.101)
(log) Years of education				-0.025	-0.042	-0.093	-0.085	-0.026
				(0.161)	(0.162)	(0.173)	(0.175)	(0.053)
(log) Annual income					0.528***	0.495***	0.494***	0.151***
					(0.177)	(0.179)	(0.176)	(0.053)
Household size						0.046	0.051	0.016
						(0.035)	(0.036)	(0.011)
Dependency ratio							-0.091	-0.028
							(0.188)	(0.058)
Arrondissement	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	-0.618***	-0.678***	1.014	1.046	-6.507**	-6.208**	-6.181**	
	(0.105)	(0.228)	(1.177)	(1.185)	(2.860)	(2.891)	(2.859)	
Number of clusters	102	102	97	97	97	89	88	88
Observations	1,190	1,190	1,124	1,124	1,124	1,053	1,039	1,039

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Column (8) presents average marginal effects calculated at the mean values of other variables for the specification in column (7). For more details on the explanatory variables we refer to the notes below Table A2.

Table A.8: Probit estimation results: Use of the konou and Voodoo adherence (2006 fishery census)

Dependent variable: Use of the konou by fisher *i*							
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7) Marginal effects
Voodoo	-0.450***	-0.381***	-0.254*	-0.256*	-0.255*	-0.236*	-0.067*
	(0.156)	(0.132)	(0.132)	(0.133)	(0.143)	(0.140)	(0.037)
(log) Age			-0.631***	-0.633***	-0.730***	-0.730***	-0.217***
			(0.155)	(0.155)	(0.187)	(0.189)	(0.055)
Literacy				-0.017	-0.003	0.016	0.005
				(0.044)	(0.046)	(0.058)	(0.017)
Number of children					0.019	0.018	0.005
					(0.012)	(0.012)	(0.004)
Village	No	Yes	Yes	Yes	Yes	Yes	Yes
Ethnicity	No	No	No	No	Yes	Yes	Yes
Constant	-0.408***	-2.088***	0.104	0.135	0.606	0.742	
	(0.125)	(0.036)	(0.536)	(0.541)	(0.665)	(0.776)	
Number of clusters	34	34	34	34	34	34	34
Observations	5,852	5,852	5,824	5,824	5,162	5,160	5,160

Notes: Coefficients are reported with standard errors clustered at the village level in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Column (7) presents average marginal effects calculated at the mean values of other variables for the specification in column (6). For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.9: Probit estimation results: Use of the konou in closed weeks (2009 household survey – subsample of konou users)

Dependent variable: Use of the konou in week *t*								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) Marginal effects
Closed	-0.340***	-0.312***	-0.308***	-0.309***	-0.310***	-0.305***	-0.334***	-0.133***
	(0.082)	(0.089)	(0.090)	(0.089)	(0.089)	(0.087)	(0.085)	(0.034)
Week		0.069***	0.073***	0.073***	0.072***	0.078***	0.080***	0.032***
		(0.023)	(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.010)
(log) Age			-0.377	-0.384	-0.388	-0.692**	-0.693**	-0.277**
			(0.340)	(0.347)	(0.342)	(0.294)	(0.296)	(0.118)
(log) Years of education				-0.030	-0.032	0.022	0.022	0.009
				(0.196)	(0.197)	(0.160)	(0.155)	(0.062)
(log) Annual income					-0.027	0.131	0.132	0.053
					(0.129)	(0.143)	(0.141)	(0.056)
Household size						0.100***	0.101***	0.040***
						(0.036)	(0.036)	(0.014)
Dependency ratio							-0.006	-0.002
							(0.167)	(0.067)
Arrondissement	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.042	-0.230	1.148	1.182	1.611	-0.603	-0.622	
	(0.101)	(0.210)	(1.332)	(1.366)	(2.091)	(2.300)	(2.324)	
Number of clusters	47	47	46	46	46	46	45	45
Observations	577	577	563	563	563	563	549	549

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Column (8) presents average marginal effects calculated at the mean values of other variables for the specification in column (7). For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.10: Probit estimation results: Use of the konou by Voodoo fishers in closed weeks (2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week *t*								
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8) Marginal effects
Voodoo	-0.260	-0.514	-0.496	-0.495	-0.508	-0.401	-0.422	-0.168
	(0.336)	(0.372)	(0.382)	(0.383)	(0.383)	(0.292)	(0.305)	(0.121)
Closed	-0.332***	-0.305***	-0.302***	-0.302***	-0.301***	-0.311***	-0.348***	-0.139***
	(0.090)	(0.098)	(0.099)	(0.098)	(0.097)	(0.097)	(0.095)	(0.038)
Voodoo*Closed	-0.089	-0.135	-0.131	-0.130	-0.132	-0.005	0.026	0.019
	(0.237)	(0.279)	(0.283)	(0.284)	(0.284)	(0.208)	(0.208)	(0.073)
Week		0.070***	0.073***	0.073***	0.073***	0.078***	0.079***	0.032***
		(0.023)	(0.024)	(0.024)	(0.024)	(0.024)	(0.024)	(0.010)
(log) Age			-0.307	-0.309	-0.302	-0.595**	-0.593**	-0.236**
			(0.319)	(0.322)	(0.316)	(0.297)	(0.300)	(0.120)
Literacy				-0.010	-0.007	0.034	0.037	0.015
				(0.170)	(0.171)	(0.150)	(0.147)	(0.059)
(log) Annual income					0.043	0.161	0.170	0.068
					(0.118)	(0.141)	(0.138)	(0.055)
Household size						0.090**	0.092**	0.037**
						(0.037)	(0.036)	(0.014)
Dependency ratio							-0.039	-0.016
							(0.170)	(0.068)
Arrondissement	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Constant	0.085	-0.049	1.064	1.076	0.407	-1.190	-1.322	
	(0.103)	(0.201)	(1.204)	(1.217)	(1.938)	(2.256)	(2.267)	
Number of clusters	47	47	46	46	46	46	45	45
Observations	577	577	563	563	563	563	549	549

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Column (8) presents average marginal effects calculated at the mean values of other variables for the specification in column (7). For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.11: Probit individual fixed effects estimation results: Use of the konou in closed weeks
(2009 household survey - subsample of konou users)

Dependent variable: Use of the konou in week *t*				
Variables	(1)	(2)	(3)	(4) Marginal effects
Closed	-0.352***	-0.308***	-0.311***	-0.122***
	(0.093)	(0.095)	(0.105)	(0.041)
Week		0.092***	0.092***	0.036***
		(0.030)	(0.030)	(0.012)
Voodoo*Closed			0.029	0.017
			(0.250)	(0.074)
Constant	0.678***	0.050	0.051	
	(0.030)	(0.192)	(0.194)	
Number of clusters	43	43	43	43
Observations	550	550	550	549

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Column (4) presents average marginal effects calculated at the mean values of other variables for the specification in column (3). For more details on the explanatory variables we refer to the notes below Table A.2.

Table A.12: OLS estimation results: Total use of the konou and Voodoo adherence (2009 household survey)

Dependent variable	Total number of weeks fisherman *i* used the konou						
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Voodoo	-1.874***	-2.749***	-2.529**	-2.522**	-2.809***	-3.002***	-2.884***
	(0.668)	(0.991)	(1.081)	(1.089)	(0.964)	(1.083)	(1.086)
(log) Age			-1.954*	-1.980*	-2.146**	-1.908	-1.935
			(1.075)	(1.089)	(1.012)	(1.212)	(1.217)
(log) Years of education				-0.101	-0.211	-0.354	-0.311
				(0.540)	(0.536)	(0.566)	(0.575)
(log) Annual wage					1.784***	1.722**	1.694**
					(0.640)	(0.738)	(0.739)
Household size						0.090	0.113
						(0.136)	(0.149)
Dependency Ratio							-0.443
							(0.598)
Arrondissement	No	Yes	Yes	Yes	Yes	Yes	Yes
Constant	3.160***	4.238***	11.552***	11.675***	-13.614	-13.860	-13.230
	(0.416)	(0.914)	(4.209)	(4.279)	(10.235)	(11.660)	(11.723)
Observations	103	103	97	97	97	89	88
R-squared	0.058	0.086	0.107	0.107	0.192	0.194	0.199

Notes: Coefficients are reported with heteroskedasticity-robust standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For more details on the explanatory variables we refer to the notes below Table A.2.

A.4. Full tables for analysis in section 6 (competing explanations)

A.4.1. Unobserved individual heterogeneity

Table A.13: OLS estimation results: Ownership of recent technologies and Voodoo adherence (2009 household survey - balanced sample)

Dependent variable	Individual owns mobile phone	Household owns electricity generator	Household owns radio	Household owns television
Variables	(1)	(2)	(3)	(4)
Voodoo	-0.184	0.168	0.084	-0.006
	(0.164)	(0.133)	(0.195)	(0.084)
(log) Age	-0.115	-0.077	-0.327*	-0.107
	(0.197)	(0.152)	(0.167)	(0.138)
(log) Years of education	-0.069	-0.081*	-0.039	0.021
	(0.086)	(0.046)	(0.083)	(0.067)
(log) Annual wage	0.134	-0.121*	0.016	-0.097*
	(0.093)	(0.063)	(0.092)	(0.058)
Household size	0.016	0.032**	-0.001	0.027*
	(0.017)	(0.016)	(0.017)	(0.015)
Dependency Ratio	0.072	-0.076	0.044	-0.035
	(0.093)	(0.082)	(0.083)	(0.075)
Arrondissement	-0.192	-0.026	0.179	-0.020
	(0.170)	(0.129)	(0.174)	(0.102)
Constant	-0.883	2.018*	1.532	1.744
	(1.517)	(1.153)	(1.482)	(1.067)
Observations	79	79	79	79
R-squared	0.135	0.123	0.073	0.119

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Controls are discussed in section 4.1. of the paper.

Table A.14: OLS estimation results: Ownership of new technologies and Voodoo adherence (2009 household survey – unbalanced sample)

Dependent variable	Individual owns mobile phone	Household owns electricity generator	Household owns radio	Household owns television
Variables	(1)	(2)	(3)	(4)
Voodoo	-0.076	-0.136	0.043	-0.191**
	(0.100)	(0.108)	(0.123)	(0.076)
(log) Age	-0.108	-0.074	-0.243**	-0.116
	(0.118)	(0.108)	(0.097)	(0.099)
(log) Years of education	-0.054	-0.011	0.010	0.048
	(0.069)	(0.057)	(0.061)	(0.060)
(log) Annual wage	-0.002	0.016***	0.051***	0.013**
	(0.015)	(0.006)	(0.007)	(0.006)
Household size	0.016*	0.024**	0.005	0.022**
	(0.009)	(0.010)	(0.010)	(0.009)
Dependency Ratio	0.006	-0.046	-0.020	-0.015
	(0.059)	(0.069)	(0.062)	(0.064)
Arrondissement	-0.289***	-0.015	0.136	0.013
	(0.096)	(0.100)	(0.115)	(0.081)
Constant	1.140**	0.176	0.807**	0.305
	(0.495)	(0.389)	(0.383)	(0.357)
Observations	121	121	121	121
R-squared	0.122	0.089	0.116	0.133

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Controls are discussed in section 4.1. of the paper.

Table A.15: OLS estimation results: Voodoo adherence and the use of the konou - inclusion of control variables (2009 household survey)

Dependent variable	Use of the konou in week *t*										
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Voodoo	-0.151**	-0.157***	-0.245***	-0.252***	-0.252***	-0.252***	-0.238**	-0.233**	-0.209*	-0.201*	-0.201*
	(0.059)	(0.060)	(0.086)	(0.090)	(0.091)	(0.091)	(0.098)	(0.107)	(0.116)	(0.113)	(0.114)
(log) Age				-0.161	-0.217**	-0.215**	-0.215**	-0.145	-0.145	-0.170	-0.170
				(0.098)	(0.100)	(0.101)	(0.102)	(0.100)	(0.097)	(0.104)	(0.104)
(log) Years of education				-0.023	-0.016	-0.016	-0.015	-0.023	-0.028	-0.030	-0.030
				(0.047)	(0.047)	(0.047)	(0.047)	(0.050)	(0.049)	(0.050)	(0.051)
(log) Annual income				0.149***	0.158***	0.157***	0.159***	0.140**	0.126**	0.131**	0.131**
				(0.053)	(0.053)	(0.053)	(0.053)	(0.055)	(0.059)	(0.060)	(0.060)
Household size				0.016	0.018	0.018	0.019	0.016	0.018	0.019	0.019
				(0.012)	(0.013)	(0.013)	(0.013)	(0.014)	(0.013)	(0.013)	(0.013)
Dependency ratio				-0.028	-0.048	-0.047	-0.054	-0.034	-0.047	-0.045	-0.046
				(0.053)	(0.055)	(0.055)	(0.054)	(0.057)	(0.057)	(0.057)	(0.056)
Relationship household head					-0.050**	-0.052**	-0.056***	-0.043*	-0.045*	-0.046*	-0.046*
					(0.021)	(0.020)	(0.020)	(0.026)	(0.024)	(0.023)	(0.023)
Marital status						-0.027	-0.052	-0.019	-0.046	-0.061	-0.063
						(0.123)	(0.127)	(0.146)	(0.144)	(0.150)	(0.149)
Number of wives							0.040	0.039	0.043	0.043	0.044
							(0.057)	(0.060)	(0.060)	(0.058)	(0.060)
Mobile phone								0.107*	0.134*	0.132*	0.132*
								(0.064)	(0.079)	(0.079)	(0.077)
Electricity generator									-0.086	-0.077	-0.074
									(0.112)	(0.114)	(0.136)
Radio										-0.074	-0.074
										(0.066)	(0.066)
TV											-0.006
											(0.134)
Constant	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Week	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Arrondissement	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Number of clusters	102	102	102	88	88	88	88	79	79	79	79
Observations	1,190	1,190	1,190	1,039	1,039	1,039	1,039	927	927	927	927
R-squared	0.025	0.041	0.059	0.125	0.138	0.138	0.141	0.160	0.164	0.169	0.169

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. For more details on the explanatory variables we refer to the notes below Table A.2 and section 6.1. of the paper.

A.4.2. Reporting bias regarding the use of the konou

Full results for the estimation of Eq.(5) and Eq.(6) are presented in Tables A.16 and A.17 respectively.

To verify whether the fluctuations in shrimp fishing revenue across open and closed weeks are caused by a natural cyclicality in fishing activities rather than the fishing committee rule, we run a falsification test. We implement the test by comparing the fluctuations of fishing revenue at lake Nokoué with those of lake Ahémé, another coastal lake in southern Benin close to lake Nokoué (see Figure 1). At this lake the socio-ecological system and nature of fishing activities are similar to lake Nokoué. The key differences for our purpose are the absence of the fishing committee rule and the fact that the government prohibited the use of the konou at lake Ahémé (and this prohibition is well enforced).

Our falsification test takes the form of a difference-in-differences analysis, which allows us to examine whether the fluctuations in shrimp fishing revenue at lake Nokoué are significantly larger than fluctuations in shrimp fishing revenue for the control, i.e. lake Ahémé. Finding no significant difference between the two lakes would suggest that the fluctuations observed at lake Nokoué are caused by a cyclicality of fishing activities rather than the fishing committee rule.

We augment equations (5) and (6) with interaction terms between the sets of closed and open week indicator variables, and an indicator variable that takes value 1 for lake Nokoué (and 0 for lake Ahémé).[3] We estimate the augmented regression equations for an extended household survey sample by adding 14 weekly observations for 116 fishermen living in 6 villages at lake Ahémé. Table A.18 and A.19 presents the estimation results for closed and open weeks respectively. The coefficient estimates indicate that the drop in shrimp fishing revenue in the first closed weeks and the jump in shrimp fishing revenue in the first open weeks

[3] This indicator variable for lake Nokoué is absorbed by the individual fixed effects.

are significantly larger at lake Nokoué compared to lake Ahémé. We therefore reject the hypothesis that the fluctuations in fishing revenue observed at lake Nokoué are merely the result of natural cyclicality.

Table A.16: Individual fixed effects estimation results: Shrimp fishing revenue in closed weeks (2009 household survey)

Dependent variable: (log) Average weekly fishing revenue for shrimp in week *t*					
Variable	(1)	(2)	(3)	(4)	(5)
Closed first week	-1.186***	-1.184***	-0.914***	-0.909***	-0.783***
	(0.277)	(0.275)	(0.238)	(0.295)	(0.253)
Closed second week	-0.505**	-0.499**	-0.325	-0.259	-0.094
	(0.233)	(0.232)	(0.210)	(0.258)	(0.221)
Week		0.011	-0.025	-0.064	-0.002
		(0.046)	(0.043)	(0.051)	(0.044)
(log) Fishing days			2.274***	2.413***	1.589**
			(0.280)	(0.812)	(0.715)
(log) Persons fishing				1.169	1.563
				(1.032)	(1.042)
Other fishing gear	No	No	No	No	Yes
Constant	3.485***	3.393***	0.161	-0.941	-1.008
	(0.083)	(0.372)	(0.517)	(1.765)	(1.724)
Number of clusters	103	103	103	102	102
Observations	1,438	1,438	1,438	1,197	1,184
R-squared	0.016	0.016	0.122	0.027	0.255

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. *Week* is a count variable that indicates the week of the survey period.

Table A.17: Individual fixed effects estimation results: Shrimp fishing revenue in open weeks (2009 household survey)

Dependent variable: (log) Average weekly fishing revenue for shrimp in week *t*					
Variable	(1)	(2)	(3)	(4)	(5)
Open first week	1.513***	1.512***	1.275***	1.244***	1.169***
	(0.305)	(0.303)	(0.264)	(0.312)	(0.280)
Open second week	1.179***	1.174***	1.004***	0.995***	0.670**
	(0.346)	(0.339)	(0.304)	(0.357)	(0.311)
Open third week	0.990***	0.986***	0.687**	0.733**	0.375
	(0.347)	(0.341)	(0.301)	(0.351)	(0.319)
Open fourth week	0.632**	0.631**	0.394*	0.328	0.228
	(0.245)	(0.242)	(0.222)	(0.269)	(0.243)
Week		0.003	-0.032	-0.069	-0.004
		(0.046)	(0.043)	(0.050)	(0.044)
(log) Fishing days			2.278***	2.373***	1.558**
			(0.278)	(0.808)	(0.705)
(log) Persons fishing				1.184	1.568
				(1.039)	(1.047)
Other fishing gear	No	No	No	No	Yes
Constant	2.487***	2.462***	-0.547	-1.574	-1.483
	(0.168)	(0.421)	(0.569)	(1.820)	(1.774)
Number of clusters	103	103	103	102	102
Observations	1,438	1,438	1,438	1,197	1,184
R-squared	0.022	0.022	0.128	0.034	0.260

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. *Week* is a count variable that indicates the week of the survey period.

Table A.18: Individual fixed effects estimation results
Falsification test: Shrimp fishing revenue in closed weeks at two lakes (2009 household survey)

Dependent variable: (log) Average weekly fishing revenue for shrimp in week *t*					
Variable	(1)	(2)	(3)	(4)	(5)
Closed first week	-0.233	-0.322*	-0.245	-0.260*	-0.272*
	(0.192)	(0.192)	(0.148)	(0.153)	(0.160)
Closed second week	0.393***	0.365***	0.239**	0.193*	0.092
	(0.130)	(0.130)	(0.105)	(0.103)	(0.108)
Closed first week*Nokoué	-1.078***	-1.005***	-0.681**	-0.767**	-0.566*
	(0.349)	(0.351)	(0.290)	(0.347)	(0.318)
Closed second week*Nokoué	-0.911***	-0.918***	-0.541**	-0.471	-0.186
	(0.284)	(0.285)	(0.250)	(0.305)	(0.271)
Week		-0.087***	-0.105***	-0.119***	-0.070**
		(0.031)	(0.027)	(0.030)	(0.029)
(log) Fishing days			3.201***	3.253***	2.539***
			(0.194)	(0.603)	(0.567)
(log) Persons fishing				2.493***	2.671***
				(0.568)	(0.570)
Other fishing gear	No	No	No	No	Yes
Constant	5.516***	6.235***	1.053***	-1.045	-1.414
	(0.049)	(0.254)	(0.384)	(1.218)	(1.139)
Number of clusters	219	219	219	218	218
Observations	2,939	2,939	2,939	2,576	2,532
R-squared	0.013	0.023	0.221	0.073	0.213

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. The baseline category for the indicator variable lake Nokoué is lake Ahémé. *Week* is a count variable that indicates the week of the survey period.

Table A.19: Individual fixed effects estimation results
Falsification test: Shrimp fishing revenue in open weeks at two lakes (2009 household survey)

Dependent variable: (log) Average weekly fishing revenue for shrimp in week *t*					
Variable	(1)	(2)	(3)	(4)	(5)
Open first week	0.353*	0.442**	0.298*	0.292*	0.321*
	(0.189)	(0.188)	(0.160)	(0.176)	(0.188)
Open second week	0.122	0.298	0.210	0.254	0.340*
	(0.203)	(0.203)	(0.170)	(0.180)	(0.189)
Open third week	-0.309	-0.155	-0.067	0.011	0.186
	(0.256)	(0.260)	(0.206)	(0.211)	(0.215)
Open fourth week	-0.577***	-0.504***	-0.293*	-0.231	-0.141
	(0.187)	(0.186)	(0.152)	(0.155)	(0.156)
Open first week*Nokoué	1.390***	1.333***	1.119***	1.211***	1.084***
	(0.371)	(0.371)	(0.316)	(0.375)	(0.356)
Open second week*Nokoué	1.222***	1.166***	0.973***	0.977**	0.550
	(0.426)	(0.428)	(0.374)	(0.437)	(0.400)
Open third week*Nokoué	1.358***	1.305***	0.762*	0.797*	0.174
	(0.459)	(0.461)	(0.391)	(0.449)	(0.432)
Open fourth week*Nokoué	1.184***	1.135***	0.579**	0.505	0.276
	(0.324)	(0.327)	(0.291)	(0.342)	(0.313)
Week		-0.092***	-0.109***	-0.122***	-0.072**
		(0.031)	(0.027)	(0.030)	(0.029)
(log) Fishing days			3.192***	3.209***	2.485***
			(0.191)	(0.602)	(0.563)
(log) Persons fishing				2.527***	2.716***
				(0.560)	(0.558)
Other fishing gear	No	No	No	No	Yes
Constant	5.103***	5.784***	0.750*	-1.342	-1.666
	(0.100)	(0.266)	(0.390)	(1.214)	(1.130)
Number of clusters	219	219	219	218	218
Observations	2,939	2,939	2,939	2,576	2,532
R-squared	0.019	0.031	0.227	0.079	0.219

Notes: Coefficients are reported with individually clustered standard errors in parentheses. ***, ** and * denote significance at the 1, 5 and 10 % levels respectively. Fishing revenue is expressed in CFA; one euro equaled about 656 CFA in 2009. The baseline category for the indicator variable lake Nokoué is lake Ahémé. *Week* is a count variable that indicates the week of the survey period.

B. Additional information on data collection

B.1. Details on the implementation of the 2009 household survey

For the household survey, households were visited each two weeks during the survey period. During every visit, two modules were administered: the bi-weekly module and a one-time module. One-time modules were implemented during one visit only, and each module focused on a different theme (e.g. individual characteristics of household members, household assets, schooling and health). Bi-weekly modules were implemented each bi-weekly visit and collected information for the past two weeks (separately for each week) on revenues, expenditures and activities of fishers and fishmongers.

As it was not possible to visit all households simultaneously in one week, households were divided into two groups. These groups were alternately visited during the survey period. In other words, each week one of the two groups was visited to collect bi-weekly information. This procedure implies that the first visit to one group of households took place one week earlier than the first visit to the second group of households. Similarly, the last visit to the second group of households took place one week after the last visit to the first group. Hence, although each household was visited bi-weekly during 14 weeks, the total time span of the survey was 15 weeks. Table B.1 illustrates this procedure in detail.

Because of this implementation, in the first week we only have information on fishing activities for the first group of households; in the last week we only have information on fishing activities for the second group of households.

Table B.1: Illustration of the implementation of the bi-weekly module in the 2009 household survey

Dates	**Week**	**Household group visited**	**Visit number for group 1**	**Visit number for group 2**	**Information gathered for group 1**	**Information gathered for group 2**
April 13 - 19	1				visit 1: previous week	none
April 20 - 26	2	1	visit 1		visit 1: current week	visit 1: previous week
April 27 - May 3	3	2		visit 1	visit 2: previous week	visit 1: current week
May 4 - 10	4	1	visit 2		visit 2: current week	visit 2: previous week
May 11 - 17	5	2		visit 2	visit 3: previous week	visit 2: current week
May 18 - 24	6	1	visit 3		visit 3: current week	visit 3: previous week
May 25 - 31	7	2		visit 3	visit 4: previous week	visit 3: current week
June 1 - 7	8	1	visit 4		visit 4: current week	visit 4: previous week
June 8 - 14	9	2		visit 4	visit 5: previous week	visit 4: current week
June 15 - 21	10	1	visit 5		visit 5: current week	visit 5: previous week
June 22 - 28	11	2		visit 5	visit 6: previous week	visit 5: current week
June 29 - July 5	12	1	visit 6		visit 6: current week	visit 6: previous week
July 6 - 12	13	2		visit 6	visit 7: previous week	visit 6: current week
July 13 - 19	14	1	visit 7		visit 7: current week	visit 7: previous week
July 20 - 26	15	2		visit 7	none	visit 7: current week

Our results are basically unchanged when we exclude the observations in the first and last week (i.e. weeks 1 and 15), with some minor changes in coefficient sizes for the variables of interest (results not reported, but available on request). We have therefore chosen to include the first and last weeks in our empirical analysis in order to take full advantage of the information available in the survey.

B.2. Details on variable measurement and questions asked

For both the 2009 household survey and the 2006 fishery census we provide a detailed exposition of how variables were measured and which questions were asked to obtain the necessary information.

Information on religious adherence was obtained in the one-time module on household member characteristics by asking the following question: "*What is the main religious confession of this person?*".[4] The answer coding included a separate code for Voodoo or animism (*animiste*). Weekly information on the use of the konou was obtained in the fishing activity questionnaire of the bi-weekly module. The administrator asked the following question: "*What fishing instruments have you used in the past two weeks?"*[5] and consequently read out loud a list of fishing instruments used at lake Nokoué. For each fishing instrument, the respondent indicated whether he had used it in the past week and the week before, up to a maximum of three instruments. If more than three fishing instruments had been used, the interviewer recorded the three most important ones. Included in the list of fishing instruments was the konou.

The fishery census collected information on fishing activities and a limited number of socio-economic variables through a one-time visit. The census questionnaire inquired after

[4] "*Quelle est la principale confession religieuse de cette personne?*".

[5] "*Quels engins de pêche avez-vous manipulés les 2 semaines passées?*".

religious adherence through a question about 'religion' (no full sentence was specified). The answer coding included a separate code for Voodoo or animism (*Vodoun*).[6]

Information on the use of the konou was obtained in the census by asking the following question: "*Which of these fishing instruments/techniques do you use?*"[7] One of the categories listed below this question was the konou.

Information on the closing of the lake during the household survey period was obtained through semi-structured and open-ended interviews with members of the fishing committees.

Table B.2 provides a summary of the variables used in our analysis and how information regarding these variables was collected in the survey and census.

[6] Another answer category was 'other traditional religions'. This answer category was not recorded in the entire census dataset, indicating that there are no other important traditional or animistic religions besides Voodoo in this region.

[7] "*Lesquelles de ces unités/systèmes de pêches pratiquez-vous?"*.

Table B.2: Summary of variables measured and questions asked

Panel A: Household survey	
Question/Definition	Variable measured
"What fishing instruments have you used in the past two weeks?"	Konou
"What is the main religious confession of this person?"	Voodoo
Lake Nokoué was closed to the use of the konou during this week	Closed
Age	Age
"During how many years was this person in school (present, even without passing)?"	Years of education
Average daily earnings*days worked in 2008 per activity, summed across activities[a]	Annual income
Total number of persons living in the household	Household size
Ratio of dependent and active household members[b]	Dependency ratio
"Provide the total value in FCFA obtained from the sales of shrimp catches."	Fishing revenue for shrimp
"How many days have you fished in each of the two past weeks?"	Number of fishing days
"Who has accompanied you while fishing during the past two weeks?"	Number of persons fishing
"What fishing instruments have you used in the past two weeks?"	Other fishing gear
Panel B: Fishery Census	
Question/Definition	Variable measured
"Which of these fishing instruments/techniques do you use?"	Konou
Religion	Voodoo
Age	Age
Level of education (categories, not years)	Education
Number of dependent children	Number of dependent children
Ethnicity	Ethnicity

Source: Author's 2009 household survey implemented and 2006 fishery census implemented by the government of Benin (UCN/PMEDP/Direction des Pêches) for FAO. Notes:
a: The corresponding questions in the survey are: "How many days per month did you engage in this activity in 2008?" and "How much did you earn on average per working day from this activity (net, i.e. after deduction of costs)?"
b: Dependent individuals are children (age<15) and elderly (age>60). Active members are individuals aged between 15 and 60.

C. The history of Voodoo and fisheries management in the south of Benin

According to Pliya (1980), in pre-colonial times the traditional Voodoo governance institution managed to keep resource exploitation in check, even in the face of population growth. The system started to fail, however, when the colonization of Benin brought about profound socio-economic changes (Dangbégnon, 2000; Pliya, 1980). The traditional politico-religious structures were undermined by new colonial and post-colonial powers, and these powers also introduced Christian religions that started to compete with Voodoo. As the power of Voodoo declined, the deterring effect of sanctions decreased. At the same time, the benefits of shirking increased with the rising value of fishery products following commercialization and market integration of the economy. The economic opportunities created by a growing fishing sector, combined with a booming population, brought about large flows of internal migration to the southern lakes. Newly settled agricultural communities started exploiting the lake resources as well, engaging in a competition with the communities who had been full-time fishers since pre-colonial times. These part-time fishers showed little respect for the traditional Voodoo system, fishing whenever and wherever they chose, openly disobeying rules and undermining the authority of Voodoo priests. The influx of outsiders thus further eroded the power of the Voodoo system and reduced the incentives to obey the rules (Pliya, 1980).

The waning power of the traditional Voodoo institution led to an institutional vacuum, which the Beninese government attempted to fill by creating new governance institutions. Yet, these governmentally created institutions failed to effectively regulate fishing activities (Dangbégnon, 2000; Pliya, 1980). Rules were left unmonitored, sanctions were too lenient and punishments were rarely and inconsistently implemented. For instance, civil servants designated to inspect the use of fishing gear explained to us that in the run-up to elections, the incumbent

attempts to win the votes of fishers by halting monitoring and certainly sanctioning (see also Dangbégnon, 2000). Besides failing to effectively regulate the fishing activity, the central government undermined the authority of Voodoo priests and the traditional rules that they represented by creating new fishery management institutions and replacing traditional leaders with government administrations (Pliya, 1980). For example, by enforcing the individual property claim of *acadja* owners[8], the government broke with the long-established Voodoo principle that preserved the lake and its resources as common property (Pliya, 1980).

Under the Marxist-Leninist regime in Benin (1972-1989) the government took a hostile attitude towards Voodoo, actively targeting it with anti-religious campaigns and laws against sorcery (Tall, 1995b). With the democratic renewal in the 1990s the tide turned: authorities actively supported the Voodoo religion and promoted it as a symbol of national identity and cultural heritage. Important signals of the new attitude towards Voodoo were the organization of an annual national Voodoo festival and the enlistment of Voodoo in the constitution as an official religion. The Voodoo religion regained vitality and became more and more organized as a national traditional religion (Tall, 1995b).

[8] The *acadja* is a type of brush park fishery where branches are placed in the bottom of the lake and fenced with a fishing net. Owners guard their acadjas and allow no one else to harvest fish inside the fenced area.