Cooperation and Ethnicity:
A Case Study from Southern India

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ABSTRACT

This dissertation was designed to examine the influences of ethnic diversity and ethnic hierarchy on human cooperation, with a particular focus on irrigation management. I conducted a three-phase research project in the southern Indian state of Tamil Nadu. In the upper Palani hills, I conducted a preliminary ethnography of village life across 14 villages, followed by a household survey of irrigation, village justice and caste interactions in six villages, and concluding with a cooperative game experiment.

In the first study, I present behavioral evidence that caste groupings affect individual cooperation in public goods games. The experiments revealed evidence for a negative cooperative effect of more castes, but clear and strong evidence that hierarchical caste relationships reduced individuals' willingness to cooperate. When high and low caste individuals played the public goods game together, they both reduced their contributions markedly in comparison to games in which they played exclusively with individuals from their own caste. Moreover, the addition of a third, 'middle' caste to the games, had the effect of *improving* both high and low caste cooperation. Taken together these results constitute clear evidence for both a preference for ethnocentric cooperation, and a hierarchical inflation factor for ethnically driven anti-cooperative behavior. In addition, the effects of caste combination differences were present from the first round. Expectations about peer cooperation determined initial contribution levels, and ultimate outcomes.

In the second study, I found again that caste diversity decreases the days of labor individuals volunteered to maintain the village irrigation structures, and was associated

with a reduction in irrigation fairness. Caste stratification also appears to damage fairness in the irrigation system. However, the most predictive variable in all regressions on irrigation in chapter two was irrigation access. Individuals who had access to irrigation water for their fields contributed more days of labor, and rated the system as more adequate, equal, and fair than those without access. But irrigation channels were unevenly distributed between castes. Non-Dalit castes and more populous castes were much more likely to have irrigation access to begin with. Thus, caste stratification in village irrigation is embedded directly in the channels themselves. And here, again hierarchical relationships prove to be the most pernicious of ethnic interactions.

In the third study, I explore aspects of daily life hypothesized to be important in determining ethnic interactions, namely social connectedness, and reciprocal relations. Mirroring my earlier results, I find that (1) ethnic stratification is more detrimental to cooperation than mere 'unranked' ethnic diversity, (2) social exclusivity is strongly increased by ethnic stratification, but that (3) direct reciprocity is robust to cooperative failure across hierarchical ethnic boundaries where indirect reciprocity is not.

In summary, the results presented in this dissertation reaffirm the negative cooperative effect of ethnic diversity, and extend those findings by coupling cooperative field experiments with research on extant resource management systems. Moreover, I have supplied new evidence, from both experiments and surveys, that hierarchical ethnic divisions are more detrimental to environmental cooperation than are non-hierarchical ethnic boundaries. In addition, I find evidence that direct reciprocal relationships may have an important role to play as a tool for enhancing cross ethnic cooperation.

ACKNOWLEDGEMENTS

This dissertation doubtless has its share of errors: conceptual, statistical and otherwise. The errors are all mine. Whatever value that is contained here, however, is the sum of a wonderful process of accumulation of thoughts, tools and support from many people and institutions. I am the beneficiary of that accumulation, and I owe this work to them.

I must first thank the farmers and villagers, schoolteachers and social workers of Vilpatti, Palangi, Poombarai, Manavanur, Kumbur, Keelanavayal and other villages in the upper Palani Hills for sharing their lives, stories and homes with me. During my time with these kind people, I was often asked what I might do for them, or for the village, in return for their time and answers to my questions. Aside from offering rides between villages, I was forced to respond that my research project included no funds for 'development.' Reaching the end of my time in Tamil Nadu, this imbalance became increasingly acute, and painful. My abstract hope is that something concrete may be extracted from my research, which may help someone, someday, but I still regret that I could not turn the research into tangible results for my research participants.

My connection to these villages was in large part the result of the hard work of my primary interpreter, guide and informant, Vetrivel Palanichamy. Vetrivel's gentle charisma and regional reputation allowed me to research difficult and sensitive topics that would have been socially impossible otherwise. I am also indebted to nearly a dozen research assistants across the three phases of this research. Carol, Kousalia, Johnson, Mahendran, and Senthil rose early for many mornings to drive through the mist and help me conduct surveys in the hot sun and monsoon rains, and Suderson, Matthew, Michael,

and Raja joined Senthil and Kousalia to help me complete the experimental games. Although not officially part of the research team, Rani Sahayarani and John Chelladurai contributed greatly to my overall success. Rani and John worked tirelessly day after day, helping our family, from gardening and repair work, to cooking and helping to raise Liam. Rani and John taught me more about India than any book or informant ever could.

It took over a year to get the necessary government permission and visa for my research, and this process would not have been possible without the facilitation of the American Institute of Indian Studies, and the commitment of Sharachchandra Lélé and the staff of the Centre for Interdisciplinary Studies in Environment and Development, then at the Institute for Social and Economic Change in Bangalore. Sharad was not only an official 'sponsor' of my research but was an important and tolerant mentor, whose critiques and insights I am still attempting to live up to. I am also grateful for the reception and support from the Centre for Agriculture and Rural Development Studies (CARDS) at Tamil Nadu Agricultural University (TNAU) in Coimbatore. CARDS directors Chandrasekaran and Palanisamy allowed my to use their mobile computer laboratory for economic experiments, and professors Uma Krishnasamy, Selvam Subramanian, and Suresh Kumar graciously accepted me as an academic peer.

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My graduate career as a whole rests heavily on the intellectual and practical investment from my advisors. On statistical matters, Mark Grote was always available for sage council on the Tao of statistics. Travis Lybbert's calm eloquence and generous spirit gave me perspective and lead to the methods collaboration with TNAU. Peter Richerson, Richard McElreath, Mark Lubell and Monique Borgerhoff Mulder have been tireless advocates and guides. It was Pete's work that first attracted me to Davis and exposed me to the formal theory of the evolution of culture. Richard's infectious enthusiasm for science and his clever insights energized me to become a better scholar, and Mark's crisp practical advice often shored me up when I didn't know which foot to put first.

Some of the people who work the hardest get the least recognition. My research has depended critically on the hard work of people like Pat Conners, Shirley Holm, Silvia Hillyer, Stephani Shone, and Nancy Louks. May they never again have to process eleven thousand dollars of reimbursements from receipts written in Tamil.

I have also learned a lot from fellow graduate students. Early in my graduate career, Brian Paciotti, Charles Efferson, Jeremy Brooks and Maggie Levin helped me form an image of graduate student life and research, as did my Biological Invasions IGERT cohort, Clare Aslan, Matthew Hufford, Jason Sexton, Becky Epanchin-Niell, and Jeff Port, whom I thank for community and companionship. In preparing for ecological anthropology research, I emulated Jeremy Brooks and Carl McCabe. With all older friends now gone, I have started learning from younger peers including Adrian Bell, Vicken Hillis, Katie Demps, Matt Zimmerman, Bret Beheim, and Ryan Baldini.

My passion for investigation comes strongly from my ever-curious parents, whose influence is ultimately most responsible for my career in science. And I thank my sister, Sarah Waring, for many spirited discussions of my theories and methods.

Finally, there is Katie, my life-long partner and wife. Katie first inspired me to move to India, and then toward graduate school. Katie is always my first sounding board, and my last editor. My academic peers would be shocked if they knew how much of the grant money that I've received is due *directly* to Katie's clear-headed proposal revisions and substantive advice. Her graceful patience is my motivation. I owe Katie my entire graduate career and academic trajectory. It has been a gift of deepest generosity.

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Chapter One

INTRODUCTION

Humans are uniquely cultural animals, yet the nature of human culture is contested in the theoretical literature. Some sociobiologists see human culture as being ultimately constrained by evolutionary forces operating on genetic factors (Lumsden and Wilson, 1981). Meanwhile, while many scholars in the humanities concede that cultural is of utmost importance, some in the humanities reject the notion that evolution can be meaningfully applied to cultural processes (Fracchia and Lewontin, 1999; 2005). Still, most academics and non-scholars alike agree that culture evolves in some fashion, and in doing so uniquely and significantly influences development of human societies, altering the trajectory of human history (Runciman, 2005; Wade, 2010). Despite a general appreciation of the importance of human culture, science is still only beginning to build and test theories of cultural evolution (Laland and Brown, 2002), and many scientists neglect the importance of endogenous cultural dynamics. For instance, Diamond's (2005) analysis of societal collapse leaves little scope for the impact of endogenous cultural factors (McElreath, 2005).

One of the most apparent types of endogenous cultural force is that of ethnicity, which might be defined as culturally circumscribed social grouping. While ethnicity is clearly powerful, it remains a force poorly understood. Scholars of ethnic conflict suggest that there is "too much knowledge, and not enough understanding" in the study of the dynamics of ethnic processes (Horrowitz, 2000). Some political scientists suggest that ethnic differences between civilizations are the primary determinant of future

conflict (Huntington, 1992). Although perhaps not incorrect, this view elides the dynamics of cultural variation within polities, and leaves little room for processes of ethnogenesis. To the contrary, the evolution of cultural and ethnic groups and their interaction within societies have a significant impact on the development, fortunes and collapses of those societies over time (Turchin, 2003; 2007).

Two primary dimensions of ethnic effects are those of ethnic diversity (number of ethnic groups) and ethnic stratification (power differences between ethnic groups). Recent theory on the evolution of both ethnic identity differences and hierarchical stratification in human populations helps to explain the long-run dynamics of human societies (McElreath et al., 2003; Henrich and Boyd, 2008). I summarize relevant theory and empirical results on the mechanisms and effects of ethnic differentiation and stratification as a means of introducing the research presented below.

Ethnic diversity has recently gained attention in the context of social and economic development. Ethnic diversity has been linked to reductions in the supply of public goods and services across a range of societies and sectors (Easterly et al., 1995; Alesina et al., 1999; Miguel and Gugerty, 2005; Habyarimana et al., 2007; Ruttan, 2006; Baland et al., 2007). One major theme of this research is the idea that that socio-cultural diversity, or 'ethno-linguistic fractionalization' damages the ability of societies to create and maintain public goods through a reduction in intra-ethnic cooperation. This matches theory in evolutionary anthropology proposing that cultural groups exist in part as a means to solve collective action problems (Richerson and Boyd, 2005), a premise which is supported by evidence on cooperation in psychology (Fiedler, 1966), anthropology (Henrich et al., 2004), and economics (Gintis et al., 2003; Ostrom, 2000). An important

aspect of this theory is the way in which cultural groups arise. Evolutionary theory (Boyd and Richerson, 1987; McElreath et al., 2003) suggests that cultural markings which begin as meaningless symbols uncorrelated with behavior may, under certain circumstances, come to be associated with real behavioral differences in a population, giving them meaning as 'ethnic markers'. Humans naturally seek cultural tags to use in distinguishing themselves and others for the purpose of choosing interaction partners. This mechanism of ethnogenesis has been demonstrated experimentally (Efferson et al., 2008). Ethnic groups, it seems, evolve as natural containers for in-group cooperation. Because of the parochial aspect of human cooperation (Bernhard et al., 2006) adding more ethnic groups decreases global cooperation, in part because altruism within groups positively coevolves with antagonism between groups (Choi and Bowles, 2007).

Ethnic stratification presents a second dimension of ethnic interaction. Ethnic stratification, hierarchy, or dominance involves a related but distinct set of sociological processes. Somit and Peterson (1997) propose that humans have a biological predisposition for psychological acceptance of hierarchy, dominance, and submission, a fact which leads to the preponderance of hierarchical societies over human history. This perspective, though not incorrect, is incomplete since it ignores the high frequency of egalitarianism within present and historical hunter-gathering societies (Corning, 2000). Corning (2005) argues instead that economic and environmental conditions can influence selection pressures on political institutions. This view matches with recent theory and data. Henrich and Boyd's (2008) theory of the coevolution of economic specialization and ethnic stratification predicts increasing ethnic stratification with increasing economic surplus. Henrich and Boyd's premise is supported by recent cross-cultural research

(Borgerhoff Mulder et al., 2009). Borgerhoff Mulder et al., (2009) found that agrarian societies harbor more wealth inequality than hunter-gather, horticultural, and many industrialized societies.

What, then, is the impact of ethnic stratification on cooperation between groups? If stratification reduces community-level cooperation, how does that reduction compare to the reduction due to non-stratified ethnic diversity? A stratified agricultural society would be best to test these questions. One such society is India.

India is one of the world's most diverse and stratified nations, providing an excellent opportunity to test the cooperative influence of both ethnic hierarchy and diversity. For millennia before Indian independence in 1947, the Indian subcontinent has been home to successive waves of kingdoms and empires. The home of four major world religious (Hinduism, Buddhism, Jainism, Sikhism), twenty-two official state languages over 400 extant languages (Lewis, 2009), and thousands of ethnic groups, India is perhaps the world's most diverse nation. In addition to socio-ethnic diversity, India is famous for its culture of caste stratification. Indian caste is a form of ethnic grouping in the most basic sense. Although the origin and history of the institution of Indian caste is much debated (Srinivas, 1957; Dumont, 1970; Appadurai, 1988;Bayly, 1999; Dirks, 2001) the existence, importance and stratified nature of Indian caste is not. Indian caste diversity boggled early colonial Europeans who, eager to find underlying social order and unity, often naively used the Hindu '*varna*' system of social classes as an accurate description of society on its own, harmonious terms (Micheals, 2004). Scholars of India agree instead that castes are more likely in competition with each other for status, wealth or rank (Srinivas, 1957).

To what extent, then, does the economic axiom that there are 'gains to specialization' (Smith, 1886) hold for economic specialization in caste stratification society? Are specialized and stratified societies more cooperative or productive? Luce (2007) presents extensive anecdotal evidence that modern caste affiliations damage cooperation and economic progress, although this effect might be due to either the ethnic diversity effect or an effect of ethnic hierarchy. Distinguishing these two effects is the central concern of this dissertation.

I conducted a three-phase research project in the southern Indian state of Tamil Nadu to investigate the cooperative effects of caste diversity, caste hierarchy, and their correlates. In the upper Palani hills, I conducted a preliminary ethnography of village life across 14 villages, followed by a household survey of irrigation, village justice and caste interactions in six villages, and concluding with a cooperative game experiment conducted in Poombarai village. Below I present three separate units of this research.

Chapter two presents a study of the influence of caste diversity and caste hierarchy on cooperation in an experimental public goods game. Using multi-model comparison techniques, I discover evidence that ethnic hierarchy is more detrimental to cooperation than ethnic diversity alone, and I argue that the anti-cooperative effect of ethnic hierarchy may be in part driving the observed cooperative reduction effect of ethnic diversity in other studies. Moreover, I discover that the cooperative differences were due almost entirely to individual expectations of peer cooperation prior to playing the game, offering important methodological and applied implications.

In chapter three I analyze survey data on irrigation practices using hierarchical regression analysis. I present evidence that in the everyday context of the traditional

irrigation system, caste diversity and hierarchy are both important predictors of cooperative failure. This result lends real-world validity to the parallel results from behavioral experiments in chapter two.

Chapter four also presents a multi-level regression analysis of survey data, but focuses on the social correlates of caste-based stratification and social diversity. I find that while ethnic diversity is linked to decreases in social justice, and to social donations between families, ethnic stratification between *jatis* limits cooperation in more dimensions, and is linked to greater ethnic exclusivity. In addition, direct reciprocity in the form of agricultural labor exchanges seems largely immune to the cooperative challenges posed by both hierarchy and diversity.

Taken together, the analyses and data presented here provide a surprisingly coherent message. Two forms of ethnic heterogeneity limit cooperation and social harmony in caste villages in Tamil Nadu. Non-hierarchical ethnic diversity reduces cooperation in social justice, village irrigation and in cooperative games. Hierarchical relationships between castes, however, limit cooperation much more than mere ethnic diversity. These findings match with evolutionary anthropological models of the evolution of ethic marking and ethnic stratification, suggesting that prior research may misattribute the cooperative impact of ethnic diversity by failing to measure ethnic stratification. Finally this research presents evidence that direct reciprocity between ethnic groups is robust to cross-ethnic cooperative failure, hinting at a tool for economic development in multi-ethnic societies.

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Chapter Two

Ethnic hierarchy limits cooperation more than ethnic diversity

Timothy M. Waring
February 2010

ABSTRACT

Ethnic diversity has been linked to reduced cooperation and diminished public goods in many regional development studies. I present behavioral evidence that ethnic hierarchy has a stronger negative effect on cooperation, and may be partially driving the observed effect of ethnic diversity. Ethnic hierarchy is naturally confounded with ethnic diversity, and measuring hierarchy is demanding and time consuming. To determine which factor poses a greater constraint on cooperation, I tested the influence of both ethnic diversity and hierarchy on cooperation using public goods experiments with caste groups in South India. I show that the cooperative effect of ethnic hierarchy is negative and larger than the negative influence of diversity. The negative effect of ethnic diversity is moderated in part by middle-caste groups not involved in the traditional hierarchical relationship between high and low caste groups. Finally, the main cooperative influence of both hierarchy and diversity comes to bear on the preliminary expectations of players. Expectations then determine the long-run trajectory of cooperation, and final cooperative outcomes. These findings have significant methodological and applied policy implications.

INTRODUCTION

These is no consensus on role of social and ethnic diversity in collective action. On the one hand, influential research in development economics shows that ethnic diversity reduces the ability of societies to cooperate. In many countries, ethnic diversity carries negative consequences for economic growth (Easterly et al., 1995) and the ability to provide public goods (Alesina et al., 1999), including public schools (Miguel and Gugerty, 2005), water and waste services, police (Habyarimana et al., 2007), and environmental management (Ruttan, 2006; Baland et al., 2007). With the exception of Habyarimana et al. (2007), these studies use census and survey data to reveal negative correlations between diversity and cooperation on the regional level. This contrasts with research in community-based natural resource management, which suggests that social heterogeneity is not a strong barrier to collective action on the community level (Poteete and Ostrom, 2004; Varughese and Ostrom, 2001; Somanathan et al., 2007). This causes confusion for ethnically diverse nations working towards social and economic development - should they expect to spend more in diverse areas to achieve cooperative development goals, or not? More precisely, if ethnic diversity does damage cooperation, how should development programs be tailored to the, as yet undetermined, behavioral mechanisms that retard cooperation in ethnically diverse settings?

Collier (2001) argues that the more damaging social force is not ethnic diversity, but ethnic dominance. He argues that measures of cooperation under ethnic diversity have in fact measured the effect of power relations between ethnic groups rather than simple ethnic differences. No study has compared the cooperative effects of ethnic dominance

and diversity, in part because prior studies have not measured any potentially confounding ethnic dominance.

Indian society contains both significant ethnic diversity and social hierarchy, presenting a unique opportunity to address the relative influence of each force. Caste has been targeted as a hurdle to development, both in terms of economic efficiency and social justice (Lal, 2005; Tharoor, 2007; Luce, 2007). Lal 2005 argues that caste causes cooperation problems, collective action failures, and an undersupply of public goods, hampering social and economic development. Dumont 1970 described caste as a primarily hierarchical institution, suggesting that collective action failures arise from some form of hierarchical inefficiency. Other scholars have portrayed caste variation more as a form of diversity (Srinivas, 1962), seeming to favor the ethnic diversity hypothesis (e.g. Alesina et al., 2003), which states that ethnic diversity creates social boundaries between groups that prevent the establishment of shared identities, norms, networks, and trust, ultimately limiting inter-group cooperation.

While Indian caste, a central institution of social hierarchy in India, is not traditionally equated with ethnicity, I argue that caste is an ethnic phenomenon. Commonly caste is not considered equivalent to ethnicity because ethnicity involves divisions of language and religion, while many caste divisions are within regions in which language and religion are nearly homogenous. But this simple definition misses the important point - ethnicity is not a static fact but a dynamic psychological and cultural force. Ethnicity is a multilevel phenomenon. The cognitive forces of ethnic psychology do not disappear when deprived of salient distinctions, such as skin color. Individuals construct their social or ethnic identity in relation to those around them, and the resulting social groups, coevolve with each other, on any level. Thus, while Indian caste differences may not be religious, linguistic, or regional

in scope, they are ethnic categories because they are salient, they determine behavior (i.e. marriage), and they define social identity.

In practice caste is very complex, with regional groups overlapping many local groups with deep divisions in social identity. These endogamous groups (or *jatis*) have distinct traditions in domains ranging from deity worship and profession to marriage, food and home. Srinivas (1962) argues that mutual ranking is indeterminate for many caste groups, and only the few most powerful and most oppressed groups are clearly 'ranked'. Thus it may be identity that distinguishes rather than rank and ethnic diversity may be a more powerful force than hierarchy in daily life. However, although a linear ranking is not possible, power differentials between caste groups are extremely important. Inequalities are omnipresent between particular castes, as can be seen in both the ubiquitous and outright oppression of Dalits (Mangubhai and Irudayam, 2000) and in the attempts of some castes to change their collective status (Srinivas, 1957; Charsley, 1998; Luce, 2007). Strong power inequalities may explain why caste has proven to be so resilient to the leveling forces of a market economy (Scoville, 1996; Luce, 2007). Thus both forces seem powerful within Indian society, and without clear behavioral evidence, it is hard to assess which is the larger barrier to cooperative development. In this regard a more realistic model of caste dynamics may be that of Henrich & Boyd, (2008), which demonstrate that ethnic groupings and hierarchical inequality are mutually reinforcing.

The current study uses a combination of ethnographic research and experimental economic games to compare the cooperative effects of diversity and hierarchy a rural agricultural village of the Palani Hills of Tamil Nadu.

STUDY SITES

The middle and upper Palani Hills of Tamil Nadu are home to 20 agricultural villages varying in size from 500 to 6000 people distributed among 3 to 13 caste groups. These villages, originally settled by the Manadiar group, retain traditional governance institutions separate from the official government panchayat system. The similarity of these institutions to those on the Tamil plains (Mosse, 2006), oral tradition, and historical evidence (Francis, 1914; Bahadur and Aiyangar, 1942) all suggest that they are a cultural legacy of the *Pandiya* kingdom that the Manadiar brought with them when they first migrated into the hills approximately six centuries ago (Francis, 1914).

Five months of ethnographic investigation on the social identity, oral history and village organization across the Upper Palani villages form the basis by which caste relationships were classified.

Caste hierarchy in the Palani Hills region is centered on two focal caste groups at opposite ends of the power spectrum, which share a long history (Figure 1). The Manadiar caste are in the center of village power; in most villages the Manadiar hold some or all of the hereditary leadership positions called *thalaivarhal* (literally, 'headmen'), and their influence within the village justice system or *podhu kootam* ('common crowd'). By contrast, the Sakkliyar, a Dalit group which shares a deep history with the Manadiar, having arrived around the same time as the Manadair, have no formal power. For instance, women and Sakkliyar individuals are excluded from the semi-sacred village commons called the *manthai* where village meetings are held, and thereby physically blocking access to the space of village justice.

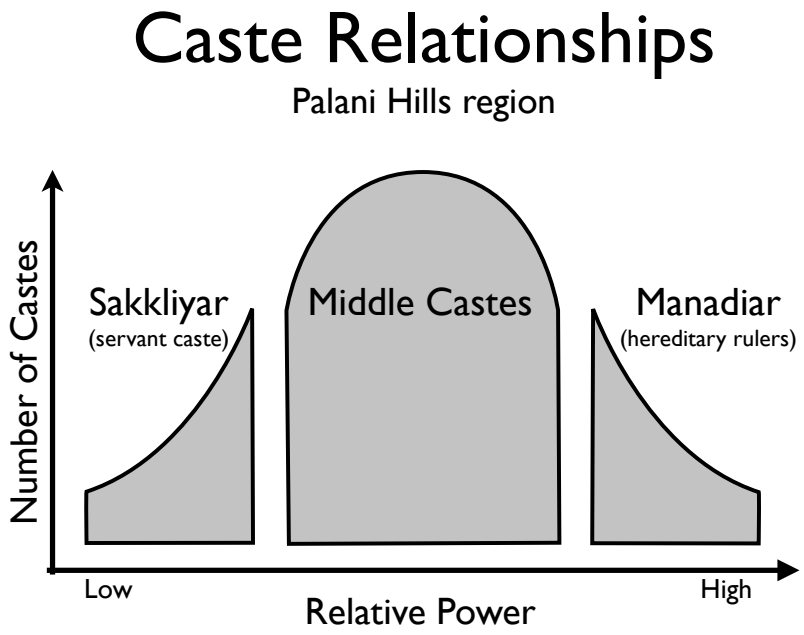

Figure 1: The Manadiar hold special traditional, political and often economic power. The Sakkliyar are collectively subjugated by all caste groups. Most other caste groups in the Palani Hills have no significant or traditional power status. See supporting material for ethnographic details.

In Palani Hills villages the first *thalaivar* position is called the *Manadiar* and in Poombari it is occupied eponymously, while two further headman positions are occupied by the Thevar (*Periyathanam*) and the Mudhaliar (*Manthiriar*) elders. The Sakkliyar also bear traditional village servant positions, including the village crier (*thandalkarar*), the water controller (*neer-nikum*), and the festival celebrant (*vettiyan*). No middle castes hold any high-status or low-status traditional roles. These formal roles betray the historical caste-driven power asymmetry, and are summarized in Figure 2.

Just as the oppression of Dalit groups is common in much of Tamil society (Mangubhai and Irudayam, 2000), the life of the Sakkliyar is one of subjugation in all aspects of village life, social and economic, informal and institutionalized (Waring, forthcoming). The hierarchical relationship between the Manadiar and the Sakkliyar is an ancient and central

aspect of caste relations in the Palani Hills.

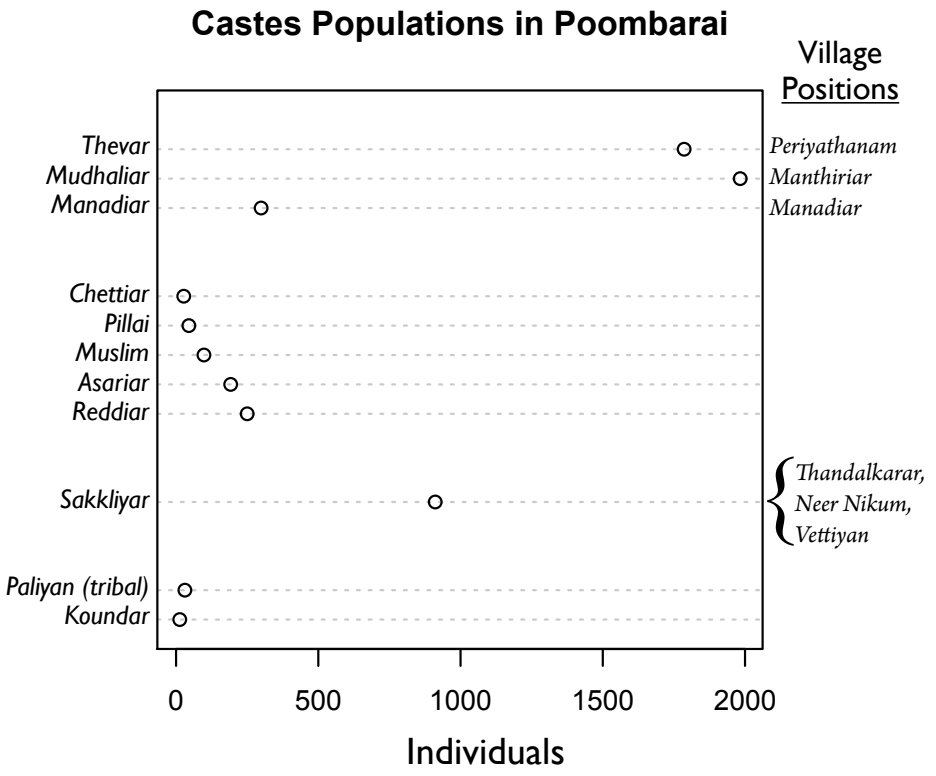

Figure 2: Aside from the Manadiar, the two most populous castes are also classified here as 'High' because of their excess power within the village. Source: Poombarai Panchayat Clerk Population Estimates, 11/19/2007; Census of India, 2001

As new caste communities have settled in these villages they have rarely come to occupy any of the traditional village positions or roles. As a result these newer communities are neither ruling or ruled. In terms of relative power, newer castes mostly fall in a third category, outside of the traditional Manadiar/Sakkliyar hierarchy - not as powerful as the Manadiar, and severely oppressed as the Sakkliyar. I refer to these castes as 'middle' castes, since on the one hand they are allowed to represent themselves in the *podhu kootam* and sometimes even hold *thalaivar* positions, but on the other, they do not seek the traditional positions or status of the Sakkliyar. It should be stressed that it is not that the middle castes have not power relationship, but rather that any power relationships they do have is

dwarfed by the established hierarchy in this area. All non-Sakkliyar households deny the Sakkliyar many respects that they frequently pay to other castes. The most common of these power-boundaries are the threshold (Sakkliyar are forbidden to enter non-Sakkliyar houses) and the meal (Sakkliyar are forbidden to share food with non-Sakkliyar people). Thus, the Sakkliyar are exposed, without exception, to a sort of collective subjugation by all other groups, a fact which has massive impacts on their quality of life.

The village chosen for this study was Poombarai, a village of 6000 persons and 13 castes. For the purpose of these experimental games, the caste groups in Poombarai were grouped as follows: 'high' castes: Manadiar, Mudhaliar, and Thevar[1], 'middle' castes: Reddiar, Asariar, Muslim, Pillai, Chettiar and Naidu, scheduled caste: Sakkliyar. These three categories are referred to here as caste *strata*.

EXPERIMENTAL ANTHROPOLOGY

Experimental games have recently been adopted in anthropology to illustrate how cultural differences control economic behavior (Henrich et al., 2004), and experimental research on social cues (Cronk, 2007) and group membership cues (Paciotti & Hadley, 2003; Gil-White in Foundations, 2004) have demonstrated that game methodology is responsive to social stimuli. In one of the only experimental economic investigations of Indian caste, Hoff and Pandey (2005) demonstrated that the expectation of fair treatment is damaged by the salience of caste cues in a social situation. When caste membership was publicly announced, subjects from the lower caste decreased their performance (by 42%) in expec-

[1]The Mudhaliar and Thevar are demographically dominant groups within Poombarai, and hold Thalaivar positions, wealth and land. In addition the Thevar are the are renown throughout the Palani Hills and beyond for a violent demeanor, and are often given a wide latitude.

tation of prejudicial treatment. However, in the same situation when caste was not made salient, the performance difference between castes disappeared. While Hoff and Pandey (2005) tested the influence of caste cues on individual action, I used experiments to test the nature of sharing within and between castes in a social setting.

To test the relative influence of hierarchy and diversity on cooperation within a caste village, experimental games offer two distinct advantages over alternative methods. First, because experimental games present a controlled realm of social interaction to which participants bring their own expectations and habits, games research is well suited to comparison between groups, locations and cultures (Henrich et al. 2005). Second, the structured and repeatable nature of experimental games allow social scientists to test the influence of various factors on game outcomes with simple manipulations. Moreover, a majority of the literature on cooperation has used experimental games because they so directly address the questions posed by game theory.

COOPERATIVE IRRIGATION

The traditional village irrigation system is a highly cooperative enterprise, and it bears significant resemblance to other irrigation systems in the Ramnad and Sivaganga regions of Tamil Nadu (Mosse, 2006). In the Palani Hills, this irrigation system is a formal part of the village council. In Poombarai, the *thalaivarhal* will convene *pothu kootam* meetings several times a year for village business, including the organization village-wide work days for maintaining the irrigation channels and ponds. In Poombarai *thalaivarhal* also select four *neer-nikum*, who oversee the distribution of irrigation water during the dry season from January to May. Each farmer pays the *neer-nikum* a small per-acre price for the water

they receive, and the *neer-nikum* only releases water when the village storage pond is full. Farmers receive water for their fields in rotation with varying frequency depending on the amount of water available in the village.

EXPERIMENTAL METHODS

I used public goods experiments to test the relative influence of hierarchy and diversity on cooperation. Treatment conditions of social dominance (hierarchy) and social difference (diversity) were constructed using combinations of participants from the scheduled, middle, and high castes (See Figure 3).

Experiments were conducted from October to December 2008 with volunteers in Poombarai, a hill village of 5000 people and 13 caste communities. Poombarai is an exemplary village for this sort of research, as it retains most of the traditional features of village organization, but is very caste-rich and populous, making continued sampling a possibility. Games were held in a community center building, and conducted via the GameWeb experimental game engine[2]. GameWeb was deployed using a mobile computer laboratory which connected 12 handheld client devices via wireless network to a laptop running the GameWeb server software[3]. Participants were invited to play the game immediately before the game commenced. Only male farmers of twenty or older were invited because they are considered primarily responsible for matters of irrigation. Individual players were separated from each other on three sides by 4ft wooden barriers to ensure privacy, and players signaled contributions using their fingers to guarantee that contributions were confidential.

[2]GameWeb is an open source web-based platform for experimental games research, and can be found at http://sourceforge.net/projects/gameweb/.

[3]This hardware is the property of a UCDavis-TNAU collaborative research program in experimental eco-

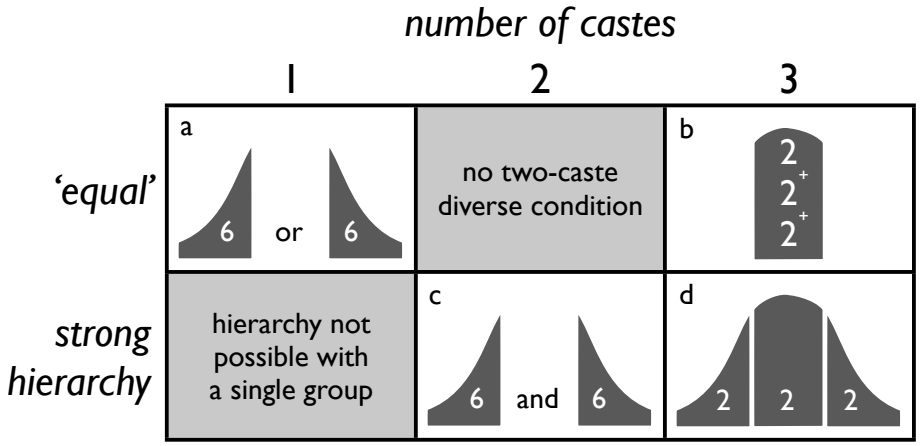

Figure 3: Treatment Conditions in the public goods game, compare with Figure 1. Treatments were composed as follows: (a) games consisted of either 6 high or 6 low caste players, (b) 2 of each of 3 middle castes, (c) 3 low and 3 high caste players, and (d) 2 low, 2 high, 2 middle caste players. Power relations between the middle castes were minor in comparison to the high/low caste relationship.

The experiment was conducted in a very orderly fashion to avoid, as much as possible, opportunities for participants to converse or influence each other before playing. Prior to the game, individuals from the desired caste groups were invited from the village at large, individually, and allowed to wait in their separate booths, and asked to wait quietly. Once all participants has arrived, the game was explained in detail in Tamil to the group. The game was framed within the irrigation context, as a means of tethering behavior to a real-world cooperative scenario and the mechanics of the public goods mechanism carefully explained. Each game session then proceeded to a series of test questions requiring calculations designed to test the understandings of the game mechanics. Next came a 4 round practice game, after which the castes playing were announced, and participants then played a 10 round paid game, and a post-game questionnaire.

nomics.

Games were played with 6 participants, selected from different castes. Two games of 6 participants would be conducted simultaneously, with each of 6 assistants helping two players engaged in separate games. Players were arranged such that they never sat next to someone in the same game. Research assistants would answer questions and used the handhelds to enter the participant's choices and read them the results after each round. The results included the all economic information (contribution, share, income and earnings) by caste, but no individual information was provided. This intentional transparency mimics the lack of anonymity within village society. This transparency is balanced because although all 12 participants saw each other before the game, they could not know which 5 of their 11 peers they would finally play with. During each of the 10 rounds of the paid game, each player recieved an endowment of 10 Rs. from which they could contribute to the public 'irrigation fund.' The contributions were doubled and divided evenly among all six players, and their earnings (savings + share) were carried into the next round. When the session was complete participants were re-sorted into game groups, introduced to their fellow players, and given a post-game questionnaire including measures of relatedness and familiarity with fellow players and prior knowledge of the game through village rumor. Finally, players were thanked and paid their final earnings, which averaged 129 Rs., equivalent to a day's wage. Games lasted approximately 1 hour.

CONTROL VARIABLES

The games were conducted in an isolated village with an lively oral tradition and an active rumor mill. In addition, players were rewarded a days wage, on average, for an hour or less of their time. News of the game spread quickly to players who had not yet played.

As time progressed it became increasingly common that new players would enter the game with pre-conceived strategy they had acquired from other villagers. The last four sessions were discarded due to the overwhelming evidence of rumor - at the very end individuals villagers knew enough about the research to arrive unbidden at the community center in caste groups of four just as the previous experiment was concluding. Figure 4 shows the increasing knowledge of the game among incoming villagers over time. The remaining data contains 7 games of six players in each of the four treatments (Homogenous, Hierarchical, Diverse and Both).

In addition, players were also asked if they had heard about the game prior to playing, and if so, if they were told how to play. The two measures of rumor were highly positively correlated, with 40% and 17% reporting that they had heard or been told how to play, respectively. These rumor variables serve as a statistical control for the larger social learning trend.

Prior to playing, individuals took a test questionnaire on the game mechanics. Players had to correctly answer 15 questions involving game mechanics and calculations before they proceeded, and the number of mistakes each individual made was recorded. The mean number of mistakes was 1.17, and 8 individuals with more than 20 mistakes were excluded from the analysis. Age of participants ranged from 20 to 90. After the game, each player was asked how may players they knew personally, and to specify any geneological relationships they had with fellow players. Players knew each other very well, reporting on average that they knew 85% (4.24) of the five other players in their game. Average reports of relatedness varied between caste groups, as seen clearly in figure 5.

Although it may be a safe assumption that relatedness follows caste boundaries, the

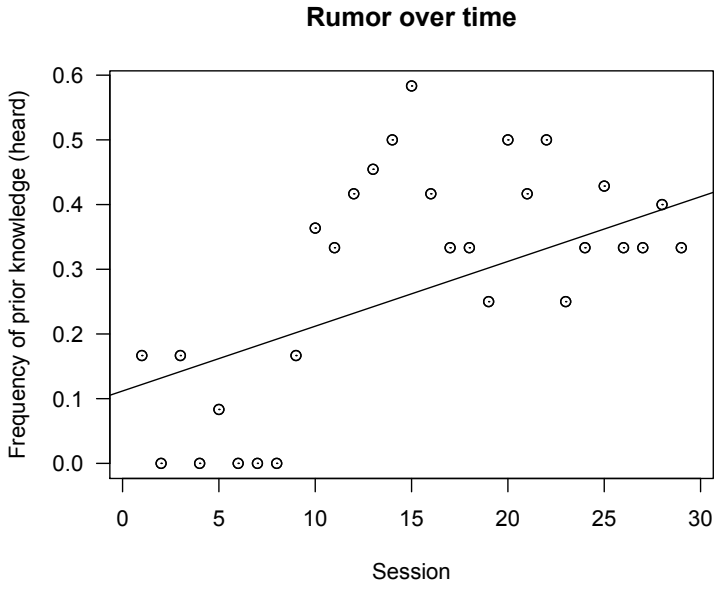

Figure 4: As measured by the question 'Have you heard about this game prior to playing today?' prior knowledge of the game increased over time as the experiment continued and rumor spread within the village.

only consistent comparisons in relatedness are between caste groups which played homogenous games, which were three high castes (Manadiar, Mudhaliar, and Thevar) and the scheduled caste (Sakkliar). The Manadiar are the most inter-related (mean Relatedness = 0.074, i.e. closer than a great great grandparent), and are the only group that is statistically distinguishable by relatedness from all other groups in a Tukey's HSD.

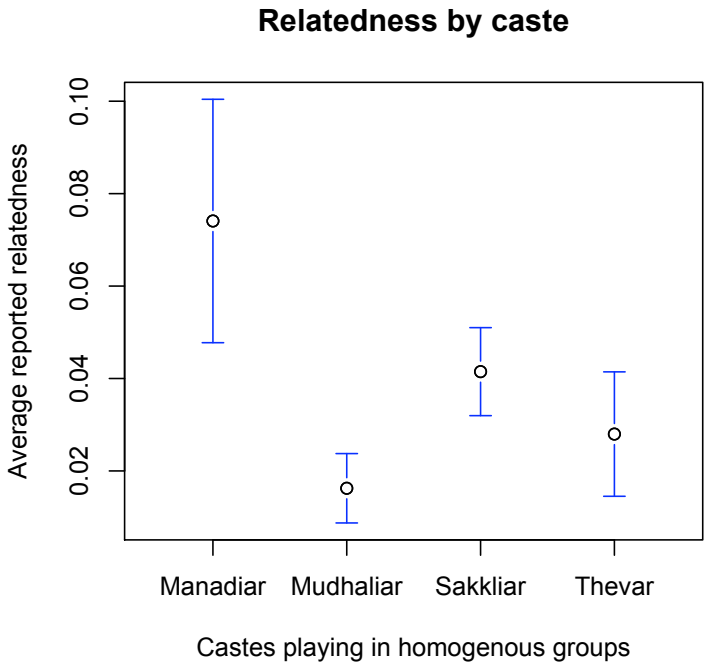

Figure 5: Mean self-reported relatedness to fellow players in castes who played in the homogenous treatment. Scale equivalent to Hamilton's r. 95% Confidence Intervals.

RESULTS

Cooperative behavior in the games is analyzed in three components: total cooperative outcomes, initial cooperation, and subsequent learning trajectories. Figure 6 displays the data trends from all four treatments, revealing a common signature from the experimental literature on cooperation. Without effective mechanisms to stabilize cooperation (Fehr and Gächter, 2000; Fehr and Gachter, 2002), contributions decline with time, as many public goods studies have shown (Fischbacher et al., 2001; Zelmer, 2003).

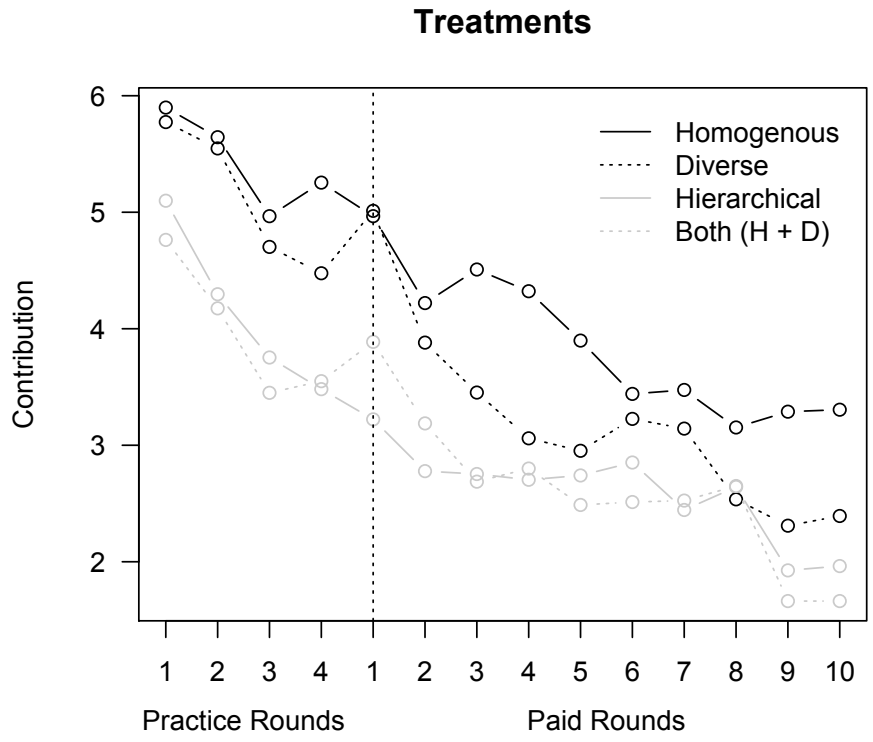

Figure 6: Contribution trajectories by treatment. N = 4256 choices (304 individuals x 14 rounds)

The total cooperative output of a social group is a fundamental means of comparison and competition between social groups, an ultimate measure of success, and a natural first analysis. Binomial models of the total contributions over the entire paid game, C_{total}, cal-

culate the probability of contributing another Indian Rupee (Rs.) out of a maximum total contribution of 100 Rs. (10 Rs. in 10 rounds).

Total Contributions

	Estimate	Std. Error	z value	Pr($>\|z\|$)
(Intercept)	-0.26	(0.09)	-2.77	0.0057
Relatedness	3.42	(0.30)	11.24	<2.0e-16
Prior Knowledge	-0.33	(0.03)	-11.21	<2.0e-16
Familiarity	-0.04	(0.01)	-5.57	2.6e-08
Hierarchy	-0.24	(0.04)	-6.88	6.0e-12
Number of Castes	-0.20	(0.05)	-3.63	0.0003
Middle Castes	0.25	(0.08)	3.03	0.0024

Table 1: Binomial regression of C_{total} in Indian Rupees (INR) on treatment and control variables. N = 432 individuals.

Participants contributed more when they were more related to fellow players, and less when they had prior knowledge of the game through village rumor. Both hierarchy and the number of castes strongly predict decreased total contributions, of roughly the same magnitude. Thus hierarchy is *at least as damaging* to cooperation as diversity, perhaps more so. When the treatment variable "caste diversity," a combination of the number of castes and middle caste variables, included directly in the regression, its estimated is -0.04 (SE=0.02, z=-2.33, p=0.02). However ethnographic results suggest that accounting for the cooperative effect the middle castes is important, because of their role outside of the main hierarchical relationship in the village. Doing so reveals that the presence of middle castes has a strongly positive influence on cooperation. Thus, in terms of total cooperation over the entire game, who you play with matters. The relevant behavioral question is now: where do these three social effects originate?

LEARNING TRAJECTORIES

One potential origin of these social effects (hierarchy, diversity and the middle-caste effect) is in the round-by-round decisions individuals make in the game. After initial contributions are made, ongoing behavior in the game is influenced by economic feedback from other players, and by any social factors that remain salient to players in each successive interaction. Here, the relevant hypotheses are iterative: "Do any social factors influence round-by-round decisions in the cooperative game, and if so, which ones?" Since individuals' contributions through time are not independent measures of cooperation, I calculate C_{norm}, the change in each player's contribution normalized to their initial contribution, C_{init}, to insure that initial expectations are not confounding true learning dynamics. Normalized contributions are

$$C_{norm} = \begin{cases} C_t/0.1 & \text{if } C_{init} = 0, \\ C_t/C_{init} & \text{if } C_{init} > 0. \end{cases}$$

where C_t is the contribution at time t. In addition, I calculate the deviation of each players previous contribution from the previous average of other players contributions. This Lagged Deviation (LagDev) captures the behavioral reinforcement effect, or learning, from the previous round. Linear models with random individual intercepts were used model natural variation in prosociality since other models are not possible with negative values of C_{norm}.

Since different combinations of these variables represent different *a priori* hypotheses

Iterative cooperation summary

		Model Weighted Estimates	Relative Variable Importance
Control Variables	LagDev	-0.25	1.00
	Prior Knowledge	-0.24	1.00
	Related	2.18	1.00
	PriorKnowl*Related	0.19	1.00
Treatment Variables	Hierarchy	0.01	0.10
	Number of Castes	0.00	0.06
	Middle	-0.01	0.12
	Stratum	0.01	0.07
Interactions	LagDev*Hier	0.00	0.00
	LagDev*Middle	0.00	0.01
	LagDev*DivMeas	0.00	0.00

Table 2: Linear models with random individual effects. AIC multi-model inference, model weighted estimates and relative variable importance, Burnham & Anderson (1998, page 168). See 6 in Appendix for full AIC table.

about the data, I use Akaike's Information Criterion (AIC) model comparison and inference techniques (Burnham & Anderson, 1998; 2001), to select models that are both parsimonious and predictive. First, combinations of all control variables were ranked using AIC, and those variables which increased the AIC (increased the predictive power more than it sacrificed in degrees of freedom) were included in the base model. In this analysis, these were the effect of rumor (prior knowledge), relatedness, their interaction, and learning term, LagDev. All four treatment variables, were included, as were their interactions with LagDev. See Table 6 for the full AIC model ranking.

As Table 2 summarizes, while relatedness and rumor have strong influences on round-by-round behavior, the treatment variables themselves (Hierarchy, Diversity, Number of Castes, Stratum) have only very weak effects, and the top ranked model includes no treatment variables. Social composition, it appears, is simply unimportant in predicting ongoing decisions in the public goods game. Instead, economic feedback, rumor and relatedness best explain cooperative behavior (see Table 6). The cooperative effects of social composi-

tion must be entering in a different way.

INITIAL COOPERATION

Initial contributions are a pure measurement of the expectations of cooperation by other players. Initial contributions have no precedent behavior, save any similarity to real life situations and the salient aspects of the experimental setting. Caste composition of each game was made salient with an announcement before the start of each paid game.

AIC model comparisons where conducted with binomial models, which are implemented upon the conditional probability of an additional Rupee (Rs.) contribution, ranging from 0 to 10. Binomial models provide a more accurate representation of the decision process than linear models, included for reference. As in the iterative analysis, AIC rankings were used to determine the strongest combination of control variables, which then formed the base model. These were player age, prior knowledge of the game, number of fellow players known, average relatedness to fellow players, and the interaction of the related and prior knowledge variables.

Relatedness to fellow players increased and prior knowledge decreased contributions. Age and 'known' had weak positive effects on initial contributions. The interaction between the relatedness and rumor variables was also strongly positive, showing that when individuals had prior knowledge of the game and were closely related to fellow players they were more cooperative than otherwise expected. This suggests a nepotistic behavior which inclines individuals to share more with relatives when they learned about the game via rumor[4].

[4]The strength and sign of this interaction indicates not just a nepotistic effect, but also reveals that players are aware of the nature of the game in a way that allows them to exploit it for the benefit of their relatives.

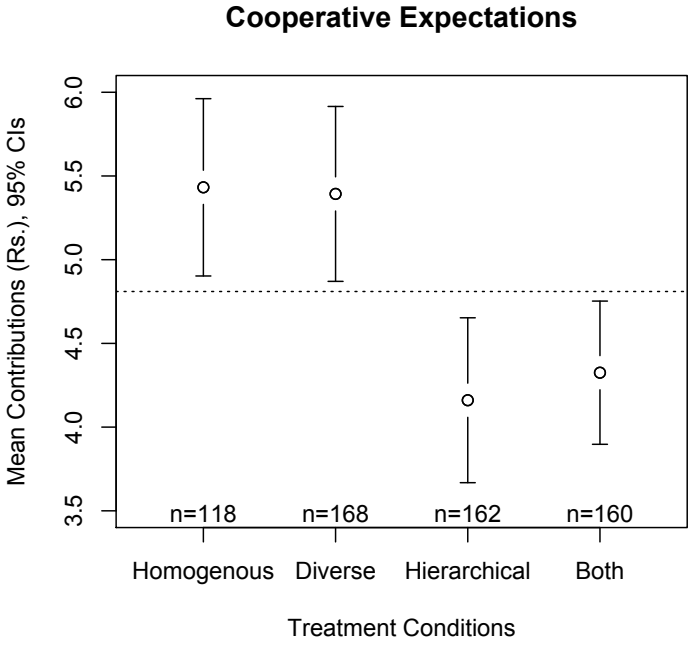

Figure 7: Initial contributions from Round 1 (paid and practice games) show a strong negative effect of hierarchy, and no effect of diversity. 95% linear confidence intervals.

Estimates of treatment effects were proportional across model families despite the fundamental differences in model structure (Table 3), yet contingent upon the variables included in a given model. There are two components to diversity, the number of castes, and the middle castes, who were included as a means of operationalizing diversity within the ethnographic context. When these two variables are not disentangled, the effect of the diversity treatment is weakly negative, but when the two variables are included separately the '# Castes' estimates show that more castes decrease initial contributions, while the presence of middle castes had a consistently positive effect. This seems to be an result of the fact that the middle castes are in many important ways external to the negative and hierarchical relationship between high and low castes evidenced in the ethnographic investigation. Thus

This is a strong confirmation that individuals understand the game mechanics.

the real effect of diversity is negative.

Stratum estimates and model-weighted averages show that stratum is a neutral or variable (Table 3). However, the consistently negative hierarchy/stratum interaction (Hier*Strat) estimates reveal that hierarchy damages cooperation through diminished high caste cooperation. The hierarchy variable itself is negative when the Hier*Strat variable is not included, revealing that the reduced cooperation of the high castes is the determining factor in reduced cooperation in hierarchical circumstances.

Cooperative expectations: multi-model estimates

		Linear		Binomial	
		Weighted Averages	Variable Importance	Weighted Averages	Variable Importance
Control Variables	(Intercept)	2.30	1.00	-0.42	1.00
	related	5.98	1.00	2.37	1.00
	rumor	-0.77	1.00	-0.34	1.00
	age	0.04	1.00	0.02	1.00
	known	0.14	1.00	0.05	1.00
	relat*rumor	9.39	1.00	3.99	1.00
Treatment Variables	Hierarchy	0.52	1.00	1.05	1.00
	Middle	0.98	0.68	0.92	1.00
	nCastes	-0.62	0.56	-0.94	1.00
	Stratum	0.17	0.66	-0.08	1.00
	Hier*Strat	-0.60	0.61	-0.55	1.00
	Castes*Strat	0.10	0.20	0.20	0.97

Table 3: MWA = Model weighted average coefficients, RVI = Relative Variable Importance.

Finally, when the Hier*Strat variable is included, the main effect hierarchy becomes positive. This occurs because, in the complete data set, the presence of middle castes is confounded with Hierarchy (see Treatment structure, Figure 3, Diverse-Hierarchical condition). This can be modeled by including the Hier*Middle interaction. Since the top-ranked models are saturated, I instead present the effect in a comparison between models with and without the Hier*Middle interaction (Figure 5). The Hier*Middle interaction

is the effect the Middle castes have on the cooperation of Sakkliyar and High castes in the Diverse-Hierarchical condition. Figure 5's comparison shows that the Hier*Middle interaction does indeed reduce the estimates of both Hierarchy and Middle precipitously. Moreover, including the Hier*Middle interaction increases the estimate of the high caste role in the cooperative failure of hierarchy found in the Hier*Stratum variable.

Top Round 1 Linear Model

	estimate (S.E.)	t	Pr($>|t|$)
(Intercept)	4.01 (1.67)	2.41	0.017
known	0.12 (0.10)	1.28	0.201
age	0.04 (0.01)	3.78	0.000
aveR	5.69 (4.65)	1.22	0.223
heard	-0.77 (0.46)	-1.66	0.097
aveR:heard	9.09 (8.14)	1.12	0.265
Hier	2.52 (1.23)	2.05	0.041
Div	2.11 (1.07)	1.98	0.049
DivMeas	-2.21 (1.00)	-2.22	0.027
Stratum	-0.18 (0.55)	-0.33	0.741
Hier:Stratum	-1.32 (0.48)	-2.79	0.006
DivMeas:Stratum	0.49 (0.29)	1.67	0.096

Table 4: The top ranked linear model for round 1 analysis.

	No Interaction				**Hier*Mid Interaction**			
	beta	S.E.	t	Pr($>|t|$)	beta	S.E.	t	Pr($>|t|$)
Hierarchy	0.67	0.91	0.74	0.462	0.36	0.93	0.38	0.702
Stratum	0.45	0.32	1.42	0.158	0.56	0.33	1.73	0.085
Hier*Stratum	-0.75	0.39	-1.91	0.057	-0.90	0.40	-2.24	0.026
Middle	0.52	0.36	1.47	0.142	-0.15	0.58	-0.25	0.800
Hier*Middle	.	.	.	.	1.08	0.73	1.47	0.142
	F = 5.192 on 9 and 289 DF				F = 4.909 on 10 and 288 DF			
	p = 1.516e-06				p = 1.466e-06			
	Multiple R^2: 0.1392				Multiple R^2: 0.1456			

Table 5: Comparison of linear models with and without the Hier*Middle interaction (control variables not displayed). When the interaction is included, the estimate of the main effects of Hierarchy and Middle both drop, while the estimate of the high caste role in the cooperative failure of hierarchy found in the Hier*Stratum variable grows.

It is important to note the effect that players from the 'Middle' category are creating. 'Middle' caste players were only included in the Diverse and Both treatments, and their initial contributions do not change between the two. However, in comparison to the hierarchical treatment, the addition of Middle castes in the Both treatment increases the initial contributions of both the Sakkliyar and the High castes, suggesting that both Sakkliyar and High castes expect a more cooperative situation when the middle castes are present.

DISCUSSION

In summary, social factors influenced play in a public goods game framed around the traditional cooperative community-based resource of irrigation water management, even taking control variables into account. The two most influential control variables, prior knowledge and relatedness, had strong negative and positive effects on contributions, respectively.

Both caste diversity and caste hierarchy reduce cooperative behavior, but the effect of hierarchy is stronger. In comparison to single-caste games, both high and low caste cooperation dropped in hierarchical games, although the high castes reduced their cooperation much more. This can either be explained as the high castes decreasing cooperation to meet that of the low castes, or, more plausibly, as the original force in response to which the low cooperative levels of the low-caste evolved. There is not as clear a case for the limitation of caste diversity as there is for caste hierarchy. This is because on the one hand an increasing number of castes has a negative cooperative effect, the addition of middle castes, the (the only operationally diverse group) has a positive cooperative effect. And, since high and low castes increase their initial cooperation when playing with middle castes in comparison to playing only with each other, it appears that interaction with groups somewhat external to

the hierarchical relationship improves hopes for a cooperative outcome. All indications, therefore, suggest that in terms of cooperation, hierarchy is a larger problem. This result highlights the importance of ethnographic research in the use of experimental games. Individual interactions between ethnic groups matter, and without detailed knowledge of those interactions the hierarchy measured here could be confounded with ethnic diversity.

Hierarchy (the combination of low and high castes as defined in the Methods section) and diversity (the number of castes) influenced overall levels of cooperation. However neither force influenced ongoing behavior within each round, while economic feedback, relatedness and rumor did. Instead treatment conditions influenced the expectations of cooperation in the very beginning of each game. These expectations set the initial levels of cooperation upon which all succeeding play was based. Thus initial expectations established a cooperative momentum which ultimately determined the cooperative fate of each group, and initial expectations were influenced by both ethnic hierarchy and diversity.

These results demonstrate that the effects of social composition (caste hierarchy and diversity), though apparent in the overall cooperative outcomes, originate exclusively in the initial cooperative behavior, not during subsequent interactions in which economic momentum takes over. This means that social effects are important in determining the cooperative outcomes, and the provision of public goods, but that their influence may be difficult to detect, since on the behavioral level, it occurs *before* the institutions commence.

CONCLUSION

The major conclusion is that socio-ethnic hierarchy, as a determinant of economic cooperation in the production of public goods is *at least as damaging* as ethnic diversity. This

throws the interpretation of recent regional economic research (Easterly et al., 1995; Miguel and Gugerty, 2005; Habyarimana et al., 2007) into question. Since those studies had no means of measuring hierarchical interactions between individual groups, social hierarchy did not enter in their analyses, and therefore these studies might overestimate the negative influence of ethnic diversity because they confound it with the potentially stronger effect of social hierarchy. At least on the behavioral level, that Collier (2001) was correct. India is a very hierarchical society, however, thus the influence of hierarchy elsewhere may be reduced in comparison. Nonetheless given the potential for cooperative damage, hierarchy as a cooperative retardant must be take seriously. Regional analyses therefore need to be reconsidered with hierarchy in mind. And while time-intensive, I suggest the use of ethnography as a primary tool in the assessment of socio-ethnic hierarchy.

On the other hand the results support the conclusions of the economic development literature, and lends behavioral evidence to the assertion that ethnic diversity does, in the end, reduce cooperation and the provision of public goods. Since ethnic diversity seems to be a negative effect on regional and behavioral scales, this calls into question the conclusions of the community-based natural resource management literature (Poteete and Ostrom, 2004; Varughese and Ostrom, 2001; Somanathan et al., 2007) which has so far failed to find a strong influence of social diversity. This lack of effect could, however, be due to the difficulty of working at the community scale. However, that may be changing. A new case study from India supports these experimental results, showing caste diversity has a negative effect on community resource management, although it too fails to measure caste hierarchy (Naidu, 2009).

The present emphasis on hierarchy is echoed in another study of the influence of social

dynamics (particularly Indian caste) on economic behavior. Hoff & Pandey (2006) demonstrate that the making caste membership salient dramatically diminishes the ability of low castes to perform simple tasks. The authors argue that low caste individuals suffer a blow to self esteem when caste membership is made public. My research supports this result and adds a new cooperative wrinkle: low and high castes both reduce economic cooperation when placed together, while groups outside the hierarchical relationship (middle castes) enhance cooperation.

This study has important applied and methodological implications. Methodologically, if the expectations of cooperation are as formative in other contexts as they were here, then the learning-force model of social influences on cooperation may be ruled out, and the multi-round public goods game replaced with lightweight experiments designed to measure expectations alone. In an applied vein, these results suggest something much more significant: until and unless social expectations for cooperative institutions can be changed, the results will continue to be controlled by social and ethnic factors. The implications for economic and social development are sweeping, suggesting that in addition to the focus on the mechanisms of maintaining economic cooperation, there is an entire second realm of behavior that needs addressing - expectations.

Finally, these data suggest that, in addition to the importance of intergenerational wealth transmission in contributing to persistent inequality in agricultural societies (Mulder et al., 2009), ethnic psychology may be a potent force in skewing the distribution of wealth. More precisely, the forces of social learning and ethnic differentiation may coevolve with unequal sharing of agricultural gains (Henrich and Boyd, 2008) leading to highly stratified hierarchical societies, in which cooperation in the public sphere is markedly diminished.

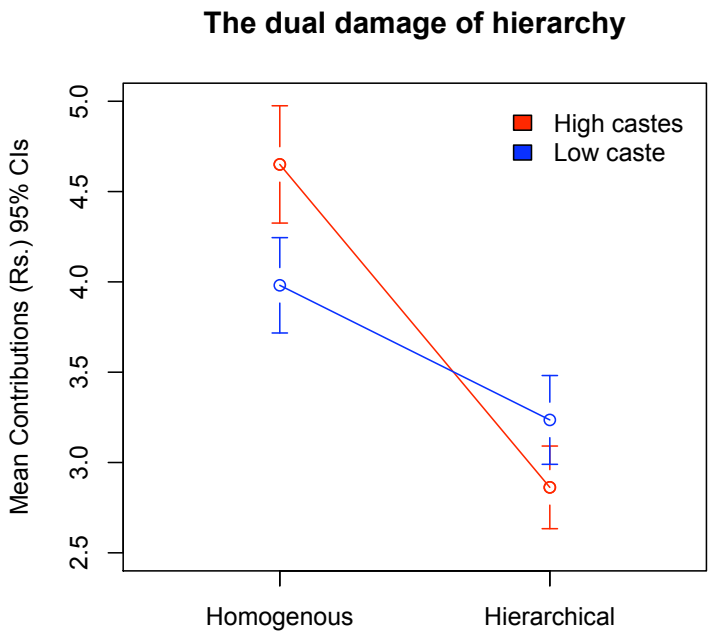

Figure 8: Contribution trajectories by treatment. In comparison to homogenous games, when high caste and scheduled caste people play together, the high caste players decrease their contributions 26% more than the scheduled castes. N = 4256 choices (304 individuals x 14 rounds)

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APPENDIX

Model Comparisons

Akaike model comparisons for both learning trajectory models and models of initial expectations are presented below, in full form.

Comparing Learning Trajectory models

AIC	df	weight	LagDev	Prior	Relat	Pri:Rel	Hierarchy	NumCastes	Middle Castes	Stratum	A	B	C
20286.1	7	0.651	-0.25	-0.24	2.20	0.19	-	-	-	-	-	-	-
20289.7	8	0.105	-0.25	-0.24	1.92	0.22	-	-	-0.10	-	-	-	-
20290.0	8	0.092	-0.25	-0.25	2.36	0.25	0.06	-	-	-	-	-	-
20290.4	8	0.072	-0.25	-0.24	2.28	0.12	-	-	-	0.07	-	-	-
20290.8	8	0.060	-0.25	-0.24	1.95	0.20	-	-0.04	-	-	-	-	-
20294.2	9	0.011	-0.28	-0.25	2.00	0.06	-	-	-0.10	-	-	0.06	-
20296.2	9	0.004	-0.26	-0.25	2.38	0.24	0.06	-	-	-	0.01	-	-
20296.3	9	0.004	-0.34	-0.24	2.08	0.02	-	-0.03	-	-	-	-	0.04
20300.3	11	$<$0.001	-0.25	-0.24	2.30	0.17	0.02	0.10	-0.25	0.08	-	-	-

Table 6: Linear mixed model AIC model comparison analysis results, including control variables, treatment variables and the learning variable, LagDev. The LagDev variable, shows a very strong negative effect on C_{norm}. This means that if, in the previous round, a player contributed more than the average of his peers, he is much more likely to reduce his contribution in the current round, and vice versa, (Table 6, below). Mirroring the total contribution results, rumor decreases contributions while relatedness increases them. Moreover their interaction is also positive, suggesting a sort of nepotistic effect. That these variables are important in the iterative analysis is somewhat surprising, since it suggest that relatedness to fellow players and prior knowledge of the game are facts which continue to influence behavior in every successive round as the games progress, even while ethnic mixing factors do not. See summary Table 2. Treatment Columns: A=LagDev:Hier, B=LagDev:Middle, C=LagDev:NumCastes.

Comparing Cooperative Expectations Models

	AIC	df	weight	(Intercept)	Hierarchy	Middle	# Castes	Stratum	Hier*Strat	nCast*Strat
Linear	1477.3	13	0.203	4.01 (1.67)	2.52 (1.23)	2.11 (1.07)	-2.21 (1.00)	-0.18 (0.55)	-1.32 (0.48)	0.49 (0.29)
	1478.1	12	0.130	2.34 (1.33)	1.43 (1.04)	2.01 (1.07)	-1.08 (0.73)	0.56 (0.33)	-0.90 (0.40)	.
	1478.2	9	0.128	1.95 (0.80)	-0.93 (0.35)	0.62 (0.35)	.	.	.	.
	1478.4	11	0.115	1.02 (0.99)	0.67 (0.91)	0.52 (0.36)	.	0.45 (0.32)	-0.75 (0.39)	.
	1478.6	10	0.103	1.25 (0.98)	0.76 (0.91)	.	.	0.55 (0.31)	-0.83 (0.39)	.
	1479.3	10	0.073	2.88 (1.29)	-0.67 (0.45)	1.54 (1.05)	-0.65 (0.71)	.	.	.
	1479.4	8	0.069	2.46 (0.75)	-1.06 (0.35)	.	.	.	.	.
	1479.5	9	0.067	1.62 (0.96)	-1.10 (0.35)	.	0.32 (0.23)	.	.	.
	1479.8	11	0.057	0.85 (1.08)	0.55 (0.94)	.	0.22 (0.24)	0.47 (0.32)	-0.75 (0.40)	.
	1481.3	11	0.027	2.90 (1.32)	-0.67 (0.45)	1.54 (1.06)	-0.65 (0.71)	-0.02 (0.20)	.	.
	1481.4	9	0.026	2.41 (0.83)	-1.05 (0.35)	.	.	0.03 (0.20)	.	.
	1486.8	7	0.002	1.50 (0.69)	.	.	.	.	.	.
	1490.7	10	<0.001	1.70 (1.46)	.	.	-0.19 (0.57)	-0.42 (0.56)	.	0.22 (0.25)
Binomial	1783.6	12	0.970	-0.40 (0.39)	1.07 (0.29)	0.92 (0.25)	-0.95 (0.23)	-0.09 (0.13)	-0.56 (0.11)	0.21 (0.07)
	1790.7	11	0.027	-1.10 (0.31)	0.60 (0.24)	0.88 (0.25)	-0.47 (0.17)	0.23 (0.07)	-0.38 (0.09)	.
	1796.2	10	0.002	-1.68 (0.23)	0.27 (0.21)	0.22 (0.08)	.	0.18 (0.07)	-0.31 (0.09)	.
	1800.7	10	<0.001	-1.74 (0.25)	0.23 (0.22)	.	0.09 (0.06)	0.19 (0.07)	-0.31 (0.09)	.
	1801.4	9	<0.001	-1.57 (0.23)	0.31 (0.21)	.	.	0.23 (0.07)	-0.35 (0.09)	.
	1802.7	9	<0.001	-0.88 (0.30)	-0.28 (0.10)	0.68 (0.25)	-0.29 (0.16)	.	.	.
	1803.9	8	<0.001	-1.30 (0.19)	-0.39 (0.08)	0.26 (0.08)	.	.	.	.
	1804.6	10	<0.001	-0.87 (0.31)	-0.28 (0.10)	0.68 (0.25)	-0.29 (0.17)	0.00 (0.05)	.	.
	1808.3	8	<0.001	-1.43 (0.22)	-0.46 (0.08)	.	0.13 (0.05)	.	.	.
	1812.5	7	<0.001	-1.08 (0.17)	-0.44 (0.08)	.	.	.	.	.
	1814.4	8	<0.001	-1.10 (0.19)	-0.44 (0.08)	.	.	0.02 (0.05)	.	.
	1840.7	9	<0.001	-1.38 (0.33)	.	.	-0.08 (0.13)	-0.17 (0.13)	.	0.09 (0.06)

Table 7: Treatment variable estimates from AIC model comparisons in both linear and binomial model families. While overall Stratum is a neutral factor, the negative Hier*Strat estimates reveal that hierarchy damages cooperation through diminished high caste cooperation. Caste diversity damaged contributions, while middle castes had a consistently positive effect. Hierarchy is negative when the Hier*Strat variable is not included. Standard errors in parentheses.

Chapter Three

Ethnic diversity and hierarchy in cooperative irrigation
A case study from south India

Timothy M. Waring
May 2010

ABSTRACT

Mounting evidence suggests that ethnic diversity damages cooperation in the provision of public goods, from public schools and police to environmental management. In fact dominance between ethnic groups may be the driver of these effects rather than diversity *per se*. Current measurements of the anti-cooperative effect of ethnic diversity may be inaccurate when they exclude measures of ethnic dominance, for three reasons: 1) ethnic dominance may have a similar negative effect on cooperation, 2) dominance requires a minimum level of ethnic diversity, and is therefore correlated with diversity, and 3) in situations of ethnic dominance, coercion can be used to enforce compliance in the cooperative venture at hand, making cooperation itself difficult to measure.

This study presents data from agricultural villages in Tamil Nadu's Palani Hills to test the relative importance of ethnic diversity and ethnic hierarchy. I provide evidence that in addition to the negative cooperative effect of ethnic diversity, factors of ethnic dominance such as hierarchical stratification and demographic dominance strongly determine outcomes in collective irrigation management. I argue that the most important measure of equity, irrigation access, is socially, technologically and institutionally embedded, and demonstrate that the distribution of irrigation channels is best predicted by measures of inequality, such as wealth, wealth inequality, Dalit status and demographic dominance.

These results highlight the importance of detecting and quantifying ethnic dominance both in terms of hierarchical stratification and demographic dominance, and

reveal ethnic dominance as a cooperative challenge to society and an important dimension in the study of cooperation across societies.

INTRODUCTION

Endogenous cultural factors have been linked to economic development across a range of societies and sectors (Easterly et al., 1995; Alesina et al., 1999; Miguel and Gugerty, 2005; Habyarimana et al., 2007; Ruttan, 2006; Baland et al., 2007). One major theme of this research is the idea that 'cultural heterogeneity', or 'ethno-linguistic fractionalization' damages the ability of societies to create and maintain public goods through a reduction in intra-ethnic cooperation. This matches theory in evolutionary anthropology suggests that cultural groups exist in part as a means to solve collective action problems (Richerson and Boyd, 2005), a premise which is supported by evidence on cooperation in psychology (Fiedler, 1966), anthropology (Henrich et al., 2004), and economics (Efferson et al, 2008; Gintis et al., 2003; Ostrom, 2000). This theory places ethnic groups as a natural containers for in-group cooperation. Thus, since cooperation is often parochial (Bernhard et al., 2006) adding more parochially cooperative ethnic groups decreases global cooperation, in part because altruism within groups coevolves with antagonism between groups (Choi and Bowles, 2007).

While the cooperative effect of ethnic diversity seems in hand both theoretically and empirically, both neglect the importance of power differences between groups. Here, I use *diversity* to mean situations in which differences in cultural identity are salient, but

relative power differences are marginal, and *hierarchy* to signify inter-group relationships in which one cultural group has real coercive power over the other (per Horrowitz, 2000).

The current paper introduces evidence on the endogenous cultural influences on cooperation from rural agricultural communities in Tamil Nadu, India. India's indigenous caste identities provide a relevant form of socio-ethnic diversity which includes significant variation in relative coercive power. I present results on the extent to which caste hierarchy and caste diversity constrain real-world cooperation in realms of irrigation and village justice.

ETHNIC BOUNDARIES AND COLLECTIVE ACTION

Since the 1970's the importance and dynamics of ethnicity has become one of the primary focuses of anthropology (Vermeulen & Govers, 1994). Barth (1970) was among the first to suggest that ethnic groups are best understood by the boundaries between them rather than by the cultural practices within each. Ethnic groups are therefore dynamic, and maintained by individual acts of identity ascription (Barth, 1970), which is sensitive to economic, political, social, cultural and physical realities.

A primary dimension of ethnic relationships is that of power or hierarchy. Horowitz (2000) distinguishes 'ranked' ethnic groups as those which coincide with social class, and 'unranked' groups as those are independent of class, and provides convincing evidence that ethnic interactions are so strong as to be a primary force in the crafting of history. Weber made the same distinction (Gerth et al., 1991). Henrich and Boyd (2008) go beyond simply labeling the dimensions of importance to specify a model of the coevolution of ethnic group identity with social stratification. Given that economic

specialization creates a surplus, ethnic groups are likely to form around an uneven split of these resources, creating hierarchical stratification, even without coercion (Henrich and Boyd, 2008). Of course coercion is a common feature of many socio-ecological systems, even those less hierarchically ranked (Ruttan and Borgerhoff Mulder, 1999). Here I am concerned with separating the effects of pure ethnic diversity versus ethnic hierarchy (class-correlated diversity, or 'hierarchically ranked' ethnic groups) on cooperation and collective action in the realm of environmental management.

The study of common resource management frames social dilemmas such as environmental conservation as problems of collective action. Despite the early assertions that rational individuals will "free ride" on commonly available resources, resulting in their depletion (Olson, 1965; Hardin, 1968), many cases of successfully managed common pool resources have been uncovered around the world (Ostrom, 1990; Ostrom, Walker, & Gardner, 1992; Ostrom, 2007). Scholars have elucidated many factors critical to successful common pool resource management (Feeny et al., 1990), yet despite such progress, no general, predictive theory of commons management exists, and new factors are still being discovered (Agrawal, 2002). The literature on collective action in community resource management is voluminous, yet its treatment of the influences ethnic and cultural diversity is light in comparison to the focus on ecological and economic variables (e.g. see, Varughese and Ostrom; 2001). Moreover, most such studies do a poor job of using meaningful definitions of socio-cultural diversity, ascribing to it trust, common beliefs and norms, and social identity.

Given this set of overlapping definitions it is no wonder that scholars and researchers have found no consensus, with reports of the effects of ethnic diversity as

positive (Anderson and Paskeviciute 2006; Ottaviano & Peri, 2006), conditional, (Agrawal & Gibson, 1999; Vedeld, 2000) and negative (Ruttan, 2006). Varughese and Ostrom (2001) treat cultural diversity as a challenge but do not propose concrete processes by which diversity affects cooperation. But the question of ethnic diversity can be made quite concrete: does the presence of greater numbers of ethnicities or socio-cultural identity groups reduce cooperation in an economically significant realm, or not? While there is growing evidence that ethnic diversity does reduce cooperation, little is understood about the ways in which that effect occurs. For instance, is the negative effect of ethnic diversity on cooperation due to an the coevolution of symbolic ethnic markers and coordination strategies (Efferson et. al., 2008), or are altruistic propensities cued by the boundaries of ethnicity (i.e. Bernhard et al., 2006), or do the difficulties of achieving cooperation between disjoint social networks and sets of knowledge the limiting factor as Habyarimana et al. suggest?

Stepping back from ethnic diversity, other aspects of ethnic group interaction could prove important in determining cooperative outcomes. Much of the collective action and development economics literatures ignores the power dimension to endogenous social interactions (but see Collier, 2001). Ethnic power inequalities may play a decisive role in cooperative social achievements.

IRRIGATION IN INDIA AND TAMIL NADU

Village irrigation systems in India have been extremely well studied. Wade's (1987) description of village irrigation systems in Andhra Pradesh provided early evidence that village-level institutions could be understood in part as a product of their

ecological environments. Wade also found that a high level of caste homogeneity (75%) was conducive to cooperation in irrigation systems.

More recent work bears more precisely on the influence of cultural and ethnic differences on cooperative irrigation. In a broad survey of 48 village irrigation systems in Tamil Nadu, Bradhan (2000) found that caste homogeneity increased the likelihood of cooperative behavior, and Dayton-Johnson (2000) also found a negative effect of 'cultural heterogeneity' (number of villages) on irrigation system maintenance in Mexico. Bardhan and Dayton-Johnson suggest that the social dynamics of cooperation are more important than traditionally assumed.

> *One theme that emerges in reviewing the role of inequality is that the problems of successful commons management are not necessarily based on the characteristics of the natural resource itself – as the earlier, tragedy-of-the-commons tradition would have it – but rather the more prosaic problem of getting people to cooperate.*
>
> - Bardhan & Dayton-Johnson, 2000, p 17.

Contrasting and criticizing Bradhan's (2000) research, Mosse (2006) conducted similar work from an anthropological perspective. He found that the norms of local irrigation management, while highly 'cooperative,' actually served as an organizing frame allowing headmen and village "VIPs" to secure extra water at public cost (Mosse, 2006). Mosse argues that in hierarchical social systems power differentials and coercion explain in practice what may appear to be simple cooperation. The current study was designed to contrast the influences of cultural diversity without strong power differentials and hierarchical relations with embedded power asymmetries across social and economic domains.

RESEARCH QUESTIONS

The focus of this research is to measure the determinants of socio-cultural diversity on cooperation in real world contexts. For this purpose India provides a rich and compelling social landscape to study the social dynamics of cooperation. As an ancient civilization, India has incorporated socio-ethnic diversity for millennia. Moreover Indian cultural diversity spans the spectrum from linguistic and 'racial' ethnic differences between regions to pure identity distinctions between groups within ethnically homogenous regions. The label 'caste system' is an attempt to name this staggering diversity as a single entity. Caste differences, of whatever level (linguistic, ethnic, religious or otherwise), exist on the national, regional, and sub-regional levels. Moreover even within relatively isolated villages in rural India there may be many caste groups, most of which are substantially endogamous. Thus Indian caste provides an excellent context for testing the influence of socio-ethnic difference on cooperation in everyday life.

STUDY SITES

This study was conducted in the Palani Hills of western Tamil Nadu, an eastern escarpment of the western ghats, bordering Kerala (see Figure 1). The upper Palani Hills are home to 20 agricultural villages varying in size from 500 to 6000 people varying in caste diversity between 3 to 13 caste groups. These villages, originally settled by the Manadiar group, retain traditional governance institutions separate from the official

government panchayat system. The similarity of these institutions to those on the Tamil plains (Mosse, 2006), oral tradition, and historical evidence (Francis, 1914; Bahadur and Aiyangar, 1942) all suggest that they are a cultural legacy of the Pandiya kingdom that the Manadiar brought with them when they migrated into the hills approximately six centuries ago (Francis, 1914).

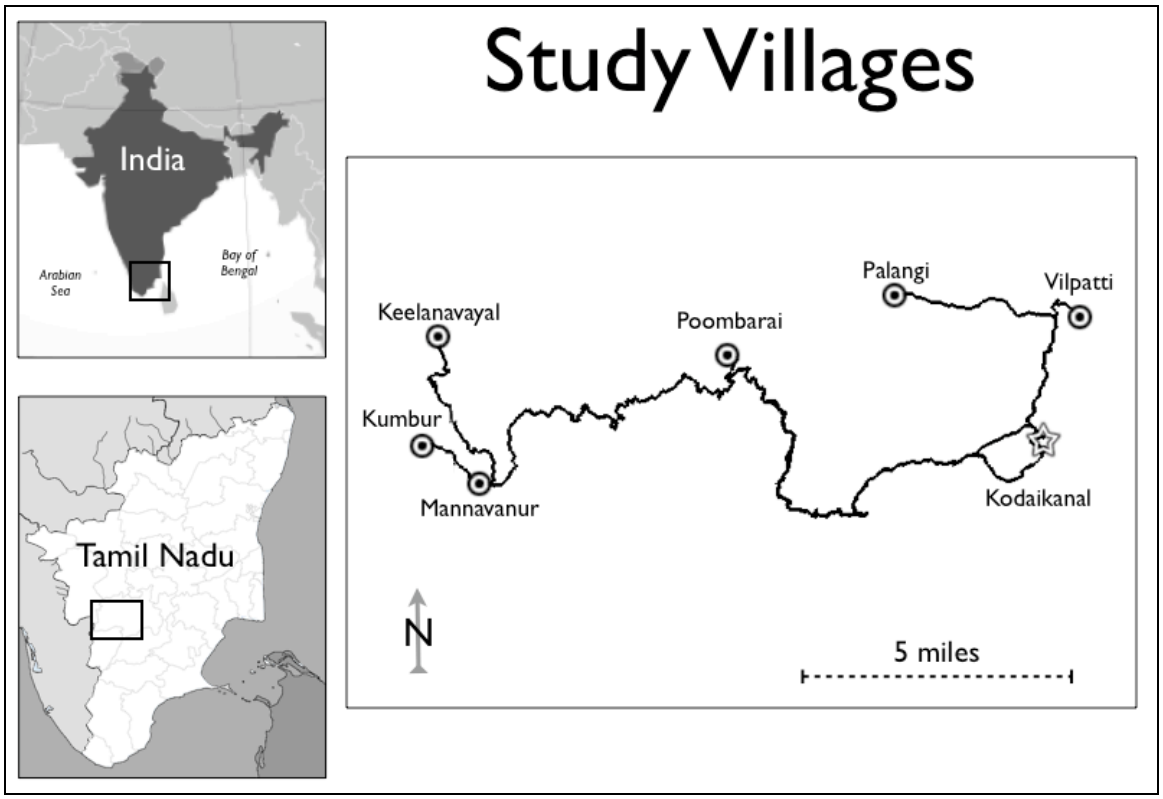


Figure 9. Study villages in the Palani Hills, Tamil Nadu, India.

Five months of ethnographic investigation on the social identity, oral history and village organization across the Upper Palani villages form the basis by which caste relationships were classified. Caste hierarchy in the Palani Hills region is centered on two focal caste groups at opposite ends of the power spectrum, which share a long history. The Manadiar caste are in the center of village power; in most villages the Manadiar hold some or all of the hereditary leadership positions called *thalaivarhal*

(literally, 'headmen'), and their influence within the village justice system or Podhu Kootam ('common crowd'). By contrast, the Sakkliyar, a Dalit group which shares a deep history with the Manadiar, having arrived around the same time as the Manadiar, have no formal power. For instance, women and Sakkliyar individuals are excluded from the semi-sacred village commons called the *manthai* where village meetings are held, and thereby physically blocking access to the space of village justice.

In Palani Hills villages the first *thalaivar* position is called the Manadiar and in Poombari it is occupied eponymously, while two further *thalaivar* positions are occupied by the Thevar (*Periyathanam*) and the Mudhaliar (*Manthiriar*) elders. The Sakkliyar also bear traditional village servant positions, including the village crier (*thandalkarar*), the water controller (*neer-nikam*), and the festival celebrant (*vettiyan*). No middle castes hold any high-status or low-status traditional roles. These formal roles betray the historical caste-driven power asymmetry, and are summarized in Table 1.

Just as the oppression of Dalit groups is common in much of Tamil society (Mangubhai and Irudayam, 2000), the life of most Sakkliyar in the Palani hills is one of subjugation in all aspects of village life, social and economic, informal and institutionalized. The hierarchical relationship between the Manadiar and the Sakkliyar is an ancient and central aspect of life.

Table 8. Distribution of caste members in village positions

	Poombarai		**Mannavanur**		**Kumbur**		**Keelanavayal**		**Vilpatti**		**Pallangi**	
Thalaivarhal (leadership positions, inherited)												
Manadiar	1	Manadi	3	Manadi	5	Asari	3	Asari	4	Manadi	1	Manadi
Manthiriar	1	Mudali	1	Pillai	1	Chetti	1	Mudali	2	Pillai	1	Mudali
*Other**	1	Thevar	1	Manadi	1	Chetti	1	Reddi	1	Retti		
Servant (servant positions, selected)												
Thandalkarar	3	SC	1	SC	1	SC	1	SC	1	SC	1	SC
Neer Nikam	4	Panchayat	5	SC	3	SC	2	any	3	any	0	Thandal

Vettiyan	20	SC	13	SC	15	SC	8	SC	16	SC	10	SC

SC = Sakkliyar, the major Dalit caste in the Palani hills region.
Servant positions are selected by the thalaivar ('headmen') for 1-3 yr terms
*Other = Village specific thalaivar postions, including Periyathanam (wealthy leader), Maniyakarar, Kariyamanadi, Pattakarar, and Mem-, Chola-, Shantha-, Karu-manadi.

SAMPLING

An extensive semi-structured, caste-stratified survey of farming households was conducted across six villages with communal irrigation systems varying in size, number of castes, and distance from the local city, Kodaikanal. In each village all castes with ten or more households were sub-sampled, and a minimum of 9 households were surveyed for each caste group. Like in many regions of India, these villages were largely composed of neighborhoods segregated by caste. This afforded an efficient randomized sampling scheme. Since the spatial dimensions of caste neighborhoods and the caste populations of each village were known approximately beforehand, I calculated the sample size for each caste, and sampled at random within each spatially constrained ethnic neighborhood. Overall, 269 heads of household were interviewed, 11 of these were later excluded resulting in a total of 258 surveys.

The survey was conducted between April and June, 2008[1]. During sampling days, the research team would rise early for the travel to the villages in order to arrive before the farmers had left for work in the field. The majority of sampling occurred between the hours of 8 and 10 am and 2 and 5 pm, when most farmers were at home.

Table 9. Sampling scheme

Village	pop.	households	castes	10+ house hold castes	n	average caste-wise household sample

[1] The survey tool was the final of eight iterations of testing and revision. The first two version 8 surveys were conducted in Manavanur in January and February of 2008, the remainder were conducted between April and June, 2008.

Mannavanur	5029	762	8	4	43	33%
Poombarai	4456	1262	11	8	69	14%
Vilpatti	2032	508	10	6	58	13%
Kumbur	1051	208	5	3	33	18%
Keelanavayal	700	104	8	2	30	44%
Pallangi	700	133	3	3	26	33%

POPULATION CHARACTERISTICS

Of the surveyed heads of households, the average age was 46.7 with the youngest 19, and the oldest 87. The mean household size was 4.5 and the average years of education of the household head was 4.9, but over one quarter reported zero years of education, while one person reported 17 years. Of all household heads, four were women, and only 2% reported any additional occupation to farming.

The cost and availability of transport makes these villages very isolated. As a result many factors decline with the distance from Kodaikanal, including the mean years of household education. Mean household education starts from 6.7 yrs on average in Vilpatti, and declines by approximately one month per kilometer over the 44 miles to Keelanavayal, where the mean is 3 yrs lower on average (single correlation, $R2 = 0.16$). Similarly, yearly exposures to external culture (see Table 3 for variable description) shows a similar pattern starting from ~1500 yearly exposures in Vilpatti and Pallangi and effectively dropping nearly 16 exposures per mile to reach a yearly 803 exposures in Keelanavayal. Such a difference in exposure likely has a strong influence on the social norms of the people living in these villages. Agricultural income also declines with distance from Kodaikanal, dropping 66 Rs. from Vilpatti to Keelanavayal, a 30% reduction in daily pay.

In this region, aside from plowing with oxen, the agricultural enterprise is exclusively manual. Out of necessity, this splits individuals on any given day into the land owners and workers, or 'coolies'. All individuals work on their own fields, if they own any, and 76% work on others fields as well. 94% of Dalits work as coolies, in comparison to 77% of Manadiar. On the hiring side, only 51% of Dalits hire others to work on their fields, while 92% of Manadair hire our their work. As a result, Dalits on average earn 7,660 Rs per year from coolie labor, while Manadiar average only 4,900 Rs. On average, dalits hire 194 worker-days of labor per year, while Manadiars hire 480 worker-days, well over double the Dalit figure. These caste-correlated inequalities are also born out in land ownership and wealth.

Villagers owned an average of 2.3 acres, with 1.31 acres of irrigated land. Mean Dalit land holding was 0.46 acres, while Manadiars owned 4.45 acres on average. Of the 45 households owning no land, 58% were Dalit. Of the 14 individuals owning five 5 or more acres all are middle and high castes. A comprehensive wealth estimation was calculated based upon items such as house, land, livestock and vehicle ownership (see table 3). Mean wealth was 398,790 Rs. for Dalits and 1,270,730 Rs. for Manadiar.

Each farmer was asked to rank the importance of six factors in determining their social identity. These factors were family, caste, religion, political parties, hometown, and occupation. There was a very clear trend in pREFERENCES within the entire sample. Out of a total of 6 points, family averaged 5.9, followed by occupation (5.0). The remaining categories had overlapping confidence regions but were as follows hometown (3.5), caste (2.6), religion (2.4), political (2.1). The clear, sample wide

preference for family and occupation is relevant to the current study because caste was not even close to being a highly ranked component of reported social identity factors.

ANALYSIS

The survey data was analyzed with hierarchical multiple regressions using either the logistic, binomial, Poisson or negative binomial distributions as appropriate for each response variable. This multilevel analysis is appropriate because predictor variables come from both individual response data such as education and acres of land owned and village-level variables such as population and caste diversity. Since it is not possible to know or measure everything that may important which varies by village, I include a random effect for village. This random effect of village accounts for all those effects that may influence the results which vary by village but were unmeasured. A heuristic linear regression equation for response variable $R_{i,v}$ for individual *i* in village *v*, is:

$$R_{i,v} = \mu + \mathbf{Z}_v + \beta \times [villagesize]_v + \gamma \times [wealth]_i + \varepsilon_{i,v} \quad 1$$

where μ is the grand mean, $\mathbf{Z}_v$ is the village mean, $\varepsilon_{i,v}$ is unexplained variance, and β and γ are coefficients for a village-level and an individual-level predictors, respectively. In linear regressions, village level heterogeneity, ε_v is modeled as the Gaussian distribution, N

$$\mathbf{Z}_v \sim N(0, \sigma_v^2) \quad 2$$

with mean 0 and variance σ_v^2, while model error would be

$$\varepsilon_{i,v} \sim N(0, \sigma_\varepsilon^2) \quad 3$$

This multi-level analysis has the important benefit of allowing a determination of the proportion of variance explained by village-level versus individual-level variation. Analyses were computed in R 2.9.2. Predictor variables are detailed in tables 3-5 and response variables in table 6.

Table 10. Description of Predictor Variables

Variable	type / unit	Description
Individual Level Variables		
Age	yrs	
Household size	#	
Education	yrs	
ln(Wealth)	1,000 Rs.	Total value of owned items, in 1000 Rs. Increments. Wealth = .01 + livestock*10 + pumps*5 + house*300 + two-wheeled-vehicle*50 + four-wheeled-vehicle*750 + acres-owned*7000
FRAC	0-1	Proportion of village population represented by own caste.
Dalit	binary	Dalit (1), all others (0)
Vaikkal	binary	Irrigation dependency. Question 33: *Is the land you work on connected to the vaikkal (irrigation channel)?* 69% responded 'yes'.
Dalit * Vaikkal	binary interaction	77% of non-Dalits have a vaikkal connection, while only 38% of Dalits do. Hierarchy * Irrigation interaction.
Village Level Variables		
Population	#	Village population as reported by the 2001, Indian Census or estimated by the Panchayat clerk for that village, 2008.
Distance	km	Distance from Kodiakanal. Kodaikanal (population 32,931) is the closest city and provides influential social and economic opportunities and cultural contacts (2001, Indian Census).
Caste Diversity	#	The number of Jathis in a village with a population of more than 10 households.
Wealth Gini index*	0-1	The Gini coefficient of estimated wealth by village. Wealth estimated as above.

*Calculated per Milanovic (1997).

Table 11. Village-level predictor variables

	Population (households)	**Distance (km)**	**Castes (>10 hh)**	**Land Gini coefficient**	**Wealth Gini coefficient**
Keelanavayal	104	44	2	0.5724	0.3902
Kumbur	208	39	3	0.5600	0.4623
Mannavanur	762	36	4	0.6186	0.4529
Pallangi	133	10	3	0.7586	0.6569
Poombarai	1262	18	8	0.6395	0.4913
Vilpatti	508	5	6	0.5173	0.4283

I conducted a separate mixed effect regressions, with a random effect for village, for each of seven dependent variables, matching probability distributions to each variable as appropriate. For index variables such as *adequacy*, *fairness, influence*, and *podhukootam*, I fit binomial models because they accurately represent the structure of those composite variables, each being a sum of multiple binary variables. For binary response variables such as *equaldist* and *influence*, I use logistic regression. For the count variable *workdays* I used a negative binomial model. For parsimony, I report fixed-effects model estimates if village-level variance was close to zero (less than 0.005). Multivariate correlations showed no sign of association between dependent variables (maximum pair-wise correlation = 0.3774). I discuss only correlations with at least 95% confidence.

Table 12. Village-level predictor variable correlations

	Wealth Gini	Distance	Population	Castes >10	Castes All	Diveristy H'
Wealth Gini	1.0000	-0.3517	0.0105	0.0175	-0.5178	-0.4908
Distance	-0.3517	1.0000	-0.2408	-0.6000	-0.3019	-0.4451
Population	0.0105	-0.2408	1.0000	0.8867	0.7520	0.6753
Castes >10	0.0175	-0.6000	0.8867	1.0000	0.8077	0.8177
Castes All	-0.5178	-0.3019	0.7520	0.8077	1.0000	0.8976
Diveristy H’	-0.4908	-0.4451	0.6753	0.8177	0.8976	1.0000

Diveristy H’ = Shannon index, maximum H’=ln(# of species)Multiple diversity predictors displayed for comparison.

As Caste10 and population are highly correlated (cor = 0.887, pairwise R^2=0.786) I use AllCastes as the diversity predictor (cor = 0.752).

Table 13. Response Variable descriptions

Variable	Type	Description
Cooperation		
Work Days	days / yr poisson	Number of village-wide communal workdays attended in the last year for work on ponds, channels, paths, and emergency repairs.
Efficacy Measures		

Adequacy	0-5 index binomial	Sum of four binary response variables on the relative adequacy of the irrigation system. Questions 36, 37, 38, 39, 43 from survey appendix. Paraphrased: *Is there enough water for all?* *Is there enough water for you?* *Same or better water availability than other villages?* *Same or better water availability than 10yr ago?* *Is water distribution reliable here?* Questions 38 and 39 were recoded as binary variables. Item reliability: Cronbach's $\alpha = 0.6988$
Distributive Fairness	binary	Question 48, paraphrased: *Is water distributed equally to every farmer?*
Procedural Fairness	0-5 index binomial	Sum of five binary response variables about procedural fairness in the irrigation system. Questions 56, 57, 58, 59, 60, paraphrased: *Does NeerNikam distribute water fairly?* *Do village leaders keep NeerNikam honest? DOWN* *Are you satisfied with irrigation system fairness?* *How fair are irrigation rules?* *How fair are penalties for breaking irrigation rules?* Questions 59 and 60 recoded such that *completely* = 1 and *mostly* = 1, *not* = 0, and *no rules* = NA. Item reliability: Cronbach's $\alpha = 0.6704$
Unfair Influence	binary	Question 49, paraphrased: *Might people unfairly influence the NeerNikam?*
Social Justice		
Podhu Kootam	index 0-9	Sum of nine binary response variables about the equity of the Podhu Kootam system. Questions 23, 24, 25, 26a-c, 30, 31, paraphrased: *Podhu Kootam give you equal influence?* *Podhu Kootam meet today's needs?* *New groups included?* *New groups given Podhu Kootam leadership positions?* *New groups given other positions?* *Choose Podhu Kootam over Panchayat?* *Choose Podhu Kootam over Police?* *Trust Podhu Kootam to be equal?* *Podhu Kootam leadership skill* Questions 24 and 26 were recoded as binary variables. Item reliability: Cronbach's $\alpha = 0.6787$

*The maximum pair-wise correlation between indices was 0.2461, n = 258.

Table 14. Response Variable Summaries

	Keelanavayal	Kumbur	Mannavanur	Pallangi	Poombarai	Vilpatti	Sample
Collective Work							
Days	4.10	1.39	5.88	1.58	2.49	2.86	2.68[#]
	(11.66)	(2.22)	(8.33)	(1.30)	(1.59)	(1.78)	(2.86)[#]
Adequacy							
Index	2.23	1.06	2.16	1.92	2.11	2.00	1.97
	(1.61)	(1.03)	(1.38)	(1.72)	(1.52)	(1.51)	(1.50)
Distributive Fairness							

Equal Distrib*	0.92	1.00	1.00	0.92	0.87	0.98	0.94
	(0.27)	(0.00)	(0.00)	(0.28)	(0.34)	(0.15)	(0.24)
Procedural Fairness							
Index	3.40	2.35	3.60	0.65	2.56	2.69	2.64
	(1.75)	(2.22)	(1.76)	(1.50)	(2.17)	(1.98)	(2.10)
Unfair Influ*	0.17	0.07	0.11	0.00	0.10	0.12	0.11
	(0.39)	(0.26)	(0.32)	(0.00)	(0.31)	(0.33)	(0.32)
Village Justice							
Podhu Kootam	6.77	7.52	6.67	5.00	4.74	5.57	5.84
	(0.33)	(0.19)	(0.21)	(0.48)	(0.29)	(0.27)	(0.14)

Including two outliers mean = 3.10, st.dev=5.56
* Binary variables.

Table 15. Response variable correlations

	PK Index	**Work Days**	**Adequacy**	**Equal Dist**	**Proc Fair**	**Influence**
PK Index	1	0.058	-0.03	0.003	0.296	-0.139
Work Days	0.058	1	0.02	0.082	0.171	-0.087
Adequacy	-0.03	0.02	1	0.158	0.246	-0.259
Equal Dist	0.003	0.082	0.158	1	0.212	-0.1
Proc Fair	0.296	0.171	0.246	0.212	1	-0.42
Influence	-0.139	-0.087	-0.259	-0.1	-0.42	1

Multivariate correlations calculated using REML (restricted maximum likelihood) method.

RESULTS

Correlations varied greatly between response variables. See regression table (Table 9) for model estimates.

Collective Work

The number of village-organized communal workdays attended in the last year is the sum of days spend working on ponds, channels, paths, and emergency repairs in the last year, and an excellent measure of individual cooperation in the irrigation system. Attendance is voluntary and enforcement is mostly verbal. Free-riders still gain the benefits of a functioning irrigation system. The mean days worked was 3.1, and while

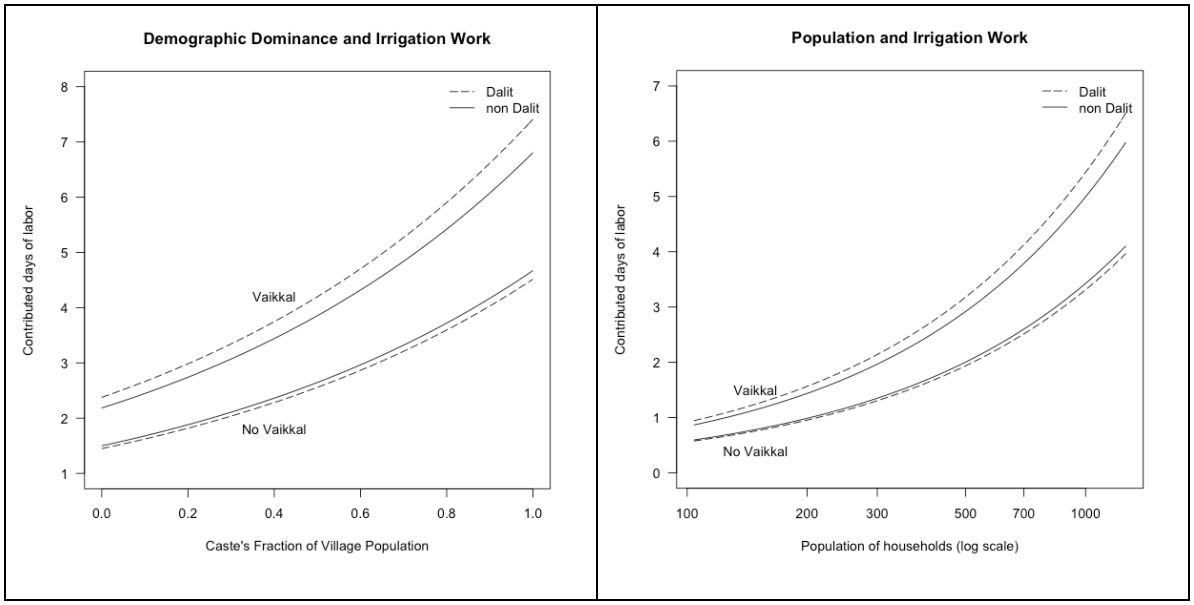
only eight farmers reported above ten workdays, two reported more than 30 (49 and 64). Since these two outliers are *prima facie* unbelievable, and were further given low reliability rankings by research assistants, they were thus excluded from the analysis.

As a count variable, *workdays* can be modeled as a poisson distribution. Village level variance in the empty model was 0.16, and remained high (0.04) in the full model if the caste diversity variable was *AllCastes*, and zero when it was *Castes10*. A deviance to degrees of freedom ratio test indicated poisson over-dispersion (dev/df = 2.17; Lindsey, 1999). I therefore used a negative binomial model with no village random effects, which passed Lindsey's A deviance to degrees of freedom ratio criterion of < 2.0 (dev/df = 1.29).

Population, FRAC and *Vaikkal* were positively associated with workdays. Holding other factors constant, increasing a village population by 1000 households, a change equivalent to the difference between the smallest and largest villages in the sample, would increase the number of workdays an individual attends by a factor of 1.7 (a 70% growth). Population correlations with cooperation have gained recent attention in large cross-cultural studies (Henrich et al., 2010). And increase in demographic dominance is also associated with an increase in workday contributed, such that increasing the size of ones caste from zero until it accounted for 50% of the village population was linked with a 77% increase in the number of days worked. A farmer with a *vaikkal*, all else being equal, would contribute 150% the number of workdays that a farmer without a *vaikkal* would contribute, on average.

Castes10 was negatively correlated with work contributions. Thus the model predicts that the addition of a single new caste with 10 households or greater, would

reduce the average workdays contributed by 25%. *Distance* was also negatively correlated with workdays in the model such that a 20km additional distance to the regional population center also equated to a 25% reduction in workdays contributed. *WealthGini* was negatively associated with workdays, but the effect was exceedingly weak (a change of 0.27 *WealthGini* only equates to a 1% decrease in workdays contributed).



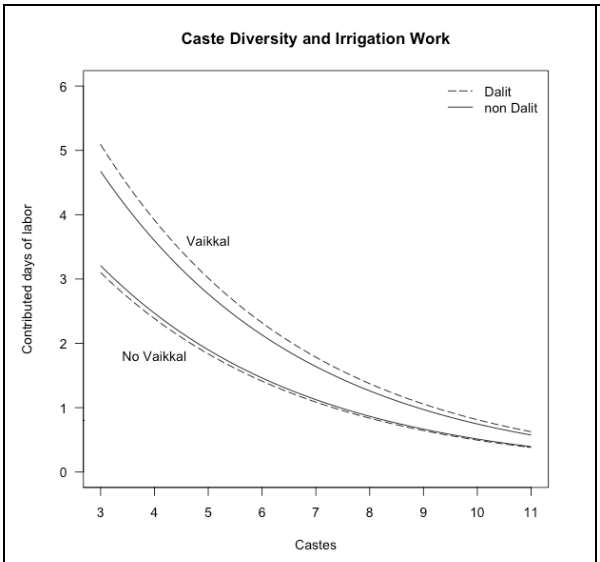


Figure 10: Effects of demographic dominance, village population, and caste diversity on irrigation labor contributions.

Adequacy

The irrigation adequacy index is the sum of five yes/no responses, and ranges from zero to five (mean=1.9, SD=1.5). 66% of farmers scored two or less. *AllCastes*, *lnWealth,* and *Vaikkal* were all positively associated with the irrigation adequacy index. In the model, having a *vaikkal* connection makes farmers 2.6 times more likely to answer 'yes' to an additional question in the adequacy battery than if they did not. Holding all else constant, an additional caste equates to a 17% increase in the odds of reporting another unit in the irrigation adequacy score. And, an increase wealth inequality equivalent to the change from Keelanavayal (top 20% most wealthy own 60% of total wealth) to Pallangi (top 20% most wealthy own 80% of total wealth) increases the odds of another adequacy mark by only 1%.

Equal Distribution

The variance of the village level effect was zero. The only strongly correlated predictor of *Equal Distribution* was *Vaikkal*. Given the model, having a *vaikkal* made the odds of a farmer replaying that water distribution was equal 70 times the odds for a farmer without a *vaikkal*.

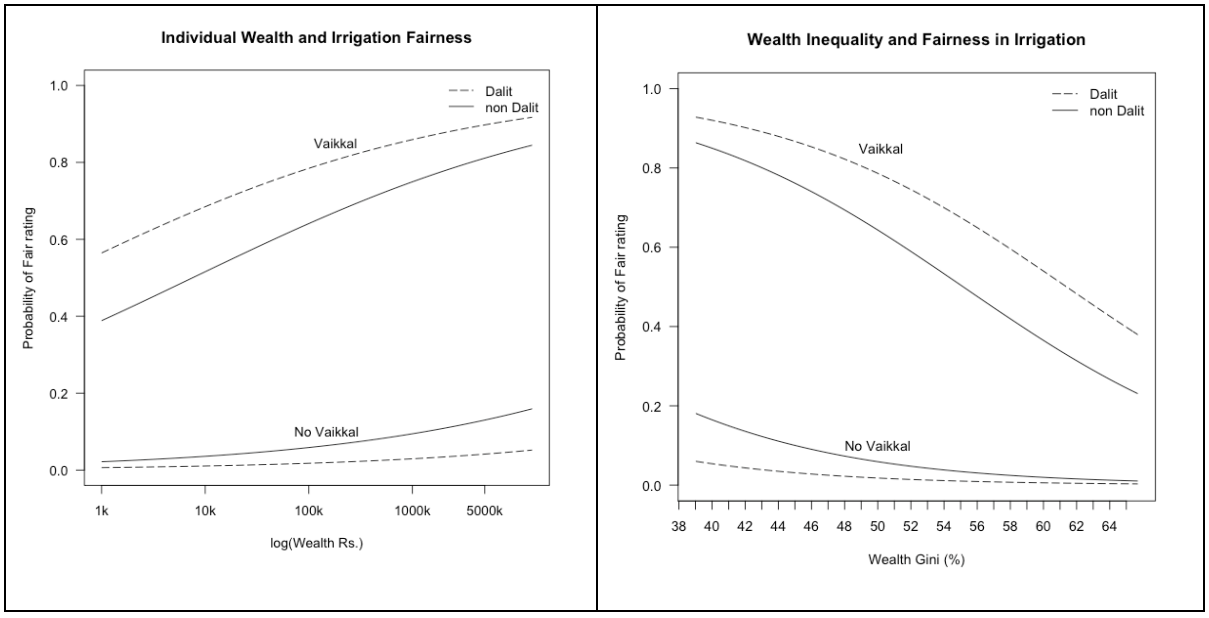
Procedural Fairness

Procedural Fairness was the sum of five binary response variables on the institutional equity of the irrigation system. Responses were bimodal, with 34% producing a score of zero, and 51% rating the system with a score of 4 or 5. Village level variance was zero. A fixed effects-only model produced effectively identical estimates. Unlike measures of adequacy and distributive fairness, procedural fairness was strongly correlated with many predictors.

The odds of farmers with a *vaikkal* responding with an additional 'yes' to the questions on procedural fairness was nearly 30 times the odds of those without. Holding other factors constant, Dalits responded 'yes' with only at 0.3 times the rate non-Dalit did. The *Dalit*Vaikkal* interaction was also a remarkably strong positive effect. Given the main effects above, the odds of a Dalit with a vaikkal indicating another unit of fairness was seven times that of a Dalit without a vaikkal. Given the model fit, an additional million rupees of wealth correlates with a fivefold increase in the likelihood to rate the irrigation system as fair. An additional two persons in a household was associated with a 36% increase in the odds of a fair rating. Finally, a change in *FRAC*

(demographic dominance) of 0.5 corresponds to a fourfold increase in the odds of a fair rating.

Weaker effects included *lnPop*, *AllCastes*, *WealthGini*, and *Distance*. Holding other effects constant, the model estimates that the odds of an additional unit score are 49% greater for a population with an additional 1000 households, and 46% greater for a village an additional 20 km from Kodaikanal, while 11% less for villages with an extra caste, and 3% less for an increase wealth inequality equivalent to the change from Palangi to Keelanavayal.



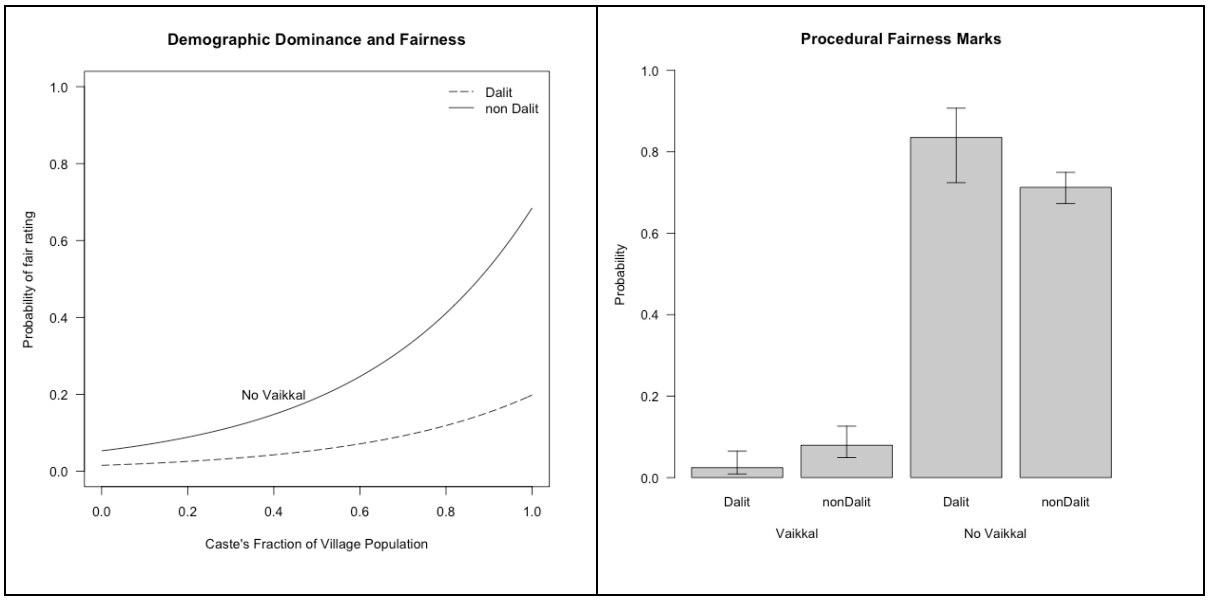


Figure 11: Effects of wealth, wealth inequality, demographic dominance, and Dalit status on fairness in irrigation.

Unfair Influence

Unfair influence was a single yes/no response to the question "Is it possible to unfairly influence the Neer Nikam in any way?" 89% responded 'no,' and only 16 responded positively, of these 16 all but one had a vaikkal, and only one was a Dalit. Village level variance in the mixed model was 4e-13. Again, *Vaikkal*, and *Dalit*vaikkal*, were important variables, as was *WealthGini*.

Within the model, for farmers with a *vaikkal*, the odds of indicating that such unfair influence was possible were 21 times those for farmers without. As the *Dalit*vaikkal* effect is predicated on a single response, the estimate is dubious, but the direction of the effect is probably accurate. Holding other factors constant, an increase in the *WealthGini* index of 0.27, equivalent to the change from Keelanavayal (top 20% most

wealthy own 60% of total wealth) to Pallangi (top 20% most wealthy own 80% of total wealth), reduces the odds of indicating that influence is possible by 4%.

Table 16. Regression results

	Workdays*	Adequacy	Equal Distribution	Fairness	Influence
Family	neg. binom.	binomial	logistic	binomial	logistic
(Intercept)	-1.58 (0.83)	**-3.43 (1.03)**	-2.94 (3.84)	-2.45 (1.31)	3.88 (2.83)
Village-level predictors					
lnPop	**0.77 (0.15)**	-0.25 (0.13)	-0.71 (0.57)	**0.57 (0.19)**	0.66 (0.45)
Distance	**-0.01 (0.01)**	0.00 (0.01)	0.02 (0.02)	**0.02 (0.01)**	0.00 (0.02)
Castes	**-0.26 (0.08)**	**0.16 (0.06)**	0.33 (0.25)	-0.11 (0.09)	-0.40 (0.20)
WealthGini	**-0.03 (0.01)**	**0.05 (0.02)**	0.06 (0.06)	**-0.11 (0.02)**	**-0.16 (0.05)**
Household-level predictors					
Age	0.00 (0.00)	0.00 (0.00)	0.01 (0.02)	0.00 (0.01)	0.00 (0.01)
Educ	-0.01 (0.02)	-0.01 (0.02)	0.05 (0.07)	-0.02 (0.02)	-0.08 (0.05)
HHsize	0.06 (0.04)	0.06 (0.05)	-0.08 (0.18)	**0.15 (0.06)**	0.11 (0.13)
lnWealth	-0.01 (0.04)	-0.01 (0.04)	-0.01 (0.11)	**0.22 (0.06)**	0.14 (0.12)
FRAC	**1.14 (0.44)**	0.27 (0.44)	-2.47 (1.70)	**2.56 (0.64)**	1.52 (1.37)
Dalit	-0.03 (0.23)	-0.15 (0.25)	0.03 (0.64)	**-1.24 (0.58)**	-2.01 (1.15)
Vaikkal	**0.38 (0.17)**	**0.96 (0.18)**	**4.24 (0.58)**	**3.36 (0.28)**	**3.04 (0.55)**
Dalit:Vaikkal	0.12 (0.31)	0.36 (0.33)	15.6 (1,458)	**1.95 (0.67)**	**3.45 (1.58)**
Village variance					
Empty Model	0.16	0.10	0.27	0.79	0.64
Full Model	6E-14	0.001	4E-13	0	4E-13
Model Fit					
AIC	1060.0	925.2	168.8	694.5	233.4
Log Likelihood	-516.0	-449.1	-71.4	-334.2	-103.7
ML pseudo-R^2	0.22	0.28	0.47	0.94	0.44

Bold estimates have 95% confidence or greater.

*Village-level variances calculated with poisson regression, Caste10 was caste diversity variable.

DISCUSSION

Control variables

Most individual level control variables (age, years of education, and household size) were rarely important predictors, having very small effects on response variables. Wealth was an important predictor of perceived irrigation fairness. Farmers with greater

wealth were more likely to report the irrigation system as fair, indicating a potential for bribery.

Of the village level control variables, population and distance were both important. Increasing population was associated with more volunteered labor, and a higher fairness rating. This positive effect of population size contradicts the standard game theoretic framing of cooperative dilemmas in which cooperation is expected to become more difficult to achieve as group size increases. These results suggest instead that cooperation (workdays contributed) and perceived fairness increase with population. This finding aligns with a strong cross-cultural pattern which finds greater cooperative punishment in larger populations (Henrich et al., 2010).

Distance from Kodaikanal was associated with less volunteer work on irrigation projects and a greater fairness rating. The effect of distance may be due to the effect of cultural exposure, not included in the models. The Wealth Gini measure of inequality, often strongly correlated with response variables, consistently had a very small effect size (less than 5% change). It seems unlikely, therefore, that wealth inequality is a major driver in the system.

Response variables

The variables of central concern, namely Caste diversity (*AllCastes, Castes10*), hierarchical caste status (*Dalit*) and demographic dominance of a caste (*FRAC*) tell a clear story of how ethnic and social forces influence real-world economic institutions and cooperation. Caste diversity decreases cooperation markedly, and is associated with a reduction in fairness. These findings align with the larger literature on the influence of

ethnic diversity and public goods. Interestingly, an additional caste was associated with an 17% increase in perceived irrigation adequacy, which is difficult to reconcile with the other effects of caste diversity. As expected, demographic dominance had strong positive effects on cooperation and perceived fairness, while caste hierarchical rank, captured succinctly in the *Dalit* variable, showed a different pattern. Models predict that Dalits cooperate by contributing labor to irrigation projects just as much as non-Dalits, taking other factors into account. However, Dalits rate the fairness of the irrigation system 71% lower than non-Dalits. This pattern is perhaps most simply explained as institutionally embedded caste-based inequalities: water distribution and the contributed labor are not unequally distributed, but irrigation channels themselves are.

Irrigation Access

Naturally, access to irrigation channels (called *vaikkal*) is a defining measure of involvement in an irrigation system, and the most important control variable. Having a *vaikkal* was a central predictive factor across all response variables. We would expect that having an irrigation channel would improve evaluation of and participation in the irrigation system. Farmers with *vaikkal* channels contribute more labor to irrigation projects, rate the irrigation system as more adequate, more fair, and as being both equal in distribution but open to unfair influence.

Note that being equal in distribution and open to unfair influences are not necessarily contradictory responses. Farmers with *vaikkal* channels regard the distribution of water *to those with vaikkals* as equal, and yet through direct and frequent contact with the *neer-nikam* know that securing extra water is possible through unfair

influence. This is possible if there is a superfluity of water, and thus no zero-sum game, as there was during 2008 when the survey was conducted.

But the hidden importance of the *vaikkal* variable is in its relationship to caste boundaries. *Vaikkals* are distributed very unevenly between caste groups. While over 75% of non-Dalits have *vaikkal* access, less than 40% of Dalits have the same privilege. Because *vaikkal* might be endogenously determined by social factors, I used a multi-model comparison exercise to examine the best predictors of *vaikkal* ownership.

Table 17a. Vaikkal Model Comparison

	Inequality	Individual	All	Base	Village		
AICc	258.2	266.6	266.8	318.5	319.4	*Model weighted average*	*Relative variable importance*
df	6	8	12	2	6		
weight	0.97	0.01	0.01	0.00	0.00		
lnPop	-	-	0.13	-	0.01	0.00	0.01
Distance	-	-	0.02	-	0.01	0.00	0.01
AllCastes	-	-	0.01	-	0.09	0.00	0.01
WealthGini	**-0.08**	-	**-0.07**	-	**-0.03**	**-0.08**	**0.99**
Age	-	0.01	0.02	-	-	0.00	0.03
EduYrs	-	0.06	0.07	-	-	0.00	0.03
hhSize	-	-0.07	-0.07	-	-	0.00	0.03
lnWealth	**0.53**	**0.54**	**0.52**	-	-	**0.53**	**1.00**
Dalit	**-1.50**	**-1.28**	**-1.24**	-	-	**-1.49**	**1.00**
FRAC	**1.39**	**0.73**	**1.65**	-	-	**1.39**	**1.00**

Table 17b. Vaikkal effect size calculations

	Difference	MWA	Effect Size
WealthGini	0.27	-0.08	0.98
lnWealth	6.91	0.53	39.65
Dalit	1	-1.49	0.23
FRAC	0.5	1.39	2.00

The winning 'inequality' model consists of wealth, wealth inequality, demographic dominance and Dalit terms alone, receiving an Akaike weight of 0.97. The effect of *WealthGini* is small, with a change in *WealthGini* equivalent to moving from Keelanavayal to Palangi corresponding to a 2% reduction in chances of having a vaikkal. Wealth has a large effect, having a million more rupees makes a farmer 39 times more likely to have a *vaikkal*. In the entire study only 30% of respondents had 1 million Rs. or

more. Increasing the demographic dominance of ones caste to 50% is associated with a having twice the odds of having a vaikkal. Finally, being a Dalit makes you 76% less likely to have a vaikkal, all else being equal.

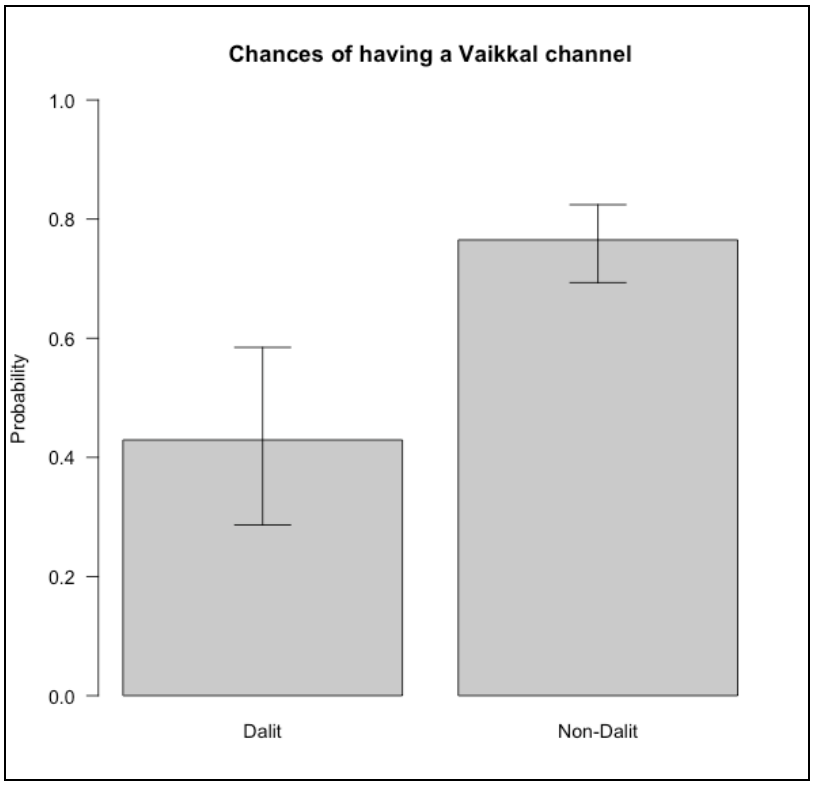


Figure 12: Chances of having a *vaikkal* irrigation channel extend to a farmers fields, by Dalit status, as predicted by the best fit model.

Since the *vaikkal* network was created by the social system and forces in these villages, and *vaikkal* distribution is best predicted by social inequalities, it is reasonable to assume that *vaikkal* distribution itself is a function of these social inequalities, including Dalit status, wealth, wealth inequality, and demographic dominance. This fact inflects the interpretation of the *vaikkal* effect, reinforcing the importance of caste-driven

forces of inequality. This interpretation is further supported by anecdotal evidence on the nature of Dalit livelihoods.

Anecdotes

In these communities, being born a member of the Dalit caste (the Sakkliyar), makes one prone to a life of discrimination and exclusion. This pattern is common across much of modern India, and is confirmed in part by the responses to the survey question "How does your caste affect you," summarized below.

A Dalit man in Keelanavayal was interviewed in his house. He mentioned that the Podhu Kootam (village justice system) is very strict. If anyone makes a mistake, the Thalaivar (village head men) will offer advice, and if that advice is not followed, they will be beaten. This sort of response was not uncommon, but during the interview a neighbor kept urging the farmer in Telegu not relate these facts out of fear of being exposed, and punished. Another Keelanavayal Dalit expressed the same dismay over oppression in his village.

> *"We must go to Kukkal [a different village] to borrow or rent equipment, no one will share with us here. Only other SC [Dalits] will trade labor with us, no one else. We are treated very badly here. Any problem is cause for the high caste people to beat the SC."*

A Dalit farmer in Kumbur related to us that he prefers not to have a *vaikkal* connection and the associated contact with the irrigation system because he is afraid of beatings from high caste people. These responses contrast markedly from the typical non-Dalit response "caste causes no problems for us." In many cases non-Dalits actively

note their own caste rank, "We are high caste, so we have no problems here." Most aspect of life in the study region revolve around Dalit status.

> *"Sometimes high caste people treat us very bad. That means we depend financially on high castes, the government does not give us proper support, and the high class people restrict SC education" – Keelanavayal Dalit*

Another Dalit farmer from Poombarai confirms that the high castes restrict their education. Moreover,

> *"We are not allowed to speak in Podhu Kootam [village council meetings]. The village people will not solicit money from SC people for temple improvement work. In this village SC people do not have land for irrigation." – Palangi Dalit*
>
> *"We share water but S.C. and S.T. people are not allowed." – Poombarai Manadiar*

Given these sorts of reports, and the rarity with which new *vaikkals* are created (no interviewee reported vaikkals being created more recently than 20 year ago), it becomes easy to believe that the Dalits are also given denied opportunities to have a *vaikkal* extended to their lands.

CONCLUSION

Consistent with results from other societies, meaningful cooperation in the irrigation sector (*workdays*) is damaged by increasing caste diversity, yet shows no strong effect of ethnic hierarchy (*dalit*). Demographic dominance (*FRAC*) , on the other hand does increase cooperation. The *equal distribution* responses reveal that the most relevant

measure of equality in the irrigation system is having a *vaikkal* at all. As being a Dalit makes one much less likely to have a *vaikkal*, or own land, the hierarchical explanation seems concise here, as well. Similarly, perceptions of *procedural fairness* were damaged caste hierarchy (*dalit*), and improved by caste demographic dominance (*FRAC*).

One interpretation is that caste-driven inequities are embedded in the *vaikkal* distribution itself, rather than in the water distribution those *vaikkal* provide. This explanation follows Mosse's (2006) qualitative description of elite privilege and water access. Perceptions of fairness may be one of the best indicators of real equity precisely because they are, as non-material private beliefs, impervious to coercion, and can reflect embedded inequalities as well as daily discrimination.

I have provided evidence that ethnic factors such as low-caste designation, caste demographic dominance, and caste diversity strongly determine cooperative outcomes in collective management of irrigation. Ethnic diversity diminishes contribution of labor to village irrigation systems. Caste rank reduces the perceived fairness of irrigation. Demographic dominance increases both cooperation and perceptions of fairness. Finally, the most predictive factor across the entire study, access to *vaikkal* irrigation channels, increases cooperation, perceptions of adequacy, fairness, and equal distribution. *Vaikkal* access is in turn determined by wealth, wealth inequality, Dalit status and demographic dominance.

These results highlight the importance of detecting and quantifying ethnic dominance both in terms of hierarchical stratification and demographic magnitude, and reveal ethnic dominance as a cooperative challenge to society and an important dimension in the study of cooperation across societies.

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Chapter Four

Social exclusivity and reciprocity in rural Tamil society

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ABSTRACT

The importance of inter-ethnic forces such as ethnic diversity and ethnic stratification in determining the social outcomes is well appreciated. Cross-cultural evidence suggests that the presence of ethnic boundaries damages the success of cooperative projects in many realms, and ethnic dominance exacerbates this effect even further. Despite this recognition, and the massive literature on the evolution of cooperation, the mechanisms underlying the anti-cooperative effect of ethnic diversity in extant societies are still poorly understood. Human cooperation beyond kin is thought to arise from pro-social instincts, depend on reciprocal altruism, and rely heavily on culturally-defined groups as natural containers of cooperative behavior. Thus social cohesion and reciprocity are critical features of any cooperative social regime.

The current study presents data on the influence of caste-based ethnic diversity and ethnic hierarchy on measures of social cohesion and reciprocity between rural farmers in villages in Tamil Nadu's Palani Hills to uncover the proximate mechanisms by which cooperative reductions occur in multi-ethnic societies. I provide corroborating evidence that increasing ethnic diversity may be linked to decreases in social justice and indirect reciprocity in the form of social donations between families. I also discover evidence that ethnic stratification between caste groups limits cooperative regimes in ways that pure ethnic diversity does not. In particular, ethnic hierarchy strongly covaries with ethnic exclusivity and a reduction in indirect reciprocity. This finding matches the predictions of a recent theoretical model on the evolution of ethnic stratification. I also find that direct reciprocity in the form of agricultural labor exchanges appears immune to the negative effects of caste diversity and hierarchy.

These results provide a unique insight into the dynamics of ethnic relationships in multi-ethnic societies, affirming that (1) ethnic stratification or hierarchy is more detrimental to cooperation than mere 'unranked' ethnic diversity, and suggesting that (2) social exclusivity is strongly increased by ethnic stratification, and (3) direct reciprocity is more robust to cooperative failure across ethnic boundaries than indirect reciprocity. These results confirm and extend current theory of human cooperative regimes, and may be of value in constructing successful community development projects in multi-ethnic communities.

INTRODUCTION

Caste society in India has for centuries provided an ideal study in social inequality and ethnicity (Weber, 1958; Srinivas, 1957; Marriott, 1976; Bayly, 1999; Dirks, 2001). Yet caste has been endlessly troublesome for anthropological scholars, and theoretical consensus has been perpetually elusive, even as social science and anthropological paradigms have waxed and waned. Early colonial Europeans, looking for a means to explain Indian social diversity, often naively used the Brahminical Hindu '*varna*' system of social classes as an accurate description of society on its own terms, mistaking Hindu religious texts for books of law (Micheals, 2004). For India, the ethnic identities have coevolved with interpretations of ethnic identities. The origin of the Indian state is inseparably intertwined with colonial British conceptions of ethnic Indian social identity (Srinivas, 1957; Dirks, 2001). Still, India provides a rich natural experiment on the ethnic dynamics. A important and contentious aspect of Indian history is ethnic stratification in the context of Indian caste.

Kroeber (in Seligman, 1930) described caste is a special case of social class. Two important elaborations can be made upon this definition. First, as Gadgil and Malhotra (1983) observed, many *jatis* originate as local ethnic and tribal groups, originally differentiated largely by ecological particulars and local separation. India contains literally thousands of such *jatis*. Second, while the few most powerful and most oppressed groups are clearly ranked, the majority of *jatis* cannot be specifically ranked, and any hierarchical position is vague, unspecified or contested (Srinivas, 1962).

Though heavily debated and critiqued, Dumont's (1970) famous attempt to distill the most important aspects of caste society, has nonetheless formed a necessary

foundation upon or against which succeeding theories have stood. Dumont's *Homo hierarchicus* theory suggested that caste is best understood as the social outcome of a hierarchical ideology common across India. While succinct, Dumont's theory is largely a static and ahistorical model of Indian society (Vincentnathan, 1996). Although Appadurai (1986, 1988) critiques Dumont for essentializing and exoticizing the concept of hierarchy, his contribution remains important. Although hierarchy is predominant in India, it is not total, not can the foundations of Indian society be reduced to hierarchy. Indeed, non-hierarchical cultures exist within caste villages (Deliége, 1994) and tribal populations (Gardner, 2000), and modern economic forces are having some erosive effect on caste society in cities (but see Luce, 2007).

Recent histories of India (Bayly, 1999) paint a very complex picture of the origin and evolution of caste, and suggest ultimately that caste is the dynamic result the many contingencies of politics, demographics, and social identity. Scholars agree that caste has been historically (Bayly, 1999) and socially (Dirks, 2001) constructed, but despite much agreement about the current state of Indian caste, a single accepted theory of the most important aspects driving the evolution of Indian caste has yet to coalesce.

THE HENRICH-BOYD MODEL OF ETHNIC STRATIFICATION

One way to advance theory is to specify dynamic mathematical models of ethnic stratification, so that scholars may focus on the relative importance of countervailing forces in creating and maintaining both social identity and power hierarchies. We must first start by carefully limiting the features and forces on the ethnography of caste to a

small, but functional core set. Velassery (2005) and Quiqley (1995) list and contrast the key elements various scholars consider central in caste society. Further consolidating these lists yields a basic set of features of caste-stratified society, against which theories of caste stratification can be based.

1. social division of society into bounded groups
2. occupational or economic separation of groups
3. social separation and cultural differences between groups
4. power hierarchies between groups

This is list merely represents a set of features, leaving out any causal interaction. Henrich and Boyd (2008) present a mathematical model of ethnic stratification, providing a functional theory of social and economic forces which drive social stratification. I argue that the Henrich and Boyd model presents a parsimonious and dynamic theory of ethnic stratification which fits the dynamics of caste society well. The Henrich and Boyd model is built on a few key premises, (a) economic specialization generates a surplus, (b) individuals preferentially imitate those with the greatest economic success, and (c) sub-populations exist. These assumptions are each simple, and individually justifiable.

The Henrich-Boyd model predicts ethnic stratification is favored by (1) greater cultural isolation between groups, (2) greater surplus, (3) more equitable divisions between specialized economic roles, and (4) greater importance of economic success in guiding cultural learning. These results come of no surprise to students of Indian caste. While ultimately the model dynamics must speak for themselves via comparisons with data, putting some of the most important dynamics of this model into common terms can aide the interpretation. The four most influential variables are the migration between sub-populations (or caste-switching), m, the size of the economic surplus, G, the added

weight that individuals give to economic success in choosing individuals to imitate, β, and the basic split of benefits between different economic specialties, γ. Each of these parameters can be interpreted in terms of caste society.

First, in caste societies, switching caste identity is nearly impossible. In the model, low migration between subpopulations, m, increases the chances for stratification, and at a given level of stratification, less migration causes increasing inequality. Second, economic surplus is one of the main effects of an agrarian economy, and as Borgerhoff Mulder et al (2009) show, agrarian societies are likely the most economically unequal form of society, in comparison to hunter-gather and industrialized societies. Borgerhoff Mulder et al speculate that agrarian surpluses are directly responsible for this extreme wealth inequality. This matches Henrich and Boyd's model in which increases in the parameter for surplus, G, causes greater stratification and inequality. Third, the Henrich-Boyd model incorporates a term, β, denoting the weight given to imitating economically successful peers. As this weight increases, so do both stratification and inequality. The reason is that, ceteris paribus, as individuals become more discerning of the success of economic strategies, they will adopt the most effective strategies *of their peers within their subpopulation*, not the strategies of other castes, form which the are isolated by the mixing rate, m. Finally, the model includes γ, the proportion of the surplus which goes to the high stratum. As γ approaches one half (an even share of the surplus) stratification becomes increasingly likely. At first this seems counter-intuitive, since equitable sharing is not associated with hierarchical ethnic stratification. However the underlying logic is sound. As sharing because increasingly unequal (γ approaches 1) high caste individuals will gain at the expense of low caste people, who will nonetheless be able to observe (at

rate m) and imitate (with bias β) those high castes. Therefore, all else being equal, as the inequality grows, the chances of low castes imitating the high case also grow, reducing the likelihood of social stratification. There is thus is a boundary tradeoff in the Henrich-Boyd model, between stratification and economic inequality.

This approach has three important benefits as a theory of caste. Primarily, the model is not a static description of a dynamic process, but a dynamic process itself, and a parsimonious description of the way a set of forces lead to the evolution of stratification. Both egalitarian and stratified societies are possible within the Henrich-Boyd model, but the combination of parameter values uniquely determine which type of society will arise. Next, social inequality and stratification can both result even when individuals are imitating the payoff maximizing strategies. Low caste individuals do not choose their strategies poorly or irrationally, but they find themselves in a situation where the only certain strategies are available, and those strategies ultimately perpetuate their status. Additionally, this model is robust because of what it does not assume. More over the model does not assume coercion of one group by another, or the existence of exogenous group differences, both of which would tend make the evolution of stratification even more likely.

My goal here is simply to lay out the most concise and dynamic theory on the evolution of caste to date, since caste-based social dynamics are the focus of this paper. India is an exemplary place to study ethnic dynamics and social inequality, because the effects are so clear in daily life. It is important to note that a dynamic model of caste such as this is not tautological simply because caste in India contains hierarchy, economic specialization, and ethnic grouping *a priori*. Instead Henrich and Boyd (2008) supply a

first version of the long desired dynamic theory of the social construction of caste, and uniquely suggest that ethnic stratification, ethnic grouping, and economic specialization positively reinforce each other through time.

If ethnic grouping and hierarchical stratification coevolve as Henrich and Boyd suggest, then how are these two features of caste inter-linked on a daily basis? More precisely, what features of human cooperation are active in causing intra-ethnic cooperative limitation?

For decades, human cooperation beyond kin has been thought to be supported by reciprocal altruism (Trivers, 1971; Axelrod and Hamilton, 1981). Theory also suggests that non-kin cooperation might arise from pro-social instincts (Fehr and Fischbacher, 2002, 2003), and highlights the importance of culturally defined groups as container of cooperation (Boyd and Richerson, 1985; Gintis et al, 2003). In this set of theory, symbolic ethnic markers evolve in tandem with cooperative behavior within social groups, and are maintained most strongly at ethnic boundaries (McElreath et al., 2003; Boyd and Richerson, 1987). Finally, indirect reciprocity makes cooperation viable within a culturally bounded group (Nowak and Sigmund, 2006; Panchanathan and Boyd, 2004). Recent evidence confirms the earlier models. Efferson et al. (2008) demonstrate that humans quickly adopt previously meaningless markers of group identity in order to assort as a means of solving cooperation problems.

RESEARCH QUESTIONS

I am primarily concerned here with the influence of ethnic diversity and ethnic stratification on cooperation. In this regard, social connectedness and the scope of

reciprocity form a datum of primary importance. How do 'non-ranked' ethnic differences (or 'pure ethnic diversity') and ethnic stratification relate to, or coevolve with cooperation, reciprocity and social connectedness? In this paper, I test how caste dominance and caste diversity influences reciprocity, social exclusivity, and social justice using survey data from rural agricultural villages in Tamil Nadu.

I further examine the influence of the domain of reciprocity on these questions. These villages have tight economic systems and acute material needs. Meeting these economic challenges involves much informal labor sharing. But these same villages also have tight social networks involving social donations across castes. I present data to answer the question, "Is reciprocity in economic or social realms more influenced by ethnic diversity or ethnic stratification?"

STUDY SITES

This study was conducted in the Palani Hills of western Tamil Nadu, an eastern escarpment of the western ghats, bordering Kerala (see Figure 1). The upper Palani Hills are home to 20 agricultural villages varying in size from 500 to 6000 people varying in caste diversity between 3 to 13 caste groups. These villages, originally settled by the Manadiar group, retain traditional governance institutions separate from the official government panchayat system. The similarity of these institutions to those on the Tamil plains (Mosse, 2006), oral tradition, and historical evidence (Francis, 1914; Bahadur and Aiyangar, 1942) all suggest that they are a cultural legacy of the Pandiya kingdom that

the Manadiar brought with them when they migrated into the hills approximately six centuries ago (Francis, 1914).

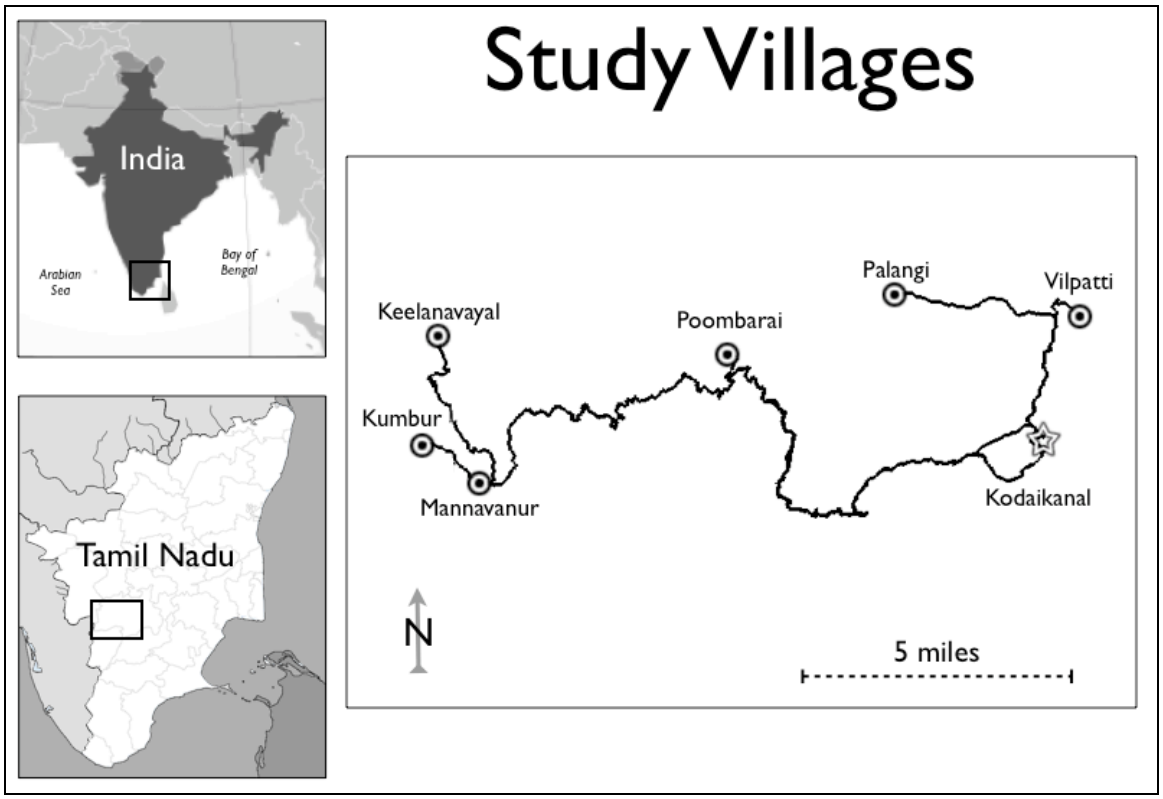

Figure 13. Study villages in the Palani Hills, Tamil Nadu, India.

Five months of ethnographic investigation on the social identity, oral history and village organization across the Upper Palani villages form the basis by which caste relationships were classified. Caste hierarchy in the Palani Hills region is centered on two focal caste groups at opposite ends of the power spectrum, which share a long history. The Manadiar caste are in the center of village power; in most villages the Manadiar hold some or all of the hereditary leadership positions called *thalaivarhal* (literally, 'headmen'), and their influence within the village justice system or Podhu Kootam ('common crowd'). By contrast, the Sakkliyar, a Dalit group which shares a deep history with the Manadiar, having arrived around the same time as the Manadiar,

have no formal power. For instance, women and Sakkliyar individuals are excluded from the semi-sacred village commons called the *manthai* where village meetings are held, and thereby physically blocking access to the space of village justice.

In Palani Hills villages the first *thalaivar* position is called the Manadiar and in Poombari it is occupied eponymously, while two further *thalaivar* positions are occupied by the Thevar (*Periyathanam*) and the Mudhaliar (*Manthiriar*) elders. The Sakkliyar also bear traditional village servant positions, including the village crier (*thandalkarar*), the water controller (*neer-nikam*), and the festival celebrant (*vettiyan*). No middle castes hold any high-status or low-status traditional roles. These formal roles betray the historical caste-driven power asymmetry, and are summarized in Table 1.

Just as the oppression of Dalit groups is common in much of Tamil society (Mangubhai and Irudayam, 2000), the life of most Sakkliyar in the Palani hills is one of subjugation in all aspects of village life, social and economic, informal and institutionalized. The hierarchical relationship between the Manadiar and the Sakkliyar is an ancient and central aspect of life.

Table 18. Caste-wise distribution of village positions.

	Poombarai		**Mannavanur**		**Kumbur**		**Keelanavayal**		**Vilpatti**		**Pallangi**	
Thalaivarhal (leadership positions, inherited)												
Manadiar	1	Manadi	3	Manadi	5	Asari	3	Asari	4	Manadi	1	Manadi
Manthiriar	1	Mudali	1	Pillai	1	Chetti	1	Mudali	2	Pillai	1	Mudali
Other Thalaivar	1	Thevar	1	Manadi	1	Chetti	1	Reddi	1	Retti		
Servant (servant positions, selected)												
Thandalkarar	3	SC	1	SC	1	SC	1	SC	1	SC	1	SC
Neer Nikam	4	Panchayat	5	SC	3	SC	2	any	3	any	0	Thandal
Vettiyan	20	SC	13	SC	15	SC	8	SC	16	SC	10	SC

SC = Scheduled Caste (Sakkliyar), the major Dalit caste in the Palani hills region.
Servant positions are selected by the Thalaivar ('headmen') for 1-3 yr terms

SAMPLING

An extensive semi-structured, caste-stratified survey of farming households was conducted across six villages with communal irrigation systems varying in size, number of castes, and distance from the local city, Kodaikanal. In each village all castes with ten or more households were sub-sampled, and a minimum of 9 households were surveyed for each caste group. Like in many regions of India, these villages were largely composed of neighborhoods segregated by caste. This afforded an efficient randomized sampling scheme. Since the spatial dimensions of caste neighborhoods and the caste populations of each village were known approximately beforehand, I calculated the sample size for each caste, and sampled at random within each spatially constrained ethnic neighborhood. Overall, 269 heads of household were interviewed, 11 of these were later excluded resulting in a total of 258 surveys.

The survey was conducted between April and June, 2008[2]. During sampling days, the research team would rise early for the travel to the villages in order to arrive before the farmers had left for work in the field. The majority of sampling occurred between the hours of 8 and 10 am and 2 and 5 pm, when most farmers were at home.

Table 19. Sample densities by village

Village	pop.	households	castes	10+ house hold castes	n	average caste-wise household sample
Mannavanur	5029	762	8	4	43	33%
Poombarai	4456	1262	11	8	69	14%
Vilpatti	2032	508	10	6	58	13%
Kumbur	1051	208	5	3	33	18%
Keelanavayal	700	104	8	2	30	44%
Pallangi	700	133	3	3	26	33%

[2] The survey tool was the final of eight iterations of testing and revision. The first two version 8 surveys were conducted in Manavanur in January and February of 2008, the remainder were conducted between April and June, 2008.

POPULATION CHARACTERISTICS

Of the surveyed heads of households, the average age was 46.7 with the youngest 19, and the oldest 87. The mean household size was 4.5 and the average years of education of the household head was 4.9, but over one quarter reported zero years of education, while one person reported 17 years. Of all household heads, four were women, and only 2% reported any additional occupation to farming.

The cost and availability of transport makes these villages very isolated. As a result many factors decline with the distance from Kodaikanal, including the mean years of household education. Mean household education starts from 6.7 yrs on average in Vilpatti, and declines by approximately one month per kilometer over the 44 miles to Keelanavayal, where the mean is 3 yrs lower on average (single correlation, $R2 = 0.16$). Similarly, yearly exposures to external culture (see Table 3 for variable description) shows a similar pattern starting from ~1500 yearly exposures in Vilpatti and Pallangi and effectively dropping nearly 16 exposures per mile to reach a yearly 803 exposures in Keelanavayal. Such a difference in exposure likely has a strong influence on the social norms of the people living in these villages. Agricultural income also declines with distance from Kodaikanal, dropping 66 Rs. From Vilpatti to Keelanavayal, a 30% reduction in daily pay.

In this region, aside from plowing with oxen, the agricultural enterprise is exclusively manual. Out of necessity, this splits individuals on any given day into the land owners and workers, or 'coolies'. All individuals work on their own fields, if they own any, and 76% work on others fields as well. 94% of Dalits work as coolies, in comparison to 77% of Manadiar. On the hiring side, only 51% of Dalits hire others to

work on their fields, while 92% of Manadair hire our their work. As a result, Dalits on average earn 7,660 Rs per year from coolie labor, while Manadiar average only 4,900 Rs. On average, dalits hire 194 worker-days of labor per year, while Manadiars hire 480 worker-days, well over double the Dalit figure. These caste-correlated inequalities are also born out in land ownership and wealth.

Villagers owned an average of 2.3 acres, with 1.31 acres of irrigated land. Mean Dalit land holding was 0.46 acres, while Manadiars owned 4.45 acres on average. Of the 45 households owning no land, 58% were Dalit. Of the 14 individuals owning five 5 or more acres all are middle and high castes. A comprehensive wealth estimation was calculated based upon items such as house, land, livestock and vehicle ownership (see table 3). Mean wealth was 398,790 Rs. For Dalits and 1,270,730 Rs. For Manadiar.

Each farmer was asked to rank the importance of six factors in determining their social identity. These factors were family, caste, religion, political parties, hometown, and occupation. There was a very clear trend in pREFERENCES within the entire sample. Out of a total of 6 points, family averaged 5.9, followed by occupation (5.0). The remaining categories had overlapping confidence regions but were as follows hometown (3.5), caste (2.6), religion (2.4), political (2.1). The clear, sample wide preference for family and occupation is relevant to the current study because caste was not even close to being an highly ranked component of reported social identity factors.

ANALYSIS

The survey data was analyzed with hierarchical multiple regressions using either the linear, logistic, binomial, poisson or negative binomial distributions as appropriate for each response variable. This multilevel analysis is appropriate because predictor variables come from both individual response data such as education and acres of land owned and village-level variables such as population and caste diversity. Since it is not possible to know or measure everything that may important which varies by village, I include a random effect for village. This random effect of village accounts for all those effects that may influence the results which vary by village but were unmeasured. A heuristic linear regression equation for response variable $R_{i,v}$ for individual *i* in village *v*, is:

$$R_{i,v} = \mu + \mathbf{Z}_v + \beta \times [villagesize]_v + \gamma \times [wealth]_i + \varepsilon_{i,v} \quad 1$$

where μ is the grand mean, $\mathbf{Z}_v$ is the village mean, $\varepsilon_{i,v}$ is unexplained variance, and β and γ are coefficients for a village-level and an individual-level predictors, respectively. In linear regressions, village level heterogeneity, ε_v is modeled as the Gaussian distribution, N

$$\mathbf{Z}_v \sim N(0, \sigma_v^2) \quad 2$$

with mean 0 and variance σ_v^2, while model error would be

$$\varepsilon_{i,v} \sim N(0, \sigma_\varepsilon^2) \quad 3$$

This multi-level analysis has the important benefit of allowing a determination of the proportion of variance explained by village-level versus individual-level variation. Analyses were computed in R 2.9.2. Predictor variables are detailed in tables 3-5 and response variables in table 6.

Table 20. Predictor variable descriptions.

Variable	type / unit	Description
Individual Level Variables		
Age	yrs	
Household size	#	
Education	yrs	
ln(Wealth)	1,000 Rs.	Total value of owned items, in 1000 Rs. Increments. Wealth = .01 + livestock*10 + pumps*5 + house*300 + two-wheeled-vehicle*50 + four-wheeled-vehicle*750 + acres-owned*7000
FRAC	0-1	Demographic dominance. Proportion of village population represented by own caste.
Dalit	binary	Dalit (1), all others (0)
STRAT	1,2 or 3	Constructed from responses from open-ended survey Question # 22 (How does your caste effect you?), and survey comments. A single self-nomination as "powerful caste" will promote that caste from 2 to 3. Manadiar always ranked 3, Sakkliyar always ranked 1. See Table 4 for details.
STRAT * FRAC	interaction	The interaction of levels of power stratification and demographic dominance.
Village Level Variables		
Population	#	Village population as reported by the 2001, Indian Census or estimated by the Panchayat clerk for that village, 2008.
Distance	km	Distance from Kodiakanal. Kodaikanal (population 32,931) is the closest city and provides influential social and economic opportunities and cultural contacts (2001, Indian Census).
Caste Diversity	#	The number of Jathis in a village with a population of more than 10 households.
Wealth Gini index*	0-1	The Gini coefficient of estimated wealth by village. Wealth estimated as above.

*Calculated per Milanovic (1997).

Table 21. Caste stratification index construction.

Caste	**Keelanavayal**	**Kumbur**	**Mannavanur**	**Pallangi**	**Poombarai**	**Vilpatti**
Mudhaliyar	2	2	2	2	3	3
Thevar	2	-	2	-	3	-
Reddiar	3	-	-	-	3	3

The village-based caste stratification system was coded from survey Question # (How does your caste effect you?), and survey comments. A single self-nomination as "powerful caste" will promote that caste from 2 to 3. Manadiar always ranked 3, Sakkliyar always ranked 1. This system only changed the stratum

of Reddiar, Thevar and Mudhaliar castes in three villages, Keelanavayal, Poombarai and Vilpatti. All other castes kept their original ranking of 2.

I conducted a separate mixed effect regressions, with a random effect for village, for each of seven dependent variables, matching probability distributions to each variable as appropriate. For index variables such as *PK Index*, and *Exclusivity*, I fit binomial models because they accurately represent the sum of multiple binary choices. For binary response variables such as *PK Castes*, I use logistic regression. For the count variables *KV days*, and *KV partners* I used negative binomial and poisson regressions, respectively. For continuous variables such as *Donations*, I log transformed the response and used standard linear models. Of all models, only *Exclusivity*, had non-negligible village-level variance, for which I report the mixed model estimates. Multivariate correlations showed no sign of association between dependent variables (maximum pair-wise correlation = 0.3655).

Table 22. Village-level predictor variables

	Population (households)	**Distance (km)**	**Castes (>10 hh)**	**Wealth Gini coefficient**
Keelanavayal	104	44	2	0.39
Kumbur	208	39	3	0.46
Mannavanur	762	36	4	0.45
Pallangi	133	10	3	0.66
Poombarai	1262	18	8	0.49
Vilpatti	508	5	6	0.43

Table 23. Village-level predictor variable correlations

	Wealth Gini	Distance	Population	Castes All
Wealth Gini	1.0000			
Distance	-0.3517	1.0000		
Population	0.0105	-0.2408	1.0000	
Castes All	-0.5178	-0.3019	0.7520	1.0000

Table 24. Response Variable descriptions

Variable	**Type**	**Description**
Village Justice		
Podhu Kootam Adequacy (PK Index)	index 0-9	Sum of nine binary response variables about the adequacy of the Podhu Kootam system. Questions 23, 24, 25, 26a-c, 30, 31, paraphrased:

		Podhu Kootam give you equal influence? *Podhu Kootam meet today's needs?* *New groups included?* *New groups given Podhu Kootam leadership positions?* *New groups given other positions?* *Choose Podhu Kootam over Panchayat?* *Choose Podhu Kootam over Police?* *Trust Podhu Kootam to be equal?* *Podhu Kootam leadership skill* Questions 24 and 26 were recoded as binary variables. Item reliability: Cronbach's $\alpha = 0.6787$
Powerful Castes (PK Castes)	binary	Question 28b, "Do any groups get special treatment or have unfair power in the Podhu Kootam or village affaris?" (y/n) (political members, rich people, powerful castes)
Exclusivity	Index 0-22	Sum of 22 opportunities to nominate individuals of one's own caste in the realms of borrowing and lending cash, agricultural equipment, social, political and economic contacts, and reciprocal agricultural labor exchange. Questions 11, 12, 13, 14, 15c, and 20. Item reliability: Cronbach's $\alpha = 0.6495$
General Cooperation		
Social Donations (Donate)	Rs.	The sum of social contributions in Rupees, Question 10. Item reliability: Cronbach's $\alpha = 0.7411$ Log transformed.
Reciprocal Labor (Kamal Velai)		
Days per month (KV Days)	count	Question 15a, "If so, how many days during the growing season do you help fellow farmers?" (days/mo.)
Partners (KV Partners)	count	Question 15bi , "If so, how many farmers do you have a reciprocal relationship with?"

Table 25. Response Variable Summaries

	PKIndex	SpecialCaste	Xindex	Donate	KVdays	KVpartners
Keelanavayal	6.8	0.8	7.5	4,603	6.6	4.2
	(1.8)	(0.4)	(5.6)	(5,140)	(5.2)	(2.6)
Kumbur	7.5	0.9	10.2	4,009	6.9	4.2
	(1.1)	(0.4)	(4.8)	(4,762)	(5.2)	(1.8)
Mannavanur	6.7	0.7	5.2	6,056	5.7	3.8
	(1.4)	(0.5)	(4.1)	(7,354)	(4.3)	(2.1)
Pallangi	5.0	0.8	8.7	1,623	3.8	2.0
	(2.4)	(0.4)	(4.3)	(2,072)	(3.4)	(1.3)
Poombarai	4.7	0.8	9.3	2,497	3.8	3.9
	(2.4)	(0.4)	(5.2)	(3,596)	(1.9)	(2.5)
Vilpatti	5.6	0.9	8.3	3,186	4.2	4.0
	(2.1)	(0.3)	(4.4)	(4,521)	(3.4)	(2.5)

Table 26. Regression Summaries

Model	**PK Index**	**PK Castes**	**Excl. Index**	**KV days**	**KV partners**	**Social Donations**
Family	binomial	logit	binomial	neg bin	poisson	log linear(DV)
Empty VSD	0.52	0.00	0.31	0.24	0.21	0.30
Full VSD	0	0	0.29	0	0	6E-06
Multi-level	fixed	fixed	mixed	fixed	fixed	fixed

	3.59	5.38	-0.94	3.30	2.31	**10.38**
(Intercept)	(0.92)	(10.31)	(2.25)	(0.95)	(0.70)	**(1.33)**
	0.19	-0.15	-0.06	0.03	0.09	0.26
lnPop	(0.12)	(1.11)	(0.24)	(0.11)	(0.09)	(0.16)
	0.01	-0.07	0.00	0.01	0.00	0.00
Distance	**(0.00)**	(0.05)	(0.01)	(0.01)	(0.00)	(0.01)
	-0.25	-0.15	0.03	-0.04	0.00	-0.13
AllCastes	**(0.06)**	(0.63)	(0.12)	(0.05)	(0.04)	(0.08)
	-0.07	-0.18	0.00	-0.02	-0.03	**-0.06**
WealthGini	**(0.01)**	(0.16)	(0.03)	(0.01)	(0.01)	**(0.02)**
	0.01	-0.01	0.00	0.00	-0.01	0.00
Age	(0.00)	(0.03)	(0.00)	(0.00)	(0.00)	(0.00)
	0.03	-0.14	**0.02**	-0.01	0.00	0.02
EduYrs	**(0.01)**	(0.12)	**(0.01)**	(0.01)	(0.01)	(0.02)
	-0.09	0.10	**-0.16**	-0.02	-0.01	**0.19**
hhSize	**(0.04)**	(0.28)	**(0.03)**	(0.04)	(0.03)	**(0.05)**
	0.01	-0.17	**0.03**	-0.05	-0.02	0.03
lnWealth	(0.03)	(0.27)	**(0.02)**	(0.02)	(0.02)	(0.04)
	2.34	31.22	1.73	0.55	0.62	-3.76
FRAC	(1.62)	(24.07)	(1.03)	(1.66)	(1.33)	(2.32)
	-0.14	**5.32**	**0.81**	-0.22	-0.02	**-0.76**
Dalit	(0.20)	**(2.26)**	**(0.13)**	(0.20)	(0.16)	**(0.28)**
	0.45	4.26	**0.29**	-0.15	0.08	**-0.69**
STRATa	**(0.17)**	(2.34)	**(0.11)**	(0.18)	(0.13)	**(0.25)**
	-0.77	-13.83	-0.02	0.09	-0.26	1.78
STRATa*FRAC	(0.63)	(9.56)	(0.40)	(0.65)	(0.51)	(0.91)
AIC	1086	70.71	1134	1224.4	1004.5	756.97
Log Likelihood	-530.74	-24.96	na	-598.78	-489.26	-364.49
ML pseudo-R2	0.53	0.17	na	0.14	0.15	0.16

Table 27. Effect sizes

	Diff	**PK Index**	**PK Castes**	**Excl. Index**	**KV days**	**KV parts**	**Donate**
lnPop	0.69	1.14	0.90	0.96	1.02	1.06	1.20
Dist	20	1.29	0.26	0.91	1.14	1.03	1.02
Castes	6	0.22	0.41	1.20	0.80	1.02	0.45
Gini	0.27	0.98	0.95	1.00	0.99	0.99	0.99
Age	10	1.07	0.95	1.02	1.00	0.93	0.96
Educ	5	1.16	0.50	1.11	0.97	1.00	1.10
HH	2	0.84	1.23	0.73	0.97	0.98	1.46
lnWealth	6.91	1.04	0.32	1.27	0.72	0.86	1.24
FRAC	0.5	3.22	6.0e6	2.38	1.32	1.36	0.15
Dalit	1	0.87	204.8	2.25	0.80	0.98	0.47
STRAT	2	2.45	4989.4	1.80	0.74	1.17	0.25
*STRT*FRAC*	1	0.46	0.00	0.98	1.10	0.77	5.95

Effects reported are odds ratios for PK Index, PK Castes, and Exclusivity Index, multiplicative count factors for KV Days and KV Partners, and additive effects for Donations.

RESULTS

Regression analysis reveals that the social impact of ethnic dominance varies markedly between different realms of life. For village-level factors, effect sizes were calculated by computing the largest difference between villages. These were as follows: 1000 additional households, 20 more km of distance from Kodaikanal, six additional castes, and an increase in WealthGini equal to 0.27 (an increase in the fraction of wealth held by the top 20% most wealthy from 60% as in Keelanavayal to 80% as in Pallangi). Effect sizes for individual factors were based upon the following variable increments: 10 additional years of age, five more years of education, 2 more individuals in a household, one million more Rupees of wealth, an increase in caste size from tiny minority to 50% of village population, being Dalit from non-Dalit, and the difference between being a Dalit and a member of a dominant caste. Effect sizes were calculated from these bases unless otherwise noted. Table 9 displays all effects, and I summarize relevant or strong effects below.

Podhu Kootam Village Council

The Podhu Kootam index combines nine responses to capture an aggregate positive sentiment toward the traditional hereditary village justice system. Caste diversity damaged Podhu Kootam ratings, while demographic dominance (FRAC) and hierarchical caste level (STRAT) improved them. The addition of six additional castes was associated with a 78% decrease in the *PK Index* adequacy rating. Increasing the size of a farmers caste from near zero to fifty percent of the village size was linked with a 3.2 fold increase in the likelihood of positive PK ratings. Similarly, moving from Dalit to

High caste equates to 2.5 fold increase in the likelihood of rating the PK well. Even taking these factors into account, the effect of being Dalit *still* reduces these odds by 13%.

Special Caste power in Podhu Kootam

Respondents were asked if they thought that certain people received special treatment within the Podhu Kootam village council, those that answered *yes* were asked to elaborate on which groups receive such preference. Households with two additional members were 1.8 times more likely to state that powerful castes received special treatment in the Podhu Kootam. Adding six castes to a village equated to a 10-fold increase in claims of powerful castes receiving special judicial treatment, and being Dalit equated with a six-fold increase in the estimated likelihood of reporting that certain powerful castes receive special judicial preference in village affairs.

Exclusivity index

The exclusivity index is the sum of all 22 opportunities that farmers had to nominate individuals of their own caste as preferred contacts in social, political, economic, and agricultural domains. An increase of 0.5 in FRAC was associated with a 2.4-fold increase in the probability of nominating someone of one's own caste, while being Dalit was linked with a 2.3-fold increase. Meanwhile moving from Dalit to high caste status was connected to a 1.8-fold increase in the probability of caste exclusivity. Thus dominant castes, Dalits and High castes are much more exclusive than middle castes and demographically small castes.

Social Donations

The social donations variable is the sum of all reported donations from seven important family events (birth, death, marriage, house warming, ear piercing, girls first menses, and religious pilgrimage), in Rupees. At the family level, adding two family members to a household was associated with a 46% increase in donations, while at the village level, adding six more castes correlated with a 55% reduction in social donations. Meanwhile, being Dalit was linked with a 53% reduction, and moving from Dalit to high caste was linked with a 25% reduction on top of that. Significantly, high castes with large demographic presence in a village were estimated to donate 6 times more than expected based on the main effects of FRAC and STRAT alone.

Reciprocal Agricultural Labor

The number of days that farmers participated in Kamal Velai is a measure of real-world reciprocity. The model estimates that individuals with a million rupees more wealth participated in 28% fewer days. Other effects were small or had low certainty. The number of partners that farmers participated in Kamal Velai is a measure of the breadth of the same agricultural reciprocity. All effects were small or had low certainty.

DISCUSSION

Control Variables

With the exception of village distance, village level control variables were not important predictors. Village distance to Kodaikanal was only important in one case, in which it was linked to increases in the perceived quality of the Podhu Kootam system. This may be due to the awareness of alternative means of justice available in Kodaikanal, especially the Police. Population effects estimates were consistently small and of low confidence, and Wealth Gini effects were never correlated with more than a 2% change in outcome.

Individual control variables displayed greater predictive power than village-level controls. Age showed consistently weak effects with low certainty across all response variables. Years of education only created weak effects when highly certain. Increased wealth was correlated with a 27% increase in caste exclusivity. Household size was the strongest individual control, with estimated effects for 2 more individuals *increasing PK Castes* 82% and *Donations* 46% and decreasing *exclusivity* by 27%.

Predictors of Interest

Caste diversity may damage the ability of the traditional village justice system (Podhu Kootam) to function effectively or equitably. Increases in the number of castes had a negative estimated effect on the perceived quality of the Podhu Kootam, and increased the estimates of caste-based privilege within the Podhu Kootam. Increases in the number of castes was also linked with a 50% decrease in donations to other families for social events.

A 50% jump in a caste's share of the village population was estimated to more than double the odds of being caste-exclusive.

The regressions estimate that being Dalit coincides with a six-fold increase in the odds of reporting caste favoritism in the village justice system, a 2.3-fold increase in caste exclusivity, and a 53% decrease in social donations, controlling for individual wealth variation. Two interviews from early ethnography suggest that regional norms may allow Dalits to be excused from certain types of generalized reciprocal donations.

> *The villagers don't restrict them* [the Scheduled Castes] *from taking from their fields because the S.C. are treated as children. – Kukkal man*
>
> *If a death occurs every house gives 10 Rs to that family. Collection occurs from all, even Muslims, except the S.C. The S.C. receive the same death benefits that others do, but it is not asked of them." – retired Poombarai headmaster*

The composite caste stratum variable, STRAT, was also predictive of a number of response variables. Models estimated that increasing from STRAT=1 (Dalit) to STRAT=3 (high caste) has the effect of a 2.5-fold increase in the odds of appreciating the Podhu Kootam, a 1.8-fold increase in the odds of being caste exclusive across social, economic, political and agricultural contexts, and a 75% drop in donations. As the high castes almost exclusively govern the Podhu Kootam we would expect them to favor it.

The interaction of caste hierarchy (STRAT) and demographic dominance (FRAC) denotes the *difference* between the high caste effects for minority versus demographically dominant castes. The interaction is associated with a six-fold increase in total amount of yearly donations, even taking individual wealth and village-wide wealth inequality into account. High castes donate more in social situations when they constitute larger fractions of the village population.

None of the diversity or hierarchy variables had important effects on either the amount (days/month) or scope (# of partners) of agricultural labor exchanges in which farmers participate.

Table 28. Ethnic effects by domain

	Diversity	**Hierarchy**		
	# castes	FRAC	Dalit	STRAT
Social Justice				
Perceived Quality	–			+
Perceived Caste Bias	+ + +		+	
Social Connection				
Caste Exclusivity		+ +	+ +	+ +
Indirect Social Reciprocity				
Donations	–		– –	– –
Direct Labor Reciprocity				
Days	None	None	None	None
Partners	None	None	None	None

CONCLUSION

The results presented here strongly suggest that ethnic factors have a major negative impact on the daily lives of farming families in rural Tamil Nadu. The question here has been how reciprocity, social exclusivity, and social justice are predicted by caste diversity and hierarchical caste dominance.

The data presented here show a much greater effect of ethnic stratification and dominance than of simple ethnic diversity without stratified power differences. Caste diversity does account for some reductions in perceptions of social justice and a decline in indirect reciprocity in social donations. However, on the whole these results are overshadowed by the effect of ethnic hierarchy. More powerful castes rate the village justice system more highly than lower castes, and in which Dalits note a caste-based bias

in the execution of village justice. The effect of Dalit status and caste rank on indirect reciprocity in social donations are greater than that of caste diversity. Moreover hierarchical variables also explain, and would appear to have a strong negative influence on caste-based social exclusivity, while caste diversity does neither.

The idea that social exclusivity is driven most by the forces of ethnic stratification not only confirms Henrich and Boyd's (2008) model, but is also readily supported from the ethnography of India. Social exclusivity takes the form of manifold restrictions on Dalit clothing, location, education, food, and house. Dalits are segregated in nearly every aspect of village life, presenting them with no choice but to assort with their co-ethnics.

> *"We go to work with everyone, but only SC people* [Dalits] *come for our work. We allow all inside our house but high caste people don't come." – Dalit man from Vilpatti*
>
> *"Only other SC* [Dalits] *will do Kamal Velai with us." – Dalit man from Keelanavayal*

For high caste individuals on the other hand, the most salient ethnic boundary is with the Dalit community. As a Manadiar man from Mannavanur responded to the question 'How does your caste affect you?'

> *"No problems, but SC and ST* [Dalits] *should be separated!"*

That the Dalit / non-Dalit divide is most stark social boundary within these communities is yet another line of evidence that social exclusivity, in the form of social segregation, coevolves and covaries with ethnic stratification, as does indirect reciprocity of family-to-family donations. Direct reciprocal relationships show a different pattern, however.

The scale of agricultural labor exchanges seem to be neatly immune ethnic effects of both types. It might be agrued that the difference between *Kamal Velai* and social

donations is that the former is economic in nature and the latter, social. While this is true in general terms, both types of reciprocity involve significant cooperative investment in economic terms (individuals often contribute many months worth of income to other families in the even of births, deaths and marriages). The most parsimonious explanation is simply that *Kamal Velai* involves one-on-one, direct reciprocation, while the realms of donations to major household events is many-to-one, and could only considered a be a form of indirect reciprocity. Thus, is seems, quite clearly that direct reciprocity is more robust to the challenges of cross-ethnic cooperation than indirect reciprocity.

In conclusion, stratified ethnic hierarchy appears much more detrimental to cooperation than and caste diversity, which has been identified as a major cooperative hurdle. The increased social exclusivity and reduced indirect reciprocity evidenced here may underlie the negative cooperative effects of seen in multi-ethnic societies.

The ethnic dominance explored here has the worst effect on those of the Sakkliyar Dalit caste. As the ethnographic evidence supports, Dalits receive the worst treatment, the smallest return for an amount of work, and are the subjects of systematic discrimination. I demonstrate that the village justice system is largely run by and for the high castes, excluding Dalit families categorically. Dalit discrimination is a broad and well-documented phenomenon (Mangubhai and Irudayam, 2000; Micheals, 2007). Combining the power of theory on the evolution of human cooperation with new data, we are approaching a mechanistic understanding of the causes and cures of exactly this kind of ethic stratification.

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Chapter Five

CONCLUSION

Many have linked India's economic problems to the culture of caste. The Indian government, recognizing that caste relationships pose a challenge to a fair and prosperous society, supports an extensive system of caste-based quotas or 'reservations' for government jobs. This reservation system has drawn criticism for exacerbating rather than relieving caste problems. That caste is a problem for India is not in dispute, but if caste slows economic progress, by what precise means does that reduction occur? Answers to this question may be useful in redesigning India's reservation system, and in improving social and economic systems both in India and beyond. This dissertation presents three studies demonstrating that two distinct aspects of caste reduce meaningful cooperation: (1) caste diversity, and (2) caste-based stratification. These cooperative reductions occur both in traditional irrigation systems, and in experimental cooperative games.

In chapter two I presented concrete behavioral evidence that the nature of caste groupings changes the outcomes of public goods games. The experiments provided weak evidence for a negative cooperative effect of more castes, but clear and strong evidence that hierarchical caste relationships reduced individuals' willingness to cooperate. When high and low caste individuals played the public goods game together, they both reduced their contributions markedly in comparison to games in which they played exclusively with individuals from their own caste. Moreover, the addition of a third, 'middle' caste,

to the games, had the effect of *improving* both high and low caste cooperation. Taken together, these results constitute clear evidence for both a preference for ethnocentric cooperation, and a hierarchical inflation factor for ethnically driven anti-cooperative behavior.

The public goods study also revealed an important insight about the way in which cooperative behavior is influenced. Since most public goods games slowly decline in contributions, one might expect that ethnic factors such as diversity or hierarchy would increase the speed of that cooperative decline. Instead, there was no difference between the treatments in the rate of cooperative decline, and the entirety of the caste-combination treatment effects was present from the first round. Participants based their play upon their expectations of cooperation from fellow players before play began. Those expectations determined initial contribution levels, and ultimate outcomes. These behavioral results are only relevant to the extent to which they match real social processes and outcomes, such as the traditional village irrigation system, which I investigated in chapter three.

In chapter three, I found again that caste diversity decreases the days of labor individuals volunteered to maintain the village irrigation structures, and was associated with a reduction in irrigation fairness. Caste stratification also appears to damage fairness in the irrigation system. However, the most predictive variable in all regressions on irrigation in chapter two was irrigation access. Individuals who had access to irrigation water for their fields contributed more days of labor, and rated the system as more adequate, equal, and fair than those without access. But irrigation channels were unevenly distributed between castes. Non-Dalit castes and more populous castes were

much more likely to have irrigation access to begin with. Thus, caste stratification in village irrigation is embedded directly in the channels themselves. And here, again, hierarchical relationships prove to be the most pernicious of ethnic interactions.

In chapter four, I explore aspects of daily life which are hypothesized to be important in determining ethnic interactions, particularly social connectedness, and reciprocal relations. Mirroring my earlier results, I find that (1) ethnic stratification is more detrimental to cooperation than mere 'unranked' ethnic diversity, (2) social exclusivity is strongly increased by ethnic stratification, but that (3) direct reciprocity is robust to cooperative failure across hierarchical ethnic boundaries where indirect reciprocity is not.

In summary, the results presented in this dissertation reaffirm the negative cooperative effect of ethnic diversity, and extend those findings by coupling cooperative field experiments with research on extant resource management systems. Moreover, I have supplied new evidence, from both experiments and surveys, that hierarchical ethnic divisions are more detrimental to cooperation than are non-hierarchical ethnic boundaries. In addition, I find evidence that direct reciprocal relationships may have an important role to play as a tool for enhancing cross-ethnic cooperation.

Indian caste is a particularly famous example of both diversity and stratification. But ethnic forces are at work in every society, and they never rest. Only by understanding these forces of human behavior in depth can we hope to overcome their negative effects. The simple results of this dissertation set a clear and mighty goal for social and economic development in any country, and suggest some powerful means of achieving that goal. The goal is to eliminate correlation between ethnic identity and

social status, and the results hint that the most lasting means of achieving that goal would be to encourage direct reciprocal relations and constant mixing of individuals between ethnic groups. This sort of policy, if successfully implemented, would not only improve social cooperation and economic growth, but may ultimately create new ethnic identities.